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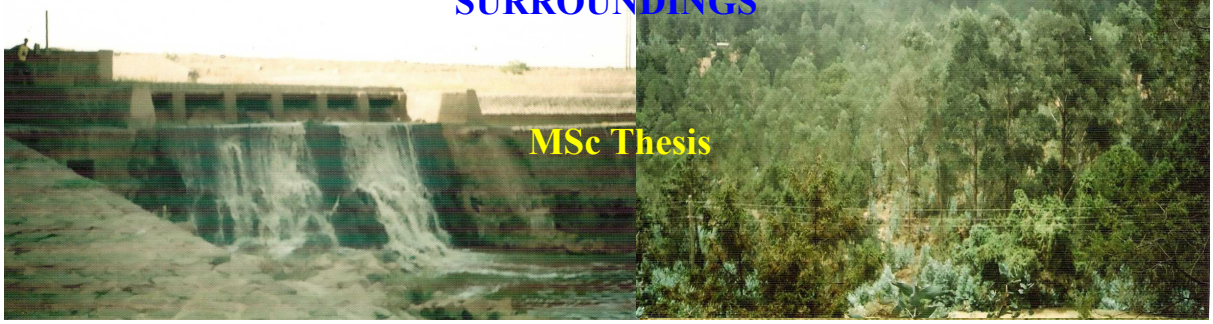
APPLICATION OF REMOTE-SENSING AND GIS FOR POTENTIAL ECOTOURISM SITE SELECTION IN ADDIS ABABA AND ITS SURROUNDINGS



MSc Thesis

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June, 2009

APPLICATION OF REMOTE SENSING AND GIS FOR POTENTIAL ECOTOURISM SITE SELECTION IN ADDIS ABABA AND ITS SURROUNDINGS

BY

DANIEL CHERNET GEBREGIORGIS

JUNE, 2009

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN GIS AND REMOTE SENSING

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Application of Remote Sensing and GIS for Potential Ecotourism Site Selection In Addis Ababa And Its Surroundings

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Table of Contents

Contents ***Pages***

List of figures

List of tables

List of Plates

Acronyms

µm	Micron (Micrometer)
Al	Aluminum
CSA	Central Statistics Authority
DEM	Digital Elevation Model
EMA	Ethiopian Mapping Agency
ESRI	Environmental System Research Institute
ETM+	Enhanced Thematic Mapper plus
FCC	False Color Composite
Fe	Iron
FOA	Food and Agricultural Organization of The United Nations
GCP	Ground Control Points
GIS	Geographic Information System
GPS	Global Position System.
Ha	Hectare
IR	Infrared
MARF	Mean Annual Rainfall
MAT	Mean Annual Temperature
MSS	Multi-Spectral Scanner
NDVI	Normalized Difference Vegetation Index
NIR	Near Infrared
PPT	Precipitation
RBV	Return Beam Vidicon
RF	Rainfall
RGB	Red Green Blue
SRTM	Shuttle Radar Topographic Mission
SWIR	Short wavelength infrared
T º	Temperature
TIR	Thermal infrared
TM	Thematic mapper
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WRB	World Reference Soil Base

ABSTRACT

Addis Ababa is the main get way into and out of the country; hence it receives many tourists. Besides this, the contribution of the tourism industry as a source of revenue in general and the contribution of ecotourism both as a source of revenue and as a means of environmental sustainability in particular is low. Therefore, there is a strong need to studying ecotourism, as part of an alternative form of tourism, for the growth of low impact tourism in the area and for its natural ecosystem maintenance as well as for the benefit of local population. Ecotourism can have many components that can broadly be categorized in to three: Natural, Cultural and Educative components. The aim of this paper is thus to identify potentially suitable sites for ecotourism in the surroundings of Addis Ababa City mainly based on the Natural components of ecotourism. Seven factors, namely: Land use-land cover, Soil, Elevation, Slope, Vegetation density, Temperature and Rainfall were considered to determine the suitability of an area for ecotourism. More emphasis was given to the classification and accuracy assessment of land use-land cover. The result, thus, showed that 84.96% overall accuracy and 0.82 overall kappa statistics which indicates better classification. Using Multi-criteria evaluation, sites suitable for ecotourism were identified. The result showed that highly suitable area accounts for 11 percent, moderately suitable area for 29 percent. Less suitable and very less suitable area, on the other hand, accounts for 33 and 27 percent, respectively. Large parts of the highly suitable areas lie in the Northern, Northwestern and southwestern parts of the study area. Specifically, it includes areas such as 'Suba Menagesha Yemengist Den', Wolmera Goro, area around Menagesh town, Menagesha Medhanealem, Suba and Elala Gojo, some parts of Intoto, Legedadi, Mount Yerer and Mount Furi. Small parts of the highly suitable areas, on the other hand, lie in the extreme parts of the southeastern part of the study area. For the moderately suitable areas, except, for few that are found in the southern parts of the study area, the rest are found nearby the highly suitable areas. The least suitable areas are found dispersedly in all part of the study area. Very least suitable areas, however, are rare in the Northern, North western and southwestern part of the study area. The southern part of the study area is dominated by very least suitable areas.

***Key words**: Ecotourism, Multi-criteria evaluation, Remote Sensing and GIS*

1. INTRODUCTION

1.1 Background Information

Human beings, at least since the Romantic period, have traveled to wilderness for the intrinsic nature of the experience (Fennel, 1999). This indicates human's long history of traveling to enjoy and admire the natural scenery. It is all about tourism, which is supposedly to be the world's biggest industry (Bhattacharya and Kumari, 2004). Tourism is mainly concerned about people and places. It is defined as the relationships and phenomenon arising out of the journeys and temporary stays of people, at least a one-night stay away from the place of permanent residence, traveling primarily for leisure or recreational purpose (Pearce, 1987).

With in the tourism industry there has been strong growth in ecotourism. Ecotourism emerged as a nature-based manifestation of alternative tourism (Angela D. and James E.S., 2005). Though a recent phenomenon, Ecotourism is one of the fastest growing sectors of the tourism industry world wide, it brought up as a development tool to protect the natural environment and cultural diversity by attracting the ecotourist and generating the source of revenue for the local people without harming nature (Bhattacharya and Kumari, 2004).

Caballous-Lascurian explained Ecotourism as "traveling to relatively undisturbed or uncontaminated natural areas with the specific objective of studying, admiring, and enjoining the scenery and its wild plants and animals, as well as any existing cultural manifestations (both past and present) found in these areas (Fennel, 1999)

Large cities are arguably the most important type of tourist destination and tourism has become an important and significant component of their economy (Law, 2002). The term urban tourism simply denotes tourism in urban areas, and begs the question what is special about urban areas (Law, 2002). Applying the practices of ecotourism to an urban environment is a relatively new concept but a concept that merits development in multiple cities. The concept of urban ecotourism, as pioneered by Toronto's Green Tourism Association, is a working example that demonstrates how a city can promote itself, individual businesses and attractions to provide a unique tourism experience and generate

demand for sustainability. The Green Tourism Association of Toronto defined urban ecotourism as

"...travel and exploration within and around an urban area that offers visitors enjoyment and appreciation of the city's natural areas and cultural resources, while inspiring physically active, intellectually stimulating and socially interactive experiences; promotes the City's long term ecological health by promoting walking, cycling, public transportation; promotes sustainable local economic and community development and vitality; celebrates local heritage and the arts; is accessible and equitable to all"

There is a growing consensus that ecotourism should include Natural and Cultural Attractions, Educational and Learning Experiences, and Environmental, Economic and Socio-Cultural Sustainability. The attractions of ecotourism, however, are primarily based in the natural environment. Cultural resources are considered as complementary but secondary attractions. Amongst the tourism sector, it is only in ecotourism that sustainability is inherent.

There is strong relationship between vegetation and ecotourism. Vegetation serves as a habitat for wild life, a pleasant place where people trust to visit, learn and enjoy, and a means of trapping pollutant gases and thus keeping the equitable state of the atmosphere. The study and analysis of vegetation is, thus, helpful in observing the trend and status of our environment. More significantly, it helps in creating and preserving an ecotourist environment.

Vegetation is defined as the mosaic of plant communities in the landscape. A plant community on the other hand may be defined as a part of the vegetation that is relatively uniform in structure and floristic composition, consisting of competing plants which depend on the environment and affect it, too (Kuchler, 1967). Major types of vegetation include forests, rangelands, shrubs, forbs, inland aquatic vegetation and seacoast vegetation (Kuchler, 1967; Lind and Morrison, 1974).

1.2. Problem statement

Ecotourism is increasingly introduced in third world countries in the form of a development package, involving capital, expertise technology and management systems, and is thus becoming something like green revolution (Bhattacharya and Kumari, 2004). However, many issues and challenges confront the practice of ecotourism and these generally differ with in regional and national contexts. Forest and marine habitats are being destroyed and some of the wildlife they contain is being driven to extinction under the pressures of hunting, logging, agriculture and local people encroachment (Mike, 1999).

Despite numerous amounts of natural resources and cultural resources Ethiopia is endowed with, in terms of tourism revenue Ethiopia is rated among the lowest in sub-Saharan country, ranking 126 in the world, based on Travel and Tourism competitiveness index 2008 (Binyam, 2008). Moreover, ecotourism's contribution to the national income as a source of revenue and to the state of the atmosphere as a means of preserving the natural environment is negligible.

Addis Ababa is the main get way into and out of the country. It is the social-economic nerve centre of the country. As a result it has served as a destination and transitional region for local and foreign tourists. Many tourists are attracted by the socio-cultural attractions, museums and city parks it has. Few of the natural attractions include water spring and its suitable climate. Significant, but unexplored, natural attractions, such as forests, water features and unique landscapes are found with in and around the city.

Delineating potential ecotourism sites in Addis Ababa and its surrounding areas is thus helpful in expanding the tourism industry, increasing the source of revenue for the city and to the country as a whole, creating clean air for the city and its environs and providing learning and recreational opportunities for both local and foreign ecotourists. This can be done by restoring lost vegetation and by conserving the cite. The delineation of the potential ecotourism site could be achieved using remote-sensing and Geographic Information Systems.

1.3. Objective

The general objective of this paper is to identify potential ecotourism sites in Addis Ababa City and its surrounding environs.

The specific objectives are:

- ✓ Producing a land use/land cover map of the study area using 2005 landsat image
- ✓ Identifying determinant factors for ecotourism site selection

1.4. Significance of the study

This study will help planners and policy makers to be aware of the significance of Ecotourism in terms of the importance it provides for generating revenue- by attracting ecotourists, conserving the natural environment and providing a play ground for promoting learning. Moreover, it enables local people to be active participant to conserve their environment and to get benefit for their livelihood.

1.5. Expected out put

The primary expected out put of this paper is a potential ecotourism site map with its area delineated. Besides, land use land cover of the study area will be generated using a 2005 landsat image.

2. STUDY AREA OVERVIEW, MATERIALS AND METHODS

2.1 Study Area Description

2.1.1. Location

The study area is situated on the Central Ethiopian Plateau at an elevation ranging from 1903 m up to 3378 m above mean sea level. It covers an approximate area of 2676 sq kilometers. Geographically, it extends from 8^0 43' 45'' N to 9^0 2' 59'' N latitude and from 38^0 27' 32'' E to 39^0 3' 42'' E longitude. At the heart of the study area is the capital city of the country, Addis Ababa which is surrounded by selected kebeles' from five woredas namely, Wolmera, Mulano Sululta, Sebeta, Akaki and Bereh. Burayu Special Zone is another area that surround the city in the North West. Figure 1 shows location map of the study area.

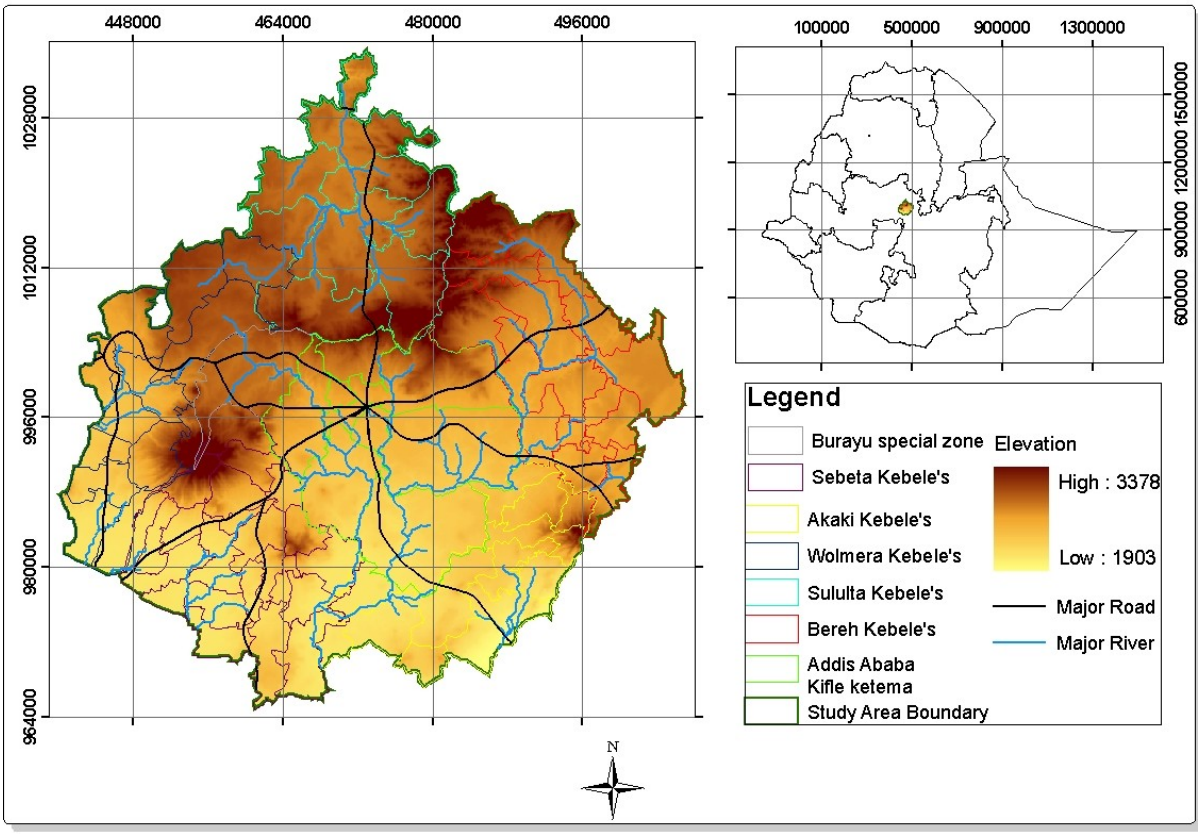


Figure 1: Location map of study area

2.1.2 Climate

Despite its proximity to the equator, the study area experienced cold and warm temperate climate. Highland and Mid-Highland type of climate is dominant in all parts of the study area. Annual rainfall ranges between 700 mm in Bereh Woreda and 1300 mm in Wolmera

Woreda. Temperature, on the other hand, varies between 6^0c in Addis Ababa (Intoto) and 27^0c in Wolmera. December and January are the driest months. The main rainy season occurs between mid June and mid September (Dams, Melaku, Wondimu et al., 2004).

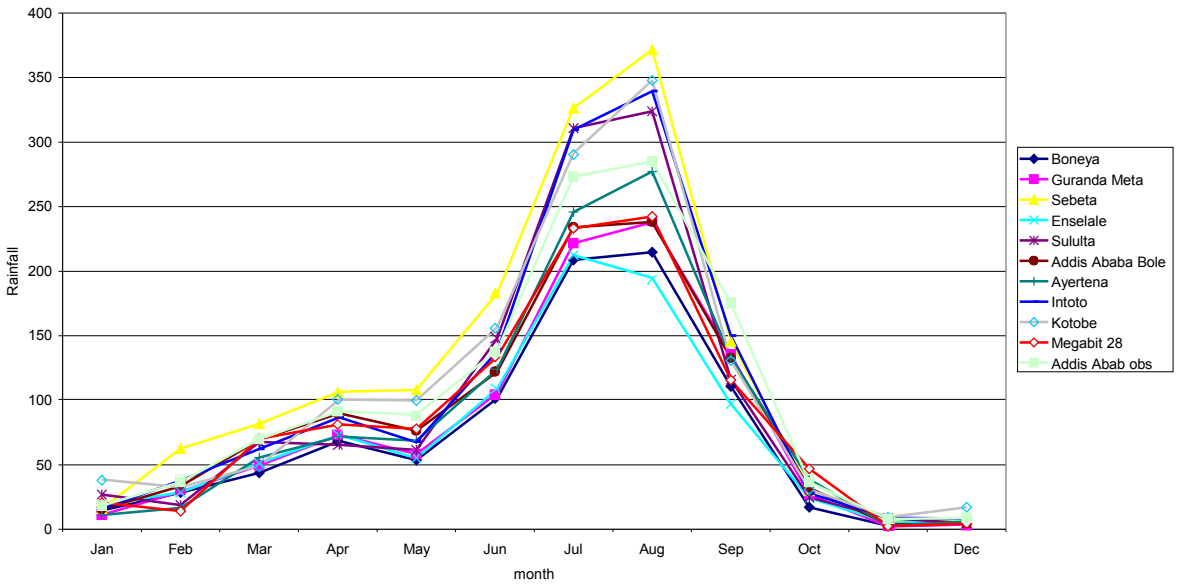


Figure 2: Monthly average rainfall

Figure 2 depicts 30 years (from 1977 to 2007) record of average monthly rainfall of eleven stations found in the study area. Accordingly, highest monthly average rainfall is recorded in Sebeta followed by Kotebe and Intoto. On the other hand, lowest monthly average rainfall is recorded in Boneya and Megabit 28. Highest monthly average rainfall for all stations is recorded during the months of June, July and August. Whereas, lowest average rainfall is recorded in November, December and January.

Figure 3 indicates monthly average maximum temperature recorded over 29 years (from 1978 to 2007) for six stations found with in the study area. Megabit 28 station has the highest monthly average record of maximum temperature, whereas Intoto has the lowest record.

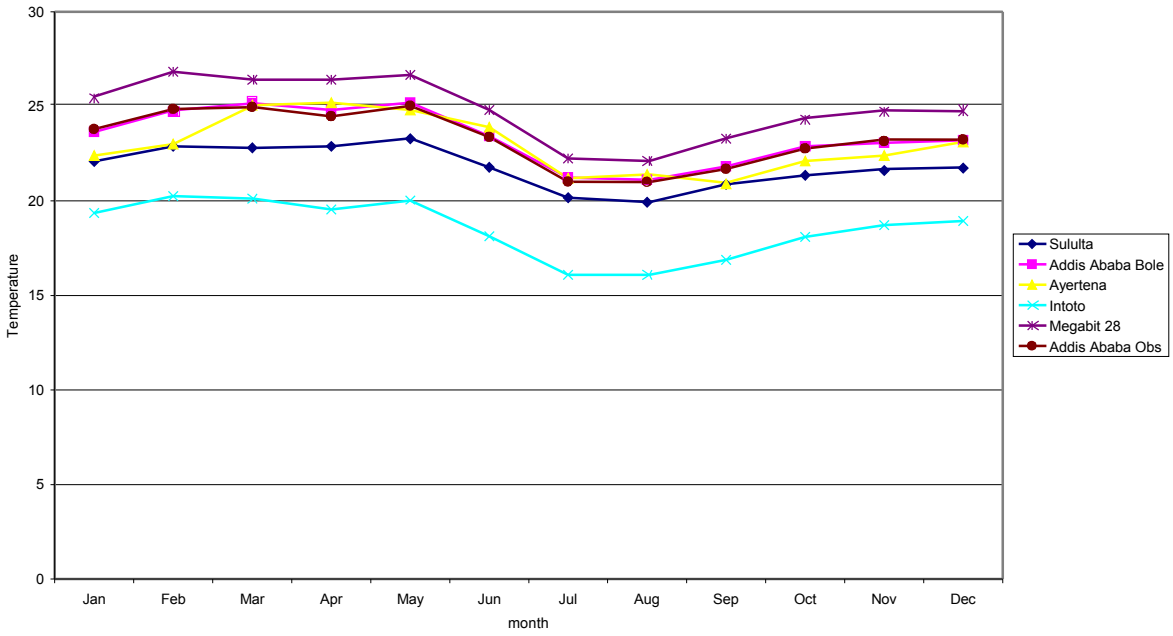


Figure 3: Monthly average maximum temperature

Figure 4 indicates monthly average minimum temperature recorded over 29 years (from 1978 to 2007) for six stations found with in the study area. Ayertena and Intoto have the lowest average record of minimum temperature, whereas megabit 28 station has the highest record

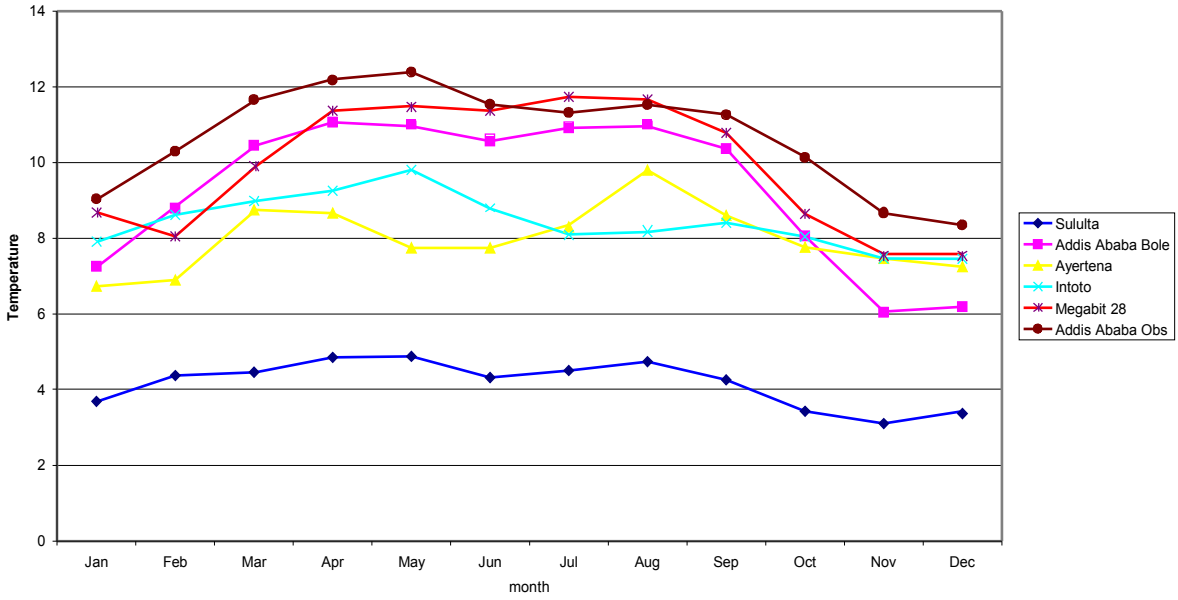


Figure 4: Monthly average minimum temperature

Therefore, from Figure 1, Figure 2 and Figure 3, it can be concluded that the temperature of the city has been varying between 6^0 and 27^0c over the past 29 years. On the other hand, the maximum monthly average rainfall record over the past 30 years is 350 mm in the month of August.

2.1.3 Soil, Geology and Physiography

There are different types of soils in the study area in which vertisols and nitisols are the most dominant. Such soil diversity in the study area is the reflection of soil diversity in Ethiopia, which is called a country of soil museum. Except the Gelic type, all soil taxonomic classifications of the UNESCO/FAO exist in the country.

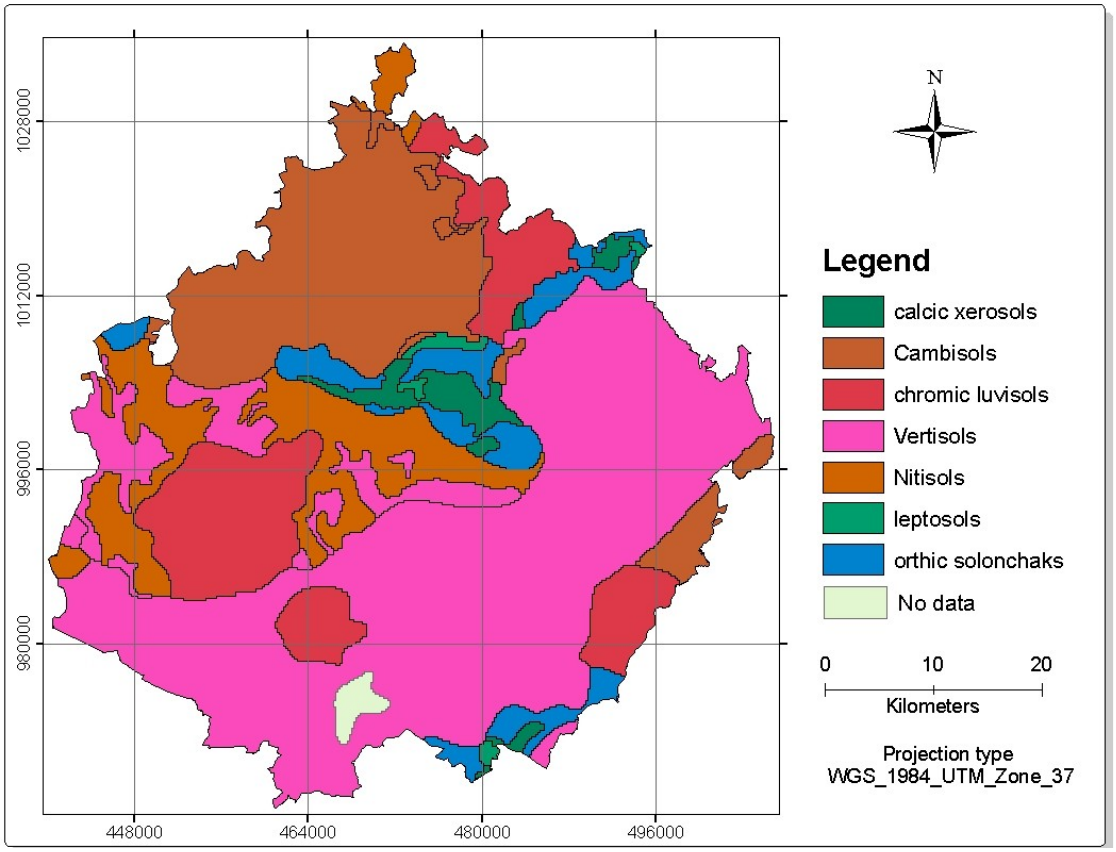


Figure 5: Major soil type

Figure 5 indicates the magor soil types of the study area. Accordingly, seven major soil types exist of which vertisols cover the largest area followed by Nitisols. Leptosols, on the other hand, covers least part of the study area.

The study area lies on volcanic rocks ranging in composition from rhyolitic to basaltic types. The main stratigraphic units are constituted by basaltic, rhyolitic, trachytic and trachy-

basaltic lava flows and welded tuff found at different localities and ages (Dams, Melaku, Wondimu et al., 2004).

Figure 6 indicates that Nazret Series followed by Alagie formation covers large part of the study area. Bishoftu formation, Prealkaline ignimbrites and trachites, Tarmaber Megezez formation and Quaternary basalts cover proportionate areas. Aiba basalts, on the other hand, cover least part of the study area.

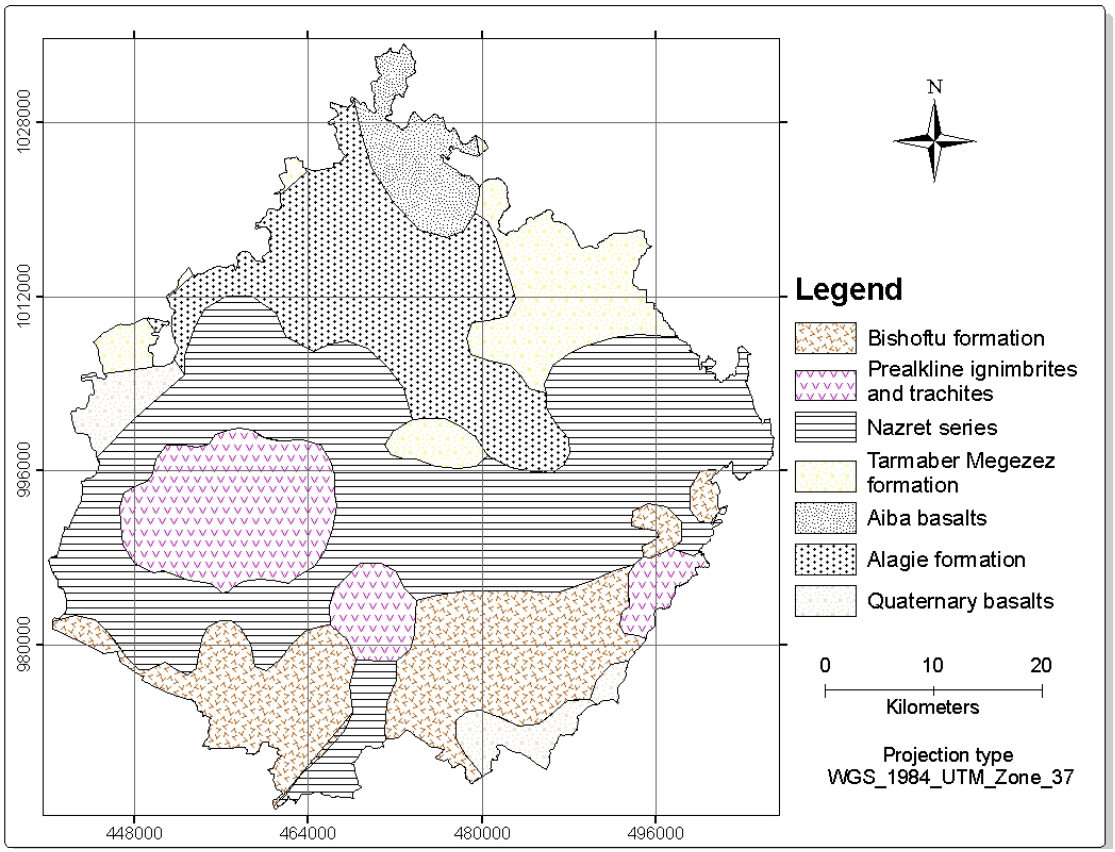


Figure 6: Geological map

The topography of the study area is characterized by the existence of peaks and valleys. At the North, East and West of the study area there are three peaks. These are mount Intoto, Mount yerer and Mount Wochocha, respectively. The southern part of the study area is lowland area characterized by the existence of rivers and Aba Samuel Lake.

2.1.4 Socio-economic information

According to the 2007 census report of CSA, the woredas' in the study area have a total population of 83, 784 for Wolmera Woreda and 30, 823 for Holeta town Woreda; for Akaki Woreda it is 77, 829; for Bereh Woreda it is 81, 205; for Sululta Woreda it is 129, 322; for Sebeta Hawas Woreda it is 133, 746 and for Sebeta town it is 56, 131. Burayu Special Zone has a total population of 63, 873. On the other hand, the population of Addis Ababa city is 2, 738, 248.

2.1.5. Tourism

The study area comprises both natural and cultural attractions. Some of the natural attractions include parks, rivers, forests, grazing (wet) lands and mountains. Forest areas include Furi, Wechecha, Meta, Suba Menagesha, Ades boha Project and Saansunzi and Lole forest.

Source: Field survey

Plate 1: Forest area in Intoto

Unique landscapes and mountains are again another attractions found in the study area. Such mountains as Mogile, Furi, Jamo, Wachacha, Wato Dalocha, Foata, Yerer, Bereh and Intoto are very attractive for tourists as other features. Plate 1, plate 2 and plate 3 represents the natural attractions found in the study area.

Source: Field survey

Plate 2: Mount Yerer and its surrounding landscapes

Wild life such as Hyena, Fox, Rabbit, 'Jart', Monkey and 'Deeroo' on one hand and local and migratory birds on the other hand make the study area more attractive for tourists.

Source: field survey

Plate 3: Birds on Sululta grazing lands

The Entoto St. Mary Museum harbors articles of historical significance (Crowns, drum of the march to the march to the battle of Adwa, ceremonial dresses of Emperor Menelik and Empres Taitu etc…). The National Museum of Ethiopia is also endowed with the earliest hominid skeletons of Lucy (3.4 million years) and Ramidus (4.4 million years old), as well as Jewelry, costumes, paintings and sculptures. Ethnographic Museum of the Institute of Ethiopian Studies is another tourist attraction. The Zoological Natural History Museum displays, from Ethiopia's wild life wealth, the sizable proportion of which are endemic species of rodents, bats, carnivores, primates, birds, snakes, lizards, amphibians, fishes and invertebrates. The city also presents to its visitor's church, Mosque and museums with their fascinating wall paintings and remains of kings in the underground crypt. Century old stamps in the Ethiopian Postal Musem, Photographs depicting the development of the city (at Addis Ababa Musem), and Parks, where lions and cubs, Monkeys and baboons are caged are some of the spots to visitors (Addis Ababa City Council).

2.2. Data Collection and Data Sources

Both primary data and secondary data are used in this study. Primary data was collected using GPS and Digital camera in the field. Secondary data types used, on the other hand, was collected from different offices such as EMA, CSA and Agricultural Bureau and they include Landsat image, SRTM data, Ethio-soil, Ethio-GIS, Population data and Topographic Map.

The following data types and data sources, with their associated processing software's, are used to produce the potential ecotourism site map

Table 1: data source

№ο	Data type	Source	Resolution (scale)	Soft wares used for processing and analysis of the data
1	Landsat ETM+ image of the year 2005	EMA	30m	ERDAS IMAGINE, ENVI, GLOBAL MAPPER and IDRISI
2	SRTM data		90m	3DEM, ERDAS IMAGINE and ArcGIS
3	Soil data (Ethio-GIS)	Agricultural Buearue	1:1,000,000	ArcGIS
4	Ethio-GIS	CSA		ArcGIS
5	Meteorological data	Meteorological service agency		Microsoft Exel, ArcGIS
6	Topographic map	EMA	1:50,000	ArcGIS
7	Geological Map		1:2,000,000	ArcGIS
8	GPS data	Field survey		ArcGIS
9	Questionnaire	Field survey		Micrsoft Word
10	Digital Photo	Field survey		Adobe photoshop and Microsoft

2.3. Data Analysis and Methods

Image preprocessing such as spectral enhancement and spatial enhancement, Georeferencing and image rectification was applied for the ETM+ of Landsat imagery. Spatial enhancement such as , Resolution merging was again applied for better visualization of the image. Noise and Haze reduction and destriping was also applied to remove the bad lines of the original landsat image. For further enhancement and vegetation density analysis, spectral enhancements such as the Tasseled Cap Transformation, the Normalized Difference Vegetation Index and other different vegetation indices were applied. Vegetation assessments were done using NDVI.

A supervised method of image pixel classification using the maximum likely hood algorithm was applied to produce the land use/land cover map of the study area. To produce the suitability map and for elevation analysis ArcGIS spatial analyst was used.

Questionnaire was distributed to and interview was made with experts found in all Woreda offices including Burayu Special Zone and Addis Ababa City. While collecting GPS data, the writer also conducted interviews with some citizens. The questionnaire was systematically compiled and analyzed to determine attraction sites and ecotourism criteria's. Figure 7 and Figure 8, respectively shows the proposed study approac and methodology.

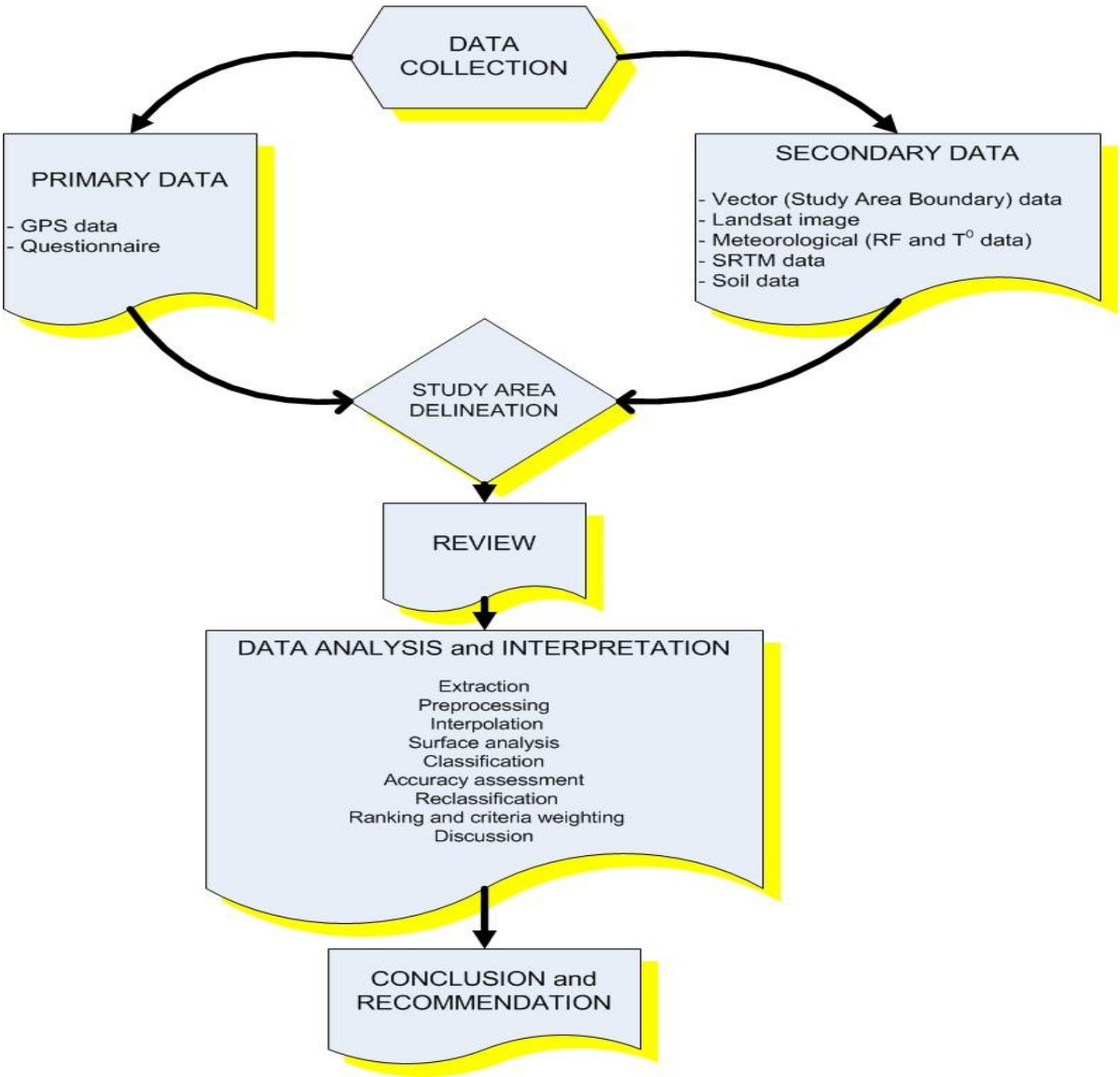


Figure 7: Proposed study area approach

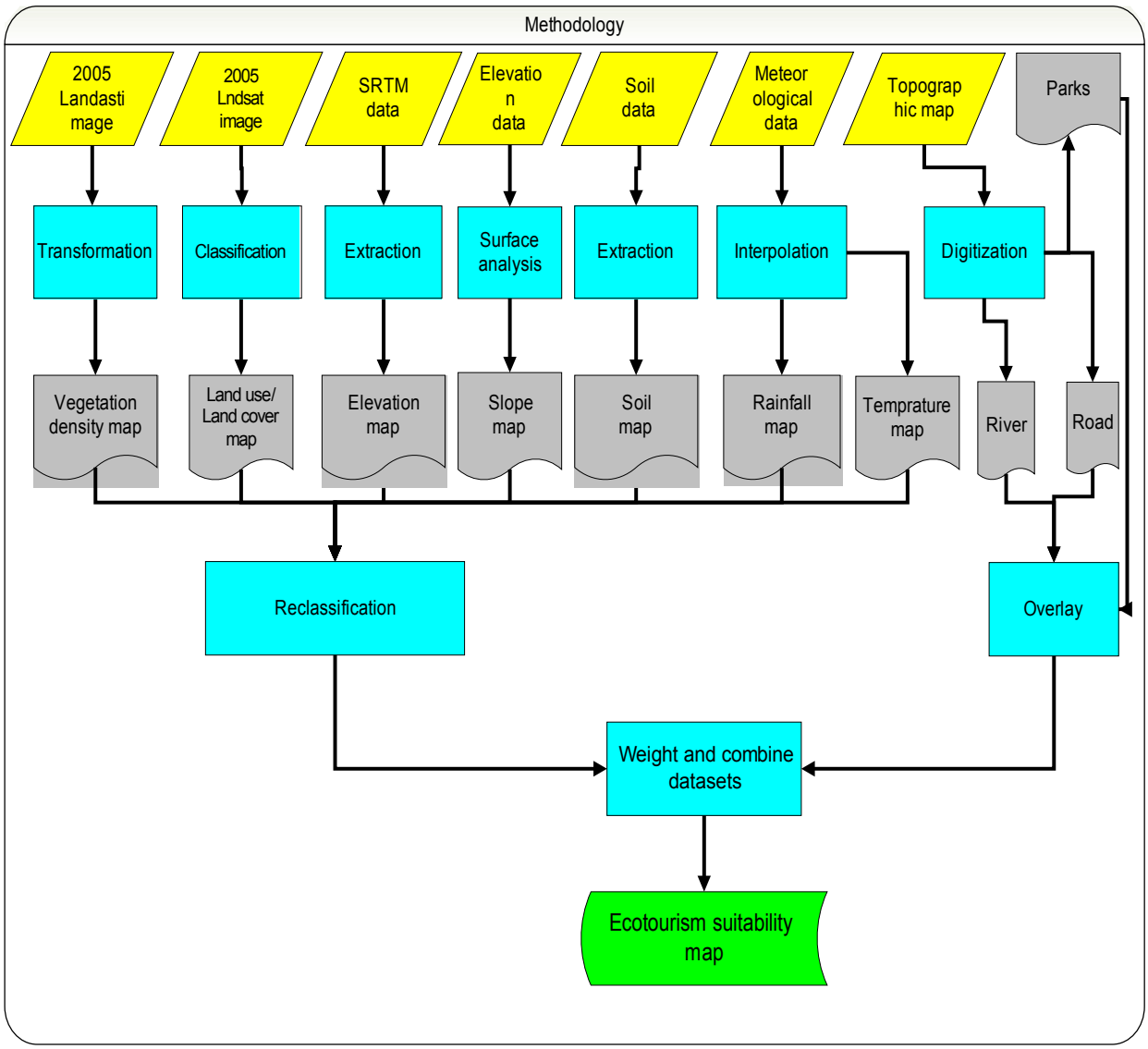


Figure 8: Methodology

3. LITRATURE REVIEW

3.1. Ecotourism Concepts, principles, Elements and Criteria's

3.1.1. Ecotourism Concepts:

The term ecotourism is liable to misuse. No exact and single definition is found for ecotourism. This resulted in the misunderstanding of what exactly the term is. Rai (2005) explained these as one of the major problems of ecotourism.

Ecotourism is often, wrongly perceived as the 'greening of a tourist business'; and/or tourism that is related to nature. Ecotourism is much more than that. The core of ecotourism is environmental sustainability and ensuring that the environmental impacts of any tourism products are minimized. Weaver (2002) explained ecotourism as a special interest, nature-based, low impact tourism; it is a type of tourism which respects local cultures, and most importantly an enjoyable and learning experience for the tourists; and it gives something back to the community in recognition of the satisfaction gained by the tourists. The definition of ecotourism is also cited in The Canadian Environmental Advisory Council as an enlightening natural travel experience that contributes to conservation of the ecosystem, while respecting the integrity of host communities (Wight, 1997). As cited in Drumm and Moore, ecotourism is environmentally responsible travel and visitation to natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features, both past and present) that promotes conservation; has a low visitor impact on nature and provides for beneficially active socio-economic involvement for local peoples (Kenan Ok, 2005).

According to White, Sustainable development and thus ecotourism first came about as a result of global recognition for the need of environmental protection. The Mohonk Agreement's definition of ecotourism is related to such sustainability, and it defined ecotourism as sustainable tourism with a natural area focus, which benefits the environment and communities visited, and fosters environmental and cultural understanding appreciation and awareness. Fennel (1999), considered ecotourism as a sustainable activity that is primarily focused experiencing and learning about nature, ethically managed to be low impact, non-consumptive, and logically oriented. However, ecotourism as a concept is

ambiguous, and has been interpreted to mean different things to different people.

White indicated that there has been extensive research into the negative environmental impacts from tourism, because tourism industry has often been criticized for its consumptive use of natural environments on which they are dependent. According to White ecotourism is tourism that occurs in and depends upon the natural environment like other forms of alternative tourism, but instead of just about being the environment, ecotourism is for the environment.

The concept of ecotourism thus involves primarily, the inclusion of nature-based attractions, interpretation of the environment, learning experiences and ecosystem management and conservation; as secondary attractions, it also includes respect of indigenous or local cultures. Generally, it is concerned with the maintenance and sustainable development of the natural environment by implementing low impact tourism and concerned with the benefit of local communities by generating revenue.

3.1.2. Ecotourism and Other Forms of Tourism

Tourism is only part of the whole idea of sustainable development (Wight, 1997). As cited in the World Tourism Organization, tourism is any form of travel that involves a stay of at least one night but less than one year away from home for the purpose of leisure and recreation.

Tourism can broadly be divided as Mass Tourism and Alternative Tourism (Rai, 2005; Fennel, 1999).

Mass Tourism is purely leisure and entertainment oriented usually offering higher degrees of comfort and convenience regardless of any environmental effects (Rai, 2005). Mass tourism leads to high concentrations of people in relatively small places and in such cases tourism often appears to be less of blessing and more of blight. Moreover, there is the danger of tourism killing tourism.

Alternative Tourism on the other hand, seeks to face mass tourism from the opposite side. This involves lesser number of people as well. Rai (2005), by citing the work of Honey, mentioned five types of Alternative tourism. These are:

I. Nature Tourism it involves travel to unspoiled areas to experience and enjoy nature. It is based directly on the use of natural resources in a relatively undeveloped state, including scenery, topography, water features, vegetation and wildlife (Rai, 2005).

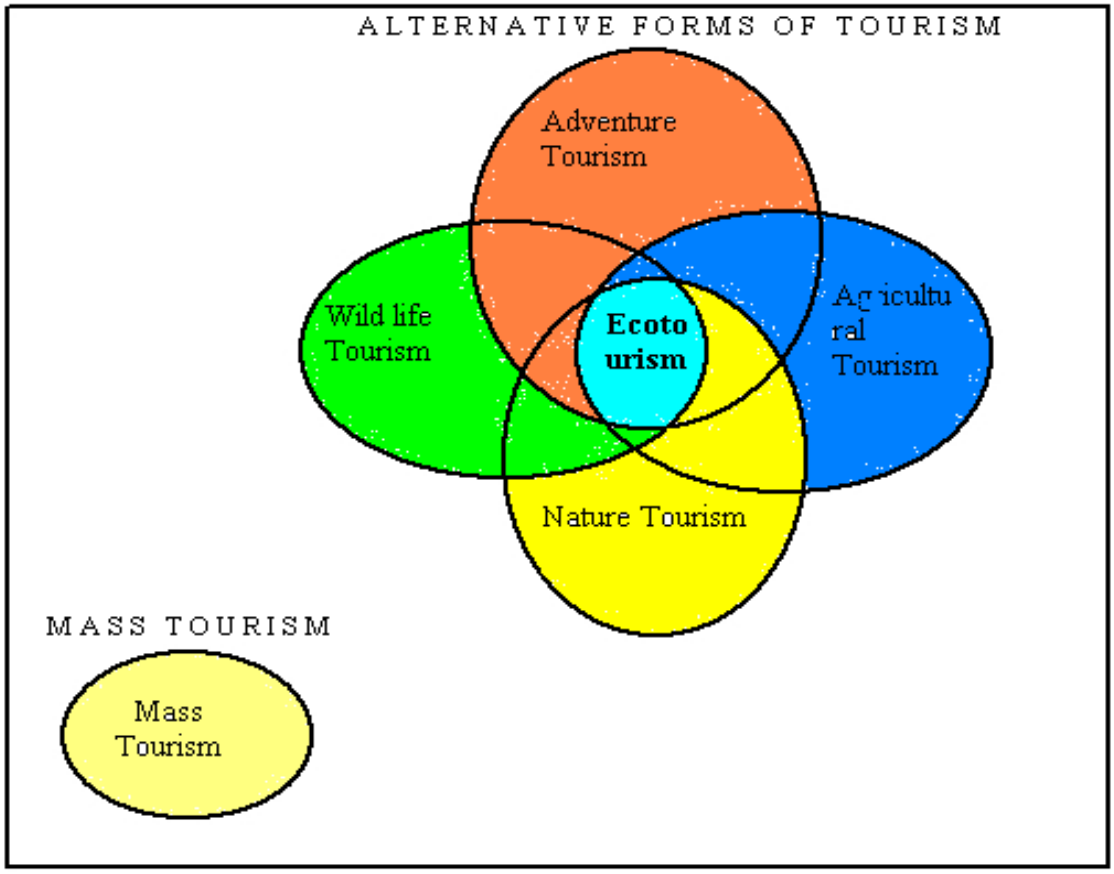
II. Adventure Tourism is nature tourism with a "kick". This requires physical skill and involves a degree of risk taking. For example, rock climbing, mountaineering and Snorkeling.

III. Wildlife Tourism it involves travel to observe animals like birds, mammals and fish in their native habitat. This includes both consumptive and non-consumptive use of wild animals. For example, visit to parks and bird watching.

IV. Agricultural/Rural Tourism is a newly emerging form of tourism where farmers offer many opportunities for tourists to find experiences closely connected with agricultural practices. For example, horse back riding and home stays.

V. Ecotourism can include all the above types of tourism. But in addition to recreation ecotourism should result in strong benefits to conservation and the local people as well.

As it is indicated in Figure 9 ecotourism can have the form of the other four types of Alternative tourism, but not that of mass tourism. This is because mass tourism is not concerned with environmental sustainability. whereas, ecotourism strongly gives emphasis to environmental sustainability. It is again clearly mentioned that there is no relationship between mass tourism and ecotourism. Strong relationship, however, exists among the five types of alternative tourism; the binding component at the centre of the relationship being that of ecotourism. This binding component became main characteristics of ecotourism because of the existence of environmental sustainability in all the types of alternative tourism.



Source: Adapted from **http://www.infa.gov.in/surabhi/surabhi.doc**

Figure 9: Relationship between Ecotourism and other forms of tourism

Obadiah categorized ecotourism as one form of nature-based tourism in which the other types are Adventure Travel, Wilderness travel and Car camping. However, there is little distinction between ecotourism and such nature based tourism. Among these subdivisions ecotourism primarily involves travel by Europeans and North-Americans to all parts of the world.

3.1.3. Principles and Elements of Ecotourism

Ecotourism is usually associated with a specific tourism activity in a specific site but can be particularly associated with the range of activities and products in a region or country (Fall, 2006). Normally it is associated with natural areas on land. It also includes cultural and educative component. However, not all ecotourism has a cultural component (Fall, 2006).

3.1.4. Criteria's For Ecotourism Sites and Attractions

Ecotourism often involves small-scale tourism oriented to natural areas, wildlife, and traditional culture. According to McGreen, the suitability of an area for ecotourism is determined largely by the presence of natural attractions. Wever (2002), on the other hand, indicated three general basic criteria for ecotourism attractions. These are:

- Nature and cultural attractions
- Educational and Learning experiences
- Environmental, Economic and Socio-Cultural sustainability

Other attractions for ecotourism are protected areas and parks. Examples of protected areas include National parks, Wildlife Reserves, Scientific Reserves, Natural Monument, Managed Nature Reserve, Protected Landscapes, Resource Reserves, Natural Biotic Areas and Multiple Use Management Areas (Kenan Ok, 2005; Wells and Brandon, 1992).

Besides their contribution to conservation and environmental sustainability, parks and protected areas have a certain mystique character to travelers interested in some of the best representative natural regions or countries. Simply stated: parks and protected areas often generate more recreational use simply because they are recognized as parks (Fennel, 1999).

Ecotourism activities and criteria's are highly related with Landscape planning. Landscape planning makes important long-term contributions to the conservation of natural resources. It not only addresses the narrower areas of particularly valuable protected sites, but also devices strategies for full coverage, sustainable conservation and long term development of nature and landscapes (Wike, Schiller, et al., 2002). Landscape planning can be applied to the populated and open areas of the landscape (kiemstedt, 1994).

The implementation of technical environmental protection measures can be made more efficient through landscape planning. Among other things, landscape planning requires the reduction of air, noise, water and ground pollution (Kiemstedt, 1994). Kiemestedt also stated that the landscape and nature are essential to man's physical and emotional well being in

today's technical environment. It is also the task of landscape planning to ensure for quite, nature related recreation.

Kiemstedt (1994) stated that Landscape planning is the basis for environmentally sound community development and offers the following functions:

- Comprehensive inventory of the landscape and nature
- Serve as an aid for urban and town revitalization
- Serve as a basis for environmentally sound agricultural and forestry practices

In order to ensure the long term and lasting protection of the capacity of the ecosystem, landscape planning focuses on three main issues (Kiemstedt, 1994). These are:

i. Species and habitat protection
ii. Nature and Landscape related recreation
iii. Soil, water, air and climate

At the first step in the landscape planning process, baseline information on the current state of nature and landscape, on the functional capacity of the natural environment, on the scenic quality of the landscape, on development potential as well as existing and foreseeable problems and conflicts with other existing or foreseeable land uses are collated (Wiek, Schiller, et al., 2002). According to Wiek and Schiller Focal topics for landscape planning are soils, water, air, climate, flora/vegetation and fauna as well as the amenity value of the landscape. As an example, inventory concerning the following information is recorded:

i. Presence and distribution of species of flora and fauna
ii. Fresh air source areas and fresh air corridors
iii. Conditions in the landscape for recreation and opportunities for experiencing nature
iv. Structural characteristics of environmental waters
v. Goal conflicts which indicate the current and prospective state of nature and the landscape

The components that make up the ecosystem, the landscape and the natural environment are the primary attractions that build ecotourism system. However, ecotourism is not only

limited to these attractions; it also, as a secondary attraction, includes local or indigenous cultures. Most significant, however, is the sustainability and educative component.

By aggregating all the major components, we can get the following detail components of ecotourism (http://www.apo-tokyo.org/gp/e_publi/gplinkeco/04chapter2.pdf; http://www.rri.wvu.edu /pdffiles/bukenya2012.pdf; Fennel, 1999; Wike, Schiller, et al., 2002; kiemstedt, 1994; Mitchell, 1989; Kenan Ok, 2005).

Table 2: Natural resource components of ecotourism

Natural Resource Components	Ecotourism activities
Vegetation cover - grasslands - Hedges - woodland and a forestation - Bushes - Trees - Gardens - Endangered/threatened plants - Weed - Status of natural vegetation - Forests	Picnicking Leaving nothing but footprints and taking nothing but photos Camping Hiking
Water - lakes - wetlands - rivers and stream - swamps	Wetland discovery activity Swimming
Topography and landforms - relief - geology - valley - open land - mountains - unique landforms	Trekking Bicycle tour Horse riding tour Hiking
Surface materials - soils - Unmaintained land - sand	Picnicking
Fauna (animals) - consumptive - species - non-consumptive - Avifauna (Number of migratory birds)	Bird watching Shooting facility
Agriculture - Farm land - Commercial Horticulture	Picnicking Leaving nothing but footprints and taking nothing but photos
Weather and Climate - Number of rainy days - Amount of ppt - Temprature	Picnicking

Parks, reserves and protected areas	Camping Picnicking
Noise level	Minimize noise
Air quality	Reduce waste and pollutants
Visual amenity	Picnicking
Solid waste disposal system	Managing solid waste disposal system
Accessibility	Hiking, biking, Horse riding
Wilderness	Leaving nothing but footprints and taking nothing but photos

Table 3: Cultural resource components of ecotourism

Cultural Resource components	Ecotourism activities
land use	
Urbanization	
Rural areas	
Special views	
Archeological sites	History and technology trip
Shrines	
Historical sites and events	History and technology trip
Major works	History and technology trip
Utilities	
Monasteries	

Table 4: Educative and sustainable components of ecotourism

Educative and Sustainable component	Ecotourism activities
Educative Component - Enhancing Knowledge - Fostering positive attitude towards environmental conservation	Education
Sustainable component - Applying sustainable tourism - Ecotourism marketing - Applying green management measures	Minimize fuel and energy Consumption Effective waste disposal system Waste recycling Education Minimizing impact

3.2 Application of Remote-Sensing and GIS

3.2.1 Application and definition of GIS

The term GIS was created using the development of the Canada Geographic Information Systems in the early 1960s by using computers and computer graphics to do tasks such as mapping. It evolved from automated cartography in response to the needs of the resource managers to analyze growing quantities of data in a timely manner (Estaes, McGwire and Star, 1997; Mitchell, 1989).

Geographic Information System involves information about human's world ranging from local scale to global scale. It is explored on a computer and performs two key activities: visualizing spatial information and performing spatial analysis.

Simply defined, GIS is the joining of maps and data and/or it is a software tool for mapping and analyzing just about any object. Best definition, however, is given by Estaes, McGwire and Star, (1997), Mitchell (1989), and www.t4cd.org as a system of computer software, hardware and data, and personnel to help manipulate, analyze and present information that is tied to a spatial location. GIS technology integrates powerful database capabilities with the unique visual perspective of a map. GIS involves information about the real world that is represented by points, lines, areas and images; at any scale ranging from local to global. It is a system designed to capture, store, integrate, retrieve, visualize, manipulate, calculate, analyze and display data, which are spatially referenced. Moreover, it is capable of allowing the input and editing of any type of geographic data, and out put information in the form of tables and/or maps.

Geographical information systems operates on two data elements. These are geographical or spatial and attribute data. The spatial data refers to locational aspects either explicitly (using a standard geographical frame of reference such as latitude and longitude) or implicitly (using surrogate spatial references such as postcode/addresses). On the other hand, the attribute data includes statistical and non-locational data associated with a spatial entity (Baharie and Elliot, 1999; Estaes, McGwire and Star, 1997).

Baharie and Elliot (1999), and Burrough and McDonnel (1998), put five types of definitions of GIS. These are:

A process based definition it is a system for capturing, storing, checking, manipulating, analyzing and displaying data which are spatially referenced to the earth.

A tool box based definition it contains a powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data

A database based definition it is a database system in which most of the data are spatially indexed, and up on which a set of procedures operated in order to answer queries about spatial entities in the database.

An application based definition its application, for example, includes cadastral information systems, planning information systems, site plan reviews, facility citing, and inventory and analysis.

Organization based definition it is a decision support system involving the integration of spatially referenced data in a problem solving environment

GIS is thus a collection of software packages for data input, storage, retrieval, analysis and out put of information in the form of tables and/or maps. It deals with both locational and non-locational information of earth surface features.

3.2.2. Application and definition of Remote-Sensing

In simple terms, Remote-Sensing is sensing the nature of earth surface objects from a distance. The Canadian Centre for Remote-Sensing defined it as 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 displaying that information.

Remotely sensed images record the interaction of electromagnetic energy with the earth's surface. Targets in Remote-Sensing images may be any feature or object, which can be observed in an image, and has the following characteristics (Lillisand, 2004):

i. Targets may be a point, line or area feature

ii. The target must be distinguishable: it must contrast with other features around in the image.

According to Lillisad (2004) and The Canadian Centre for Remote-Sensing, Remote-Sensing images can be represented either in analog or digital format. Imagery displayed in a pictorial or photograph type is in analog format; whereas, if it is represented in a computer as arrays of pixels, with each pixel corresponding to a digital number, representing the brightness level of that pixel in the image, it is in digital format.

3.2.3 Application of Remote-Sensing and GIS for Ecotourism

GIS has been widely discussed in environmental and resource management applications. In the context of ecotourism, however, it has limited but important applications. GIS provides a set of tools, which can be used for sustainable tourism planning and development (Bahaire and Elliot-White, 1999). Using GIS it is possible to integrate ecotourism information, visualize complex scenarios, present powerful ideas and derive effective solutions.

GIS has been used to analyze ecotourism related issues such as the perception and definition of wilderness, parks, reserves and protected areas. Site selection and management for ecotourism activities has been done using remote sensing and GIS in many areas. For example, in North America and England GIS has been used to accomplish the following ecotourism related issues:

- To define conservation and recreation areas and determine the ‘best’ locations for development..
- To identify those zones with greatest potential for tourism development; that is, those with opportunities (active and interpretative) based on natural resources (mountains, forests, rivers etc), cultural resources and combinations of both.
- Similarly, Boyd and Butler (1996) demonstrate the application of GIS in the identification of areas suitable for ecotourism in Northern Ontario, Canada; in particular natural areas, containing rare or endangered species or habitats in remote/peripheral areas. Basically they produce an inventory of various

characteristics associated with natural landscapes. GIS was used for inventory mapping, buffering (identifying areas of human intrusion) and overlays mapping.

- GIS produced three types of information: tourism resource maps, tourism use maps, and tourism capability maps. This enables stakeholders to analyze the resource set to:

  - ✓ Identify how much is available and where it is. To help planners and managers determine the capability of an area for the creation of new tourism products/services – identifying locations suitable to tourists/tourism.
  - ✓ Evaluate land-use options. To identify zones of conflict/complementary – access points, water, wildlife habitats etc.
  - ✓ Monitor tourist resources at risk from poor management and planning decisions.

Although interpretations of sustainability vary, tourism planning of whatever variety presupposes the existence of information on natural resources and qualities, cultural/heritage attractions, the manner in which resources are used by visitors and the economic and social impacts. Effective tourism planning also requires monitoring mechanisms and feedback information on the effect of planning decisions on the tourism resource.

GIS can be an effective tool in the design and monitoring of sustainable development (Holm-pederson & Rasmusen, 1995).

GIS can be applied in the following manner in Tourism and Ecotourism related issues (Baharie and Elliot-White, 1999).

- ✓ Data access and routine work
- ✓ Data integration and management
- ✓ Tourism (Ecoturism) Resource inventory
- ✓ Area designation and map overlays
- ✓ Comparative land-use and impact analysis
- ✓ The analysis of visual intrusion
- ✓ Identifying most suitable locations for development
- ✓ Analyzing relationships associated with resource use

- ✓ Assessing potential impacts of tourism development
- ✓ Visitor management flows
- ✓ Community involvement and participation

3.3. Image Analysis

When remote-sensing data are available in digital format, digital processing and analysis may be performed using a computer. Digital processing may be used to enhance data as a prelude to visual interpretation.

Digital processing and analysis may also be carried out to automatically identify targets and extract information completely without manual intervention by a human interpreter. However, rarely is digital processing and analysis carried out as a complete replacement for manual interpretation. Often it is done to supplement and assist the human analyst.

According to the Canadian Centre for Remote-Sensing and Lillisad (2004) most of the common image processing functions available in image analysis systems can be categorized in to the following four categories:

i. Preprocessing:

Preprocessing involves those operations that are normally required prior to the main data analysis and extraction of information and are generally grouped as radiometric or geometric correction. Radiometric correction includes the correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor. Geometric correction, on the other hand, includes correcting the geometric distortions due to sensor Earth geometry variations, and conversion of the data to real world coordinates (e.g., Latitude on the earth's surface).

ii. Image Enhancement:

The objective of image enhancement is solely to improve the appearance of the imagery to assist in visual interpretation and analysis. Examples include contrast stretching and

spatial filtering. Image enhancement is only applied to a single channel of data at a time.

iii. Image transformation:

Unlike image enhancement, image transformations are applied to multiple spectral bands. Usually, they involve combined processing of data. Arithmetic operations (i.e., subtraction, addition, multiplication and division) are performed to combine and transform the original bands into "new" images which better display or highlight certain features in the scene. Examples include Tasseled Cap and NDVI.

iv. Image classification and Analysis:

Operations are used to digitally identify and classify pixels in the data. Classifications are usually performed on multi channel datasets and their process assigns each pixel in an image to a particular class or theme based on statistical characteristics of the pixel brightness values.

3.4. Multi-Criteria Evaluation

3.4.1. Concepts of Multi-Criteria Evaluation

Multi-criteria evaluation is a means by which complex decision-making process is structured and analyzed. It tries to simplify complex decision-making tasks, which may involve diversity of possible outcomes, and some times many intangible criteria by which to assess the outcomes (Drechsler and Proctor, 2003).

Multi-criteria evaluation is a technique in which to identify trade-offs in the decision making process with the ultimate goal of achieving compromise. It seeks to identify the alternatives or options that are to be investigated in considering a decision; it also helps decision makers choose among alternatives by showing the tradeoffs between alternatives (Drechsler and Proctor, 2003).

According to Obadiah, Multiple Criteria Decision Making framework helps decision makers choose among alternatives by showing the tradeoffs between the criteria, which enables them to make choices in a rational, consistent, and documentable manner. Ronald (2001) defined MCE as a procedure of evaluating several criteria in order to meet specific objectives.

It is achieved by either Boolean overlay or weighted linear combination. In the former case 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). In the later case, however, continuous criteria (factors) are standardized to a common numeric range, and then combined by means of a weighted average. The result is a continuous mapping of suitability that may then be measured by one or more Boolean constraints to accommodate quantitative criteria, and finally threshold to yield a final decision (Ronald, 2001).

Basic advantage of multi-criteria evaluation is its ability to provide a frame work to complex decision making problems that allows the problem to be broken down in to workable units and to be structured in such away that enables the complexities of the problem to be unraveled. In theory and in practice, however, multi-criteria evaluation does not adequately address the facilitation issue of interaction between analyst and decision-makers to elicit and revise preferences as part of the iterative process particularly with multiple decision makers, multi-criteria evaluation does not provide clear guidelines on how to analyze or aggregate multiple weights (Drechsler and Proctor, 2003).

Multi-criteria evaluation has been applied for the characterization and evaluation of environmental issues, sustainable development and ecotourism site selection (Wager, 2007; Mitchel, 1989). The need for multi-criteria evaluation in such issues, according to wager (2007), is because of the following reasons:

- To take in to account both qualitative and quantitative information in decision making process

- Existence of weak comparability in ecotourism criteria's

In Multi-criteria evaluation two types of comparability exists: strong comparability and weak comparability. In strong comparability, one single comparative term exists by which all different assumptions can be ranked. In weak comparability, however, conflicts between the different options exist. It is not possible to define a status of preference and indifference between two options as one option is better than another in terms of some criteria, but worse for others.

3.4.2 Multi-Criteria Decision Making in GIS

The primary issue in MCE is concerned with how to combine the information from several criteria to form a single index of evaluation. In weighted linear combination, factors are combined by applying a weight to each followed by a summation of the results to yield a suitability map. The formula for weight combination is given as follows (Ronald, 2001):

$$S = \sum WiXi$$ where ***S*** is suitability W_i is weight of factor, X_i is Criterion score of factor ***i.***

Because of the different scales up on which criteria are measured, it is necessary that factors be standardized before combination using the above formula, and the type be transformed, if necessary, such that all factor maps are positively correlated with suitability. As it is cited in Vogged, a procedure for standardization, typically using the minimum and maximum values as scaling points (Ronald, 2001). According to Ronald (2001) the simplest linear scaling is given by Vogged as follows:

$$Xi = (Ri - R\min) \div (R\max - R\min) * \textit{Standardized range}$$

Where X_i is the criterion score of factor ***i;*** and ***R*** is row score

3.4.3. Criteria Weighting

A wide variety of techniques exists for the development of weights. Simply, criteria weights can be accomplished by dividing 1.0 among the criteria. However, when the number of criteria is more than a few and the considerations are many, it becomes quite difficult to make weight evaluations on the set as a whole (Ronald, 2001). In Multi-criteria evaluations, the preferences of the decision maker are accounted for by the weighting placed on each of the criteria and sub-criteria. These weightings may range from equal importance of all criteria, to a ranking of most to least important or to a relative weighting of all criteria (Drechsler and Proctor, 2003).

Breaking the information down into simple pairwise comparisons in which only two criteria need to be considered at a time can greatly facilitate the weighting process, and will likely produce a more set of criteria weights. A pairesise comparison method has the great advantage in setting criterion weights (Ronald, 2001). As it is mentioned in Satty's technique, the procedure for multi-criteria evaluation sums the weights to one, and weights of this nature

can be derived by taking the principal eigen vecor of a square reciprocal matrix of pairewise comparison between the criteria (Ronald, 2001. Figure 10 reveals Ratings that are provided on a 9 point continuous scale in IDRISI software.

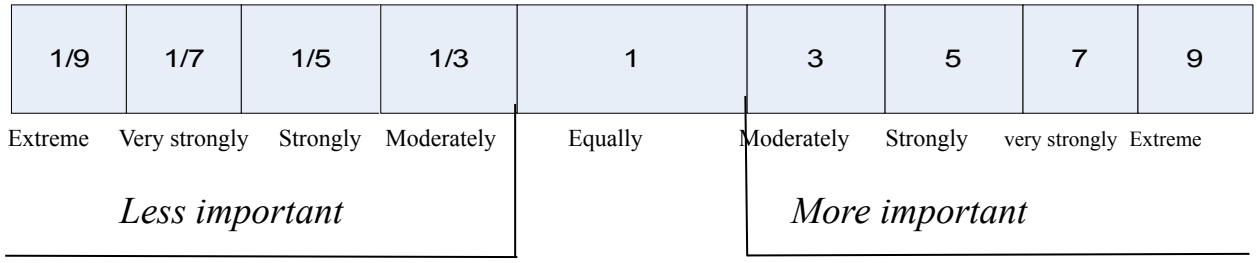


Figure 10: The continuous rating scale of multi-criteria evaluation

In developing the weights, an individual or group compares every possible pairing and enters to ratings into a pairwise comparison matrix (Ronald, 2001). After eigen vectors are generated each factor map is then multiplied by that value. The weighted aggregation method multiplies each standardized factor map by its factor weight (Burrough and McDonnel, 1998; Ronald, 2001). According to Burrough and McDonnel (1998) the final suitability map can be calculated as follows:

$$\textbf{\textit{Suitability Map}} = W_1 (factor\ map_1) + W_2 (factor\ map_2) + W3\ (factor\ map_3) \ldots + W_x (factor\ map_x)$$

where W_1-W_x is weight factor

3.4.4. Ecotourism Criteria Weighting

Assigning weights for ecotourism criteria's is not as such simple. This is because measuring or quantifying the attraction value of ecotourism in order to assign priority or rank is very difficult. Mitchel (1989) indicated that those favoring protection of the environment usually make emotional appeals about the landscape without numerical information and detailed computations.

There is a debate about the acceptable scale of ecotourism. Some advocate small-scale (village level) operations. Others believe larger operations such as resorts and theme parks can meet ecotourism criteria. There is no easy answer to this other than to say that scale does not matter if the tourism product has less impact (http://www.apo-tokyo.org/gp/e_publi/gplinkeco/04chapter2.pdf). Kiemstdet (1994) explained about the difficulty of quantifying criteria's

for landscape recreation as follows “Today the allocation of every bit of nature for recreation is no longer justifiable”.

As cited in kates, beauty can not be described, hence impossible to define. It can not be measured in quantity or quality (Mitchel,1989). Mitchel suggested that small areas of exceptional landscape value could be regarded as national heritage area, and given greater protection. Unfortunately, no guidance has been given concerning the rationale for specifying such areas. However, the philosophy underlying a general approach for landscape attractiveness is explained by Leopold (Mitchel, 1989) as follows:

> “Landscape that is unique either in a positive or negative way is of more significance to society than one that is common”

Thus, it can be concluded that no specific rules and measurements exist as to whether large-scale operations or small-scale operations are highly attractive for ecotourism. Regardless of the matter of scale, any activity or operation having low impact on the environment but that can bear high aesthetic value could be considered as an ecotourism attraction. In this study, five major factors of the natural environment are considered to determine the best suitable site for ecotourism. These are vegetation, soil, relief, land use/land cover and Weather condition

3.4.4.1 Vegetation

Vegetation may be defined as the patch work of plant species arrayed across the landscape. It includes a variety of life forms such as trees, shrubs, grasses, forbs and non-vascular plants like mosses.

Besides their contributions to food, shelter, wildlife habitat and daily supplies. Forests play an important role in balancing the earth's CO2 supply and exchange, acting as a key link between the atmosphere, geosphere, and hydrosphere (Canadian Centre For Remote-Sensing). Forests also have many ecotourism attractions. According to Zografos and Oglethorpe (2004) there is a decline in the amount of forests world wide. But demand on services such as recreation and tourism values especially generated by protected areas has increased rapidly.

3.4.4.2 Soil

Soils are major support systems of vegetation as well as human life and welfare. They provide anchorage for roots, hold water long enough for plants to make use of it, and hold nutrients that sustain life. Most of the lands biodiversity lives in the soil, not above ground.

According to the World Soil Resources Reports (2006), soil is defined as the natural medium for the growth of plants, whether or not it has discernible soil horizons. In the WRB, soil was defined as "… a continuous natural body which has three spatial and one temporal dimension". According to the above report, the three main features governing soil are:

- ✓ It is formed by mineral and organic constituents and includes solid, liquid and gaseous phases
- ✓ The constituents are organized in structures, specific for the pedological medium. These structures form the morphological aspect of the soil cover, equivalent to the anatomy of a living being.
- ✓ The soil is in consistent evolution

The study area comprises the following types of soils:

- Eutric nitisols - Vertic cambisols - chromic luvisols - Orthic solonchaks
- Chromic cambisols - Calcic xerosols - Leptosols - Pellic vertisols
- Chromic luvisols - dystic nitisols

3.4.4.3 Relief (Topography)

Altitude, also called elevation, is the height of a place above (or below) a reference level, such as mean sea level. Altitude, like latitude, acts through climatic conditions to exert a major influence upon the distribution and abundance of living things (Kuchler, 1967). Topography influences plants in several fundamental and many subtle ways.

Altitudinal vegetation zones mirror altitudinal climatic zones. Today altitudinal vegetation zones are well established, the basic zones in ascending order being submontane, montane, upper montane, subalpine, alpine, subnival and nival. However, the causes of this zonary management are not wholly resolved and are the subject of continuing research.

3.4.4.3.1. DEM

DEMs are scaled models of topography. Different types of DEMs exist such as TIN, CONTOUR and GRIDDED. Square Gridded DEMs, however, become the most common format of DEM in use, owing to their ease of computer representation and manipulation (Huggeth and Cheesman, 2002).

According to Abrams and Welch, Topographic data as well as derived slope and slope aspect are basic to all aspects of land surface research including cartography, geology, geomorphology, soil science and climate modeling. Digital elevation data are also required for atmospheric and radiometric correction of most satellite observations of the land surface. Digital elevation data are also used for practical engineering applications such as studies of drainage and run off, and site suitability studies for urban development, waste containment, and recreation.

According to Huggeth and Cheesman (2002), topographic elements of a landscape can be computed directly from a DEM and these are often classified into primary (or first-order) and secondary (or second-order) attributes. Primary attributes are calculated directly from the digital elevation data; the most commonly derived include: slope and aspect. Secondary attributes, however, combine primary attributes and include indices that describe or characterize the spatial variability of specific processes occurring on the landscape; examples are soil erosion and a wetness index.

Gridded DEMs (Huggeth and Cheesman, 2002) however, have a number of disadvantages:

- Data redundancy in areas of uniform terrain
- They can not easily handle abrupt changes or differing complexity in elevation due to resolution, so that important details of land surface in complex regions are often missed.
- The resolution of the grid influence storage requirements, computational efficiency, and results obtained.
- The computed upslope flow paths used in hydrological analysis tend to zigzag unrealistically, which hinders the accurate determination of such primary attributes as catchment area.

Using a TIN structure, however, offers a more flexible and efficient alternative to overcome many of the above problems, and in particular to avoid redundancy (Huggeth and Cheesman, 2002).

3.4.4.4. Land use/Land cover

According to The Canadian Centre for Remote-Sensing, land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Identifying, mapping and delineating land cover is important for global as well as regional monitoring studies, resource management and planning activities.

Identification of land cover establishes the baseline from which monitoring activities (change detection) can be performed and provides the ground cover information for base line thematic maps.

Land use, on the other hand, refers to the purpose the land serves. For example, recreation, wildlife habitat, or agricultural. 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. This knowledge will help develop strategies to balance conservation, conflicting uses and developmental processes (Canadian Centre for Remote Sensing).

4. DATA ANALYSIS AND INTERPRETATION

In this paper, factors for ecotourism suitability were analyzed and interpreted using standardized remote sensing and GIS techniques. Mapping of Land use land cover was done using a 2005 Landsat ETM+ image. The Landsat ETM+ image has 8 bands in which the first 3 bands record reflected light in the visible wavelengths whereas bands 4, 5 and 7 record reflected light in wavelengths that human eyes can not detect. Band 6 and band 8, on the other hand, record the thermal band and panchromatic band, respectively. In this study, however, only bands 1, 2, 3, 4, 5 and 7 were used. Figure 11 shows Landsat image of the study area in FCC with GCP's taken from the field.

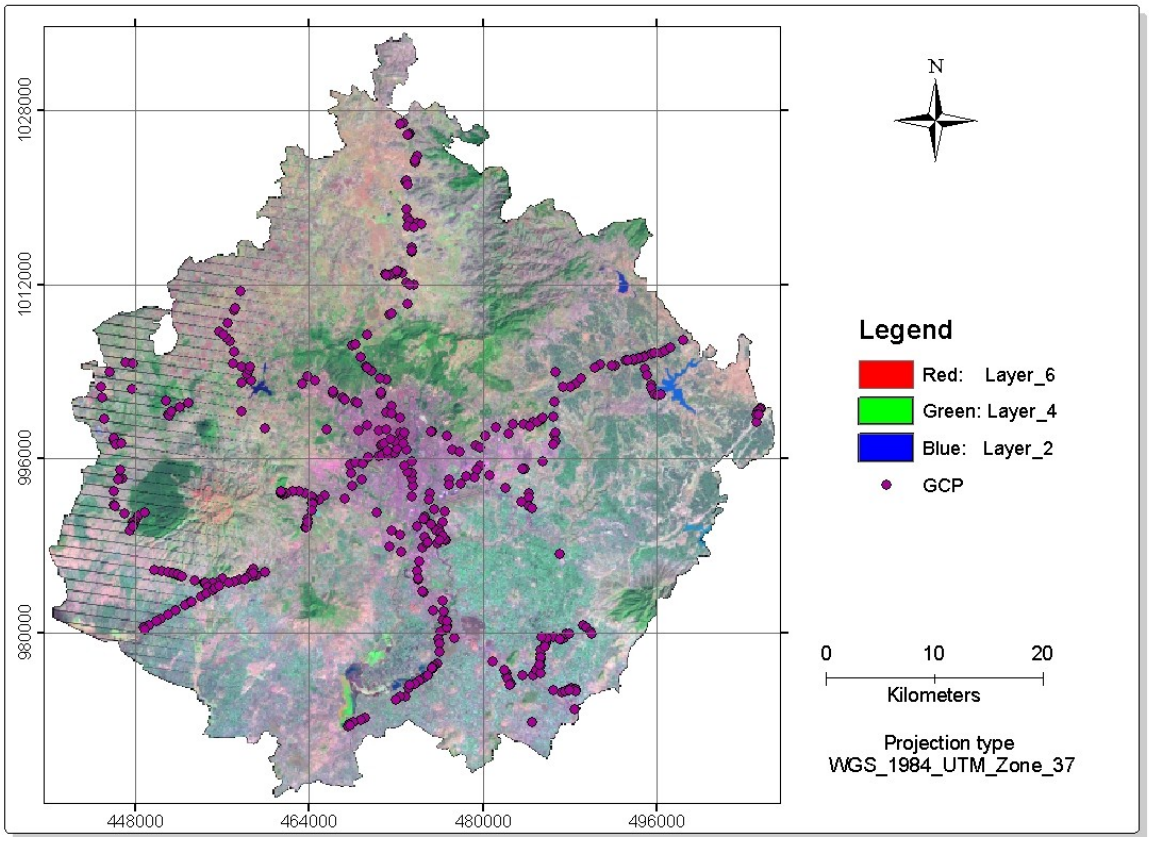


Figure 11: Landsat image of the study area with GCP in FCC

4.1. Preprocessing

Preprocessing operations involve those operations that are normally required prior to the main data analysis and extraction of information, and are generally grouped as radiometric or geometric corrections (Lillisad and Kiefer, 2004).

Both Radiometric and Geometric corrections were applied on the original image. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise. Geometric corrections, on the other hand, include correcting the data for geometric distortions due to sensor-earth geometry variations, and conversion of the data to real world coordinates on the earth's surface (Lillisad and Kiefer, 2004).

4.1.1. Geometric Corrections

The geometric correction process involves identifying the image coordinates (i.e. raw, column) of several clearly discernible points, called GCPs, in the distorted image, and matching them to their positions in ground coordinates (latitude, longitude).

To geometrically register the images in to real world coordinate systems, both image-to-map and image-to-image registration processes were applied. In image-to-map registration, true ground coordinates are typically measured from a map, either in paper or digital format, then the coordinate information is processed by the computer to determine the paper transformation equations to apply to the original (raw and column) image coordinates to map them into their new ground coordinates. In image-to-image registration, on the other hand, one image is registered to another image instead of to geographic coordinates. The Landsat image was registered to Topographic map of the study area using coordinates from well distinguishable features. Since the original image has stripes, it was destriped using a similar Landsat 2000 image. Before destriping, however, it was geometrically registered to the original Landsat image. GCP's taken over the ground was also used to correct and test the original image.

4.1.2. Radiometric Corrections

Various methods of atmospheric correction can be applied ranging from detailed modeling of the atmospheric conditions during data acquisition, to simple calculations based solely on the image data (Lillisand and Keifer, 1999).

Noise in an image may be due to irregularities or errors that occur in the sensor response and/or data recording and transmission. Common forms of noise include systematic striping

or banding and dropped lines. Both of these effects should be corrected before further enhancement or classification is performed.

The Original Landsat image of the study area of the 2005 year, as it is shown in the above figure, has such systematic stripping, especially in the western part of the study area it is full of stripes. To reduce or avoid these stripes a 2000 Landsat image, which has not any stripes, was used. To destrip the distorted image, ERDAS IMAGINE Model builder was used.

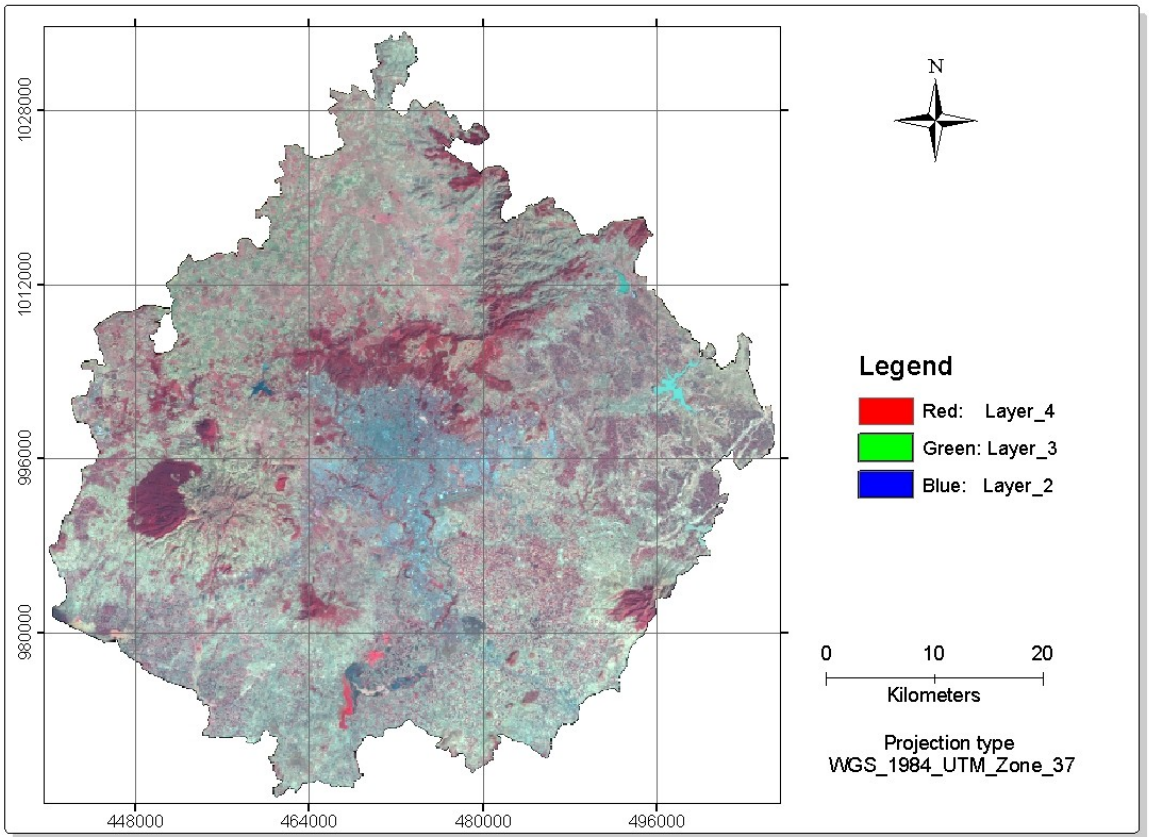


Figure 12: Destriped Landsat image in FCC

Figure 12 shows that the systematic stripes that exist in the original image being eliminated. In this image, as contrary to the image in figure 11, the western part of the study area which is located around Suba Menagesha and Holeta are free of any systematic stripes.

4.2. Image Enhancement

The advantage of digital imagery is that it allows us to manipulate the digital pixel values in an image so that the image will be enhanced for better visualization and understanding. Enhancements are, thus, used to make digital images easier for visual interpretation and understanding.

Such radiometric enhancements as Haze reduction and Noise reduction were applied after the image was destriped. Haze reduction is used to dehaze the image, whereas Noise reduction was used to remove noise from the image using an adaptive filter (ERDAS Field Guide, 2005).

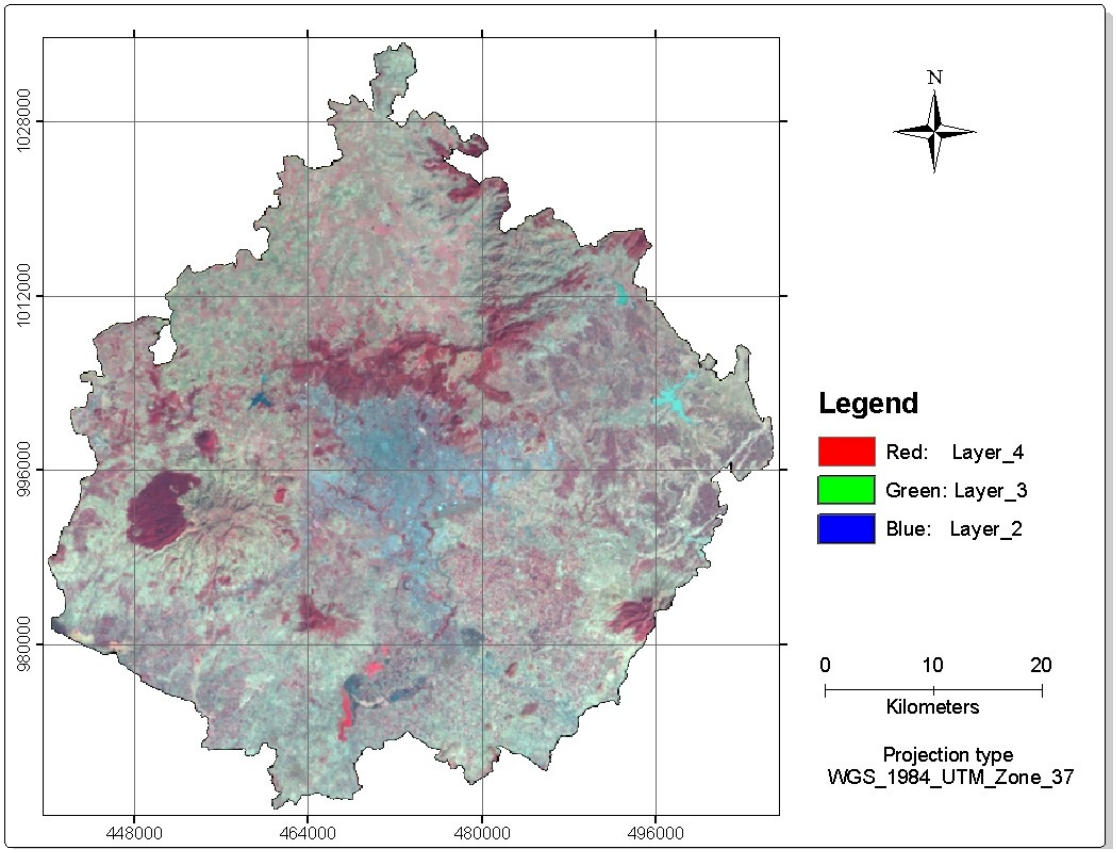


Figure 13: Dehazed and Noise reduced Landsat image in FCC

Figure 15 reveals better visual representation than the original and the destriped images. The Dark red shows forests and trees; the light red shows grasses and plantation; the cyan (light blue) color shows water body. The purple color, on the other hand, shows built up and soil.

4.3. Image Transformation

Image transformations typically involve the manipulation of multiple bands of data, whether from a single multispectral image or from two or more images of the same area acquired at different times (i.e. multitemporal image data). Either way, image transformations generate "new" images from two or more sources which highlight particular features or properties of interest, better than the original input images (Lillisand and Kiefer, 2004).

Basic image transformations apply simple arithmetic operations to the image data. Image subtraction is often used to identify changes that have occurred between images collected on different dates. Image division or spectral rationing, on the other hand, is used to highlight subtle variations in the spectral responses of various surface covers. By rationing the data from two different spectral bands, the resultant image enhances variations in the slopes of the spectral reflectance curves between the two different spectral ranges that may otherwise be masked by the pixel brightness variations in each of the bands.

The advantage of spectral rationing is that it serves to reduce shadow effects and it again used to discriminate one feature from another feature. For example if the ratio of Band 7 to Band 5 is used, vegetation will be clearly discriminated from water and soil. Similarly, the NDVI is used for vegetation discrimination from soil and water features.

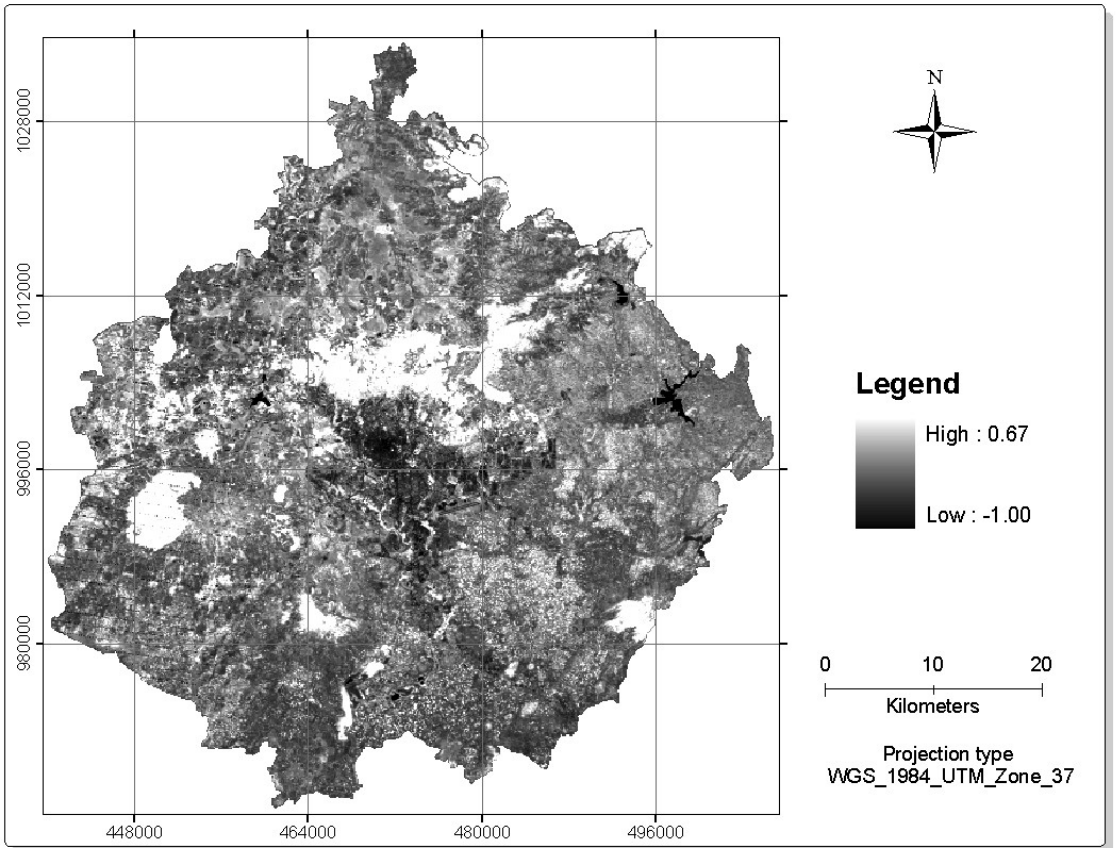


Figure 14: NDVI of Landsat image

As it is indicated in figure 14, the NDVI value of the study area varies between +0.67 and -1.0. The brighter color shows the existence of vegetation whereas, the darker color shows other features such as soil, built up and water features. The more the brighter the feature the more the existence of vegetation and the more the darker the feature the more the existence of water and similar to water features.

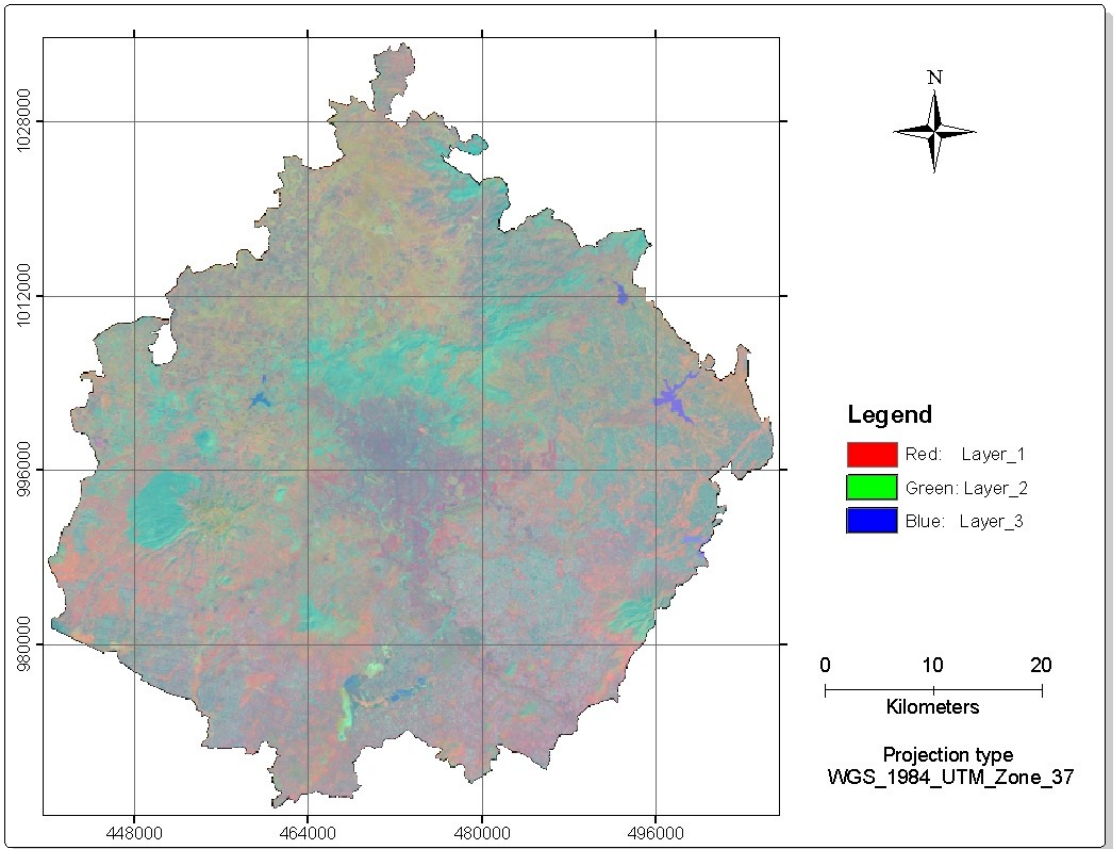


Figure15: Greeness, Wetness and Brightness component of the Tasseled cap Transformation

As it is indicated in figure 15, Band 1, Band 2 and Band 3 represent the Brightness, Greeness and Wetness components of the Tasseled Cap Transformation. The Brightness component indicates areas of low vegetation whereas the Greenness component indicates areas of green vegetation. The Wetness component, on the other hand, indicates area of water and moisture.

4.4. Image Classification and Analysis

Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and it attempts to classify each individual pixel based on this spectral information. The objective of image classification is to assign all pixels in the image to particular classes or themes Such as Water, Soil, Vegetation and Built up etc,. The resulting classified image is comprised of a mosaic of pixels, each of which belong to a particular theme, and is essentially a thematic "map" of the original image (Lillisand and Keiffer, 2004). Land use land cover of the study area is, thus, produced using the supervised method of image classification. Accordingly, there are 10 classes; namely, Forests, Water, Scattered trees, Shrub, Eucalyptus, Grass land, Farm land, Bare soil, Built up and Bare land (stony).

4.5. Criteria's for Ecotourism Suitability

4.5.1. Land use and Land cover

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 land, 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). The Canadian Centre For Remote Sensing defined Land cover as the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Land use, on the other hand, is defined as the purpose for which the land serves. For example, recreation, wildlife habitat, or agricultural.

Identifying, mapping and delineating land cover is important for global as well as regional monitoring studies, resource management and planning activities. It also establishes the baseline from which monitoring activities (change detection) and suitability can be performed and provides the ground cover information for base line thematic maps.

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. This knowledge will help develop strategies to balance conservation, conflicting uses and developmental processes. Table 5 indicates description of land use land cover type of the study area.

Table 5: Land use land cover type description

Land use/Land cover type	Description	Land use suitability for Ecotourism
Built up	Includes residential area, commercial and Services area. It also includes utilities, communication and transportation.	It can serve as accommodation site, service provider and for Infrastructure development.
Grass land	Includes grasses and at some period in a year can serve as wetlands.	Is an area of grazing land and an area where local and migratory birds can entertain.
Forest	Includes dense and closed forest	Highly important for ecotourism and sustainable environment. It can serve as main ecotourism attraction.
Water body	Includes areas completely or partially covered by water	Can serve as active recreation
Eucalyptus	Includes a diverse genus of flowering trees. Some times it is called gum trees	Less important for ecotourism but it has beneficial economic impact up on the poor population and it is a fast growing source of wood.
Scrubs	It is a horticultural rather than strictly botanical category of woody plant, distinguished from a tree by its multiple stems and lower height.	Important for ecotourism and sustainable environment.
Scattered trees	Includes open forest- it is a combination of Tid, Eucalyptus and woodlands	Moderately important for ecotourism. They are prominent features in many landscapes and have such functions as the provision of distinct microclimate and increased soil nutrients.
Farm land	Includes Agricultural land	It can be used for agro-forestry scheme, land reclamation, for agricultural use or used for urban development.
Bare land (stony)	Includes Waste land	It can serve for future settlement and construction purposes. Currently not suitable for ecotourism
Bare soil	Includes sand and soil unmaintained land for any purpose.	It can serve for infrastructure development and for hiking and horse riding

A supervised method of image classification using the maximum likelihood algorithm was used to categorize each pixel in to their respective feature classes. Training areas for each

feature class was selected based on the spectral information of the pixels. Moreover, field observation was used as an aid for categorizing features, which may create confusion if only spectral information were used. As an aid of categorizing features found inaccessible areas, topographic map of the study area and information from local field assistants was used.

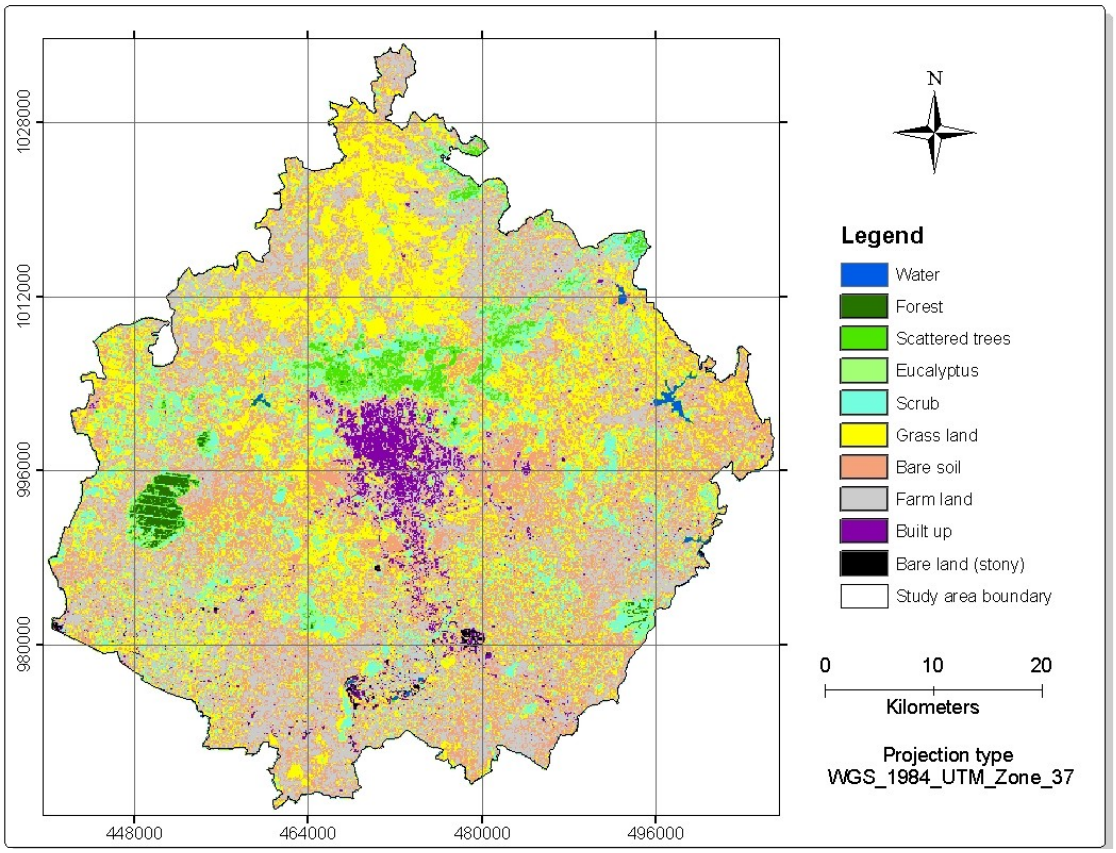


Figure 16: Land use Land cover map

As it is indicated in figure 16 and figure 17, 32 percent of the study area is covered by farmland. It is then followed by grass land which accounts for 26 percent. Bare soil and Eucalyptus trees also took 17 and 16 percent, respectively. Built up accounts for 4 percent, scattered trees for 2 percent and the rest altogether accounts for 3 percent. This indicates the proportion of land use land cover type that is highly important for ecotourism suitability covers large area. For example, forest, scattered trees, shrubs, grasslands and water bodies are highly important for ecotourism and environmental sustainability. Altogether, these features account for 44 percent of the total land cover. Other features less important for ecotourism such as farmland, bare soil, Eucalyptus and built up account similar percentage share.

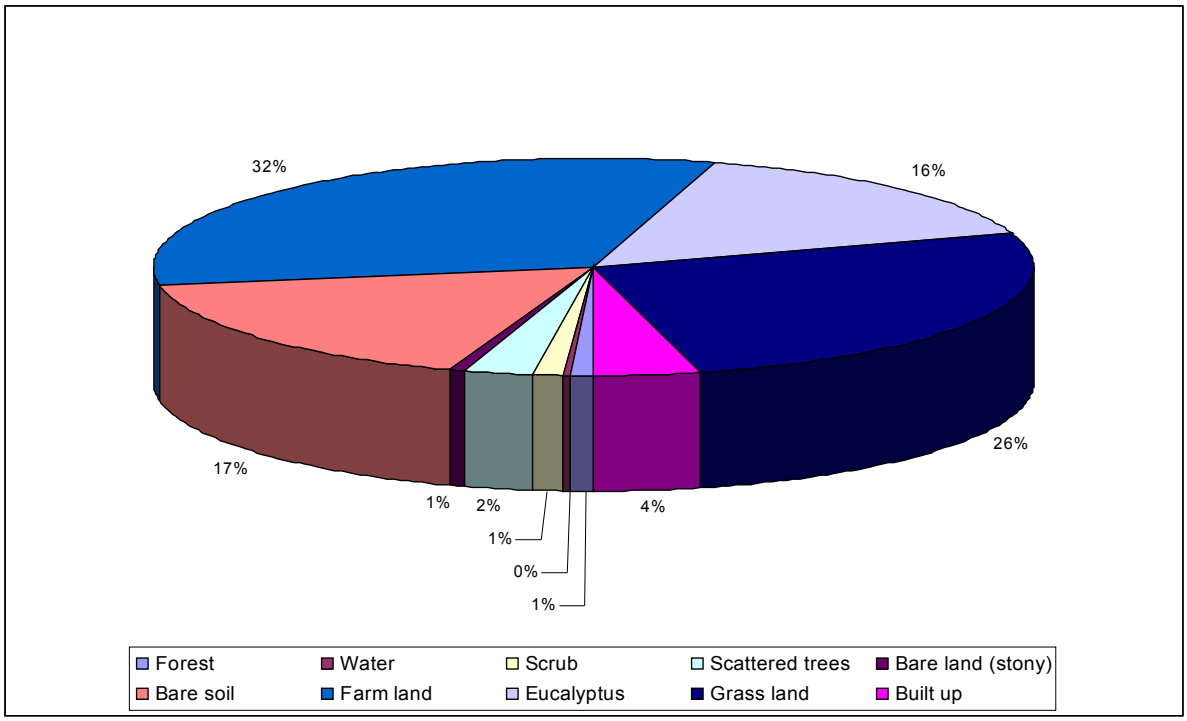


Figure 17: Percentage share of land use land cover type

Accuracy assessment

As it is mentioned in table 7 and table 8, the overall accuracy is found to be 84.96% and the overall kappa statistics is 0.82 which indicates good results of classification. The conditional kappa for each class category is also calculated, as a result it is 1 for scattered trees, forest and water.

Table 6: Error matrix

Classified data	**Reference data**											**Raw total**
	Unclassified	Built up	Grass land	Eucalyptus	Farm land	Bare soil	Bare land (stony)	Scattered trees	Scrub	Water	Forest	
Unclassified	***0***	*0*	*4*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*5*
Built up	*0*	***84***	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*88*
Grass land	*0*	*3*	***88***	*3*	*7*	*0*	*0*	*0*	*0*	*0*	*0*	*101*
Eucalyptus	*0*	*2*	*1*	***44***	*1*	*1*	*0*	*1*	*0*	*0*	*0*	*50*
Farm land	*0*	*2*	*2*	*3*	***66***	*3*	*2*	*1*	*0*	*0*	*0*	*79*
Bare soil	*0*	*6*	*0*	*3*	*10*	***51***	*0*	*1*	*0*	*0*	*0*	*71*
Bare land (stony)	*0*	*0*	*0*	*0*	*1*	*0*	***6***	*0*	*0*	*0*	*0*	*7*
Scattered trees	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***4***	*0*	*0*	*0*	*4*
Scrub	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	***3***	*0*	*0*	*4*
Water	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***6***	*0*	*6*
Forest	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***4***	*4*
Column total	*0*	*97*	*96*	*55*	*87*	*56*	*8*	*7*	*3*	*6*	*10*	***419***

It is above 8 for Built up, grass land, Eucalyptus and Bare land (stony). It is again between 7 and 8 for Scrub and Farm land. The lowest recorded is that of bare soil and it is 0.67; this is a result of the mixing of 10 classes of bare soil in to farmland.

Table 7: Accuracy totals

Class name	Accuracy totals					Conditional kappa for each class
	Reference totals	Classified totals	Number correct	Producers accuracy	Users accuracy	
Unclassified	0	5	0			0
Built up	97	88	84	86.60%	95.45%	0.9409
Grass land	96	101	88	91.67%	87.13%	0.833
Eucalyptus	55	50	44	80.00%	88.00%	0.8619
Farm land	87	79	66	75.86%	83.54%	0.7923
Bare soil	56	71	51	91.07%	71.83%	0.6749
Bare land (stony)	8	7	6	75.00%	85.71%	0.8544
Scattered trees	7	4	4	57.14%	100.00%	1
Scrub	3	4	3	100.00%	75.00%	0.7482
Water	6	6	6	100.00%	100.00%	1
Forest	4	4	4	100.00%	100.00%	1
Totals	419	419	356			

4.5.2. Vegetation Density

Vegetation density of the study area was generated using NDVI image of the study area. The NDVI is a non-linear transformation of the visible (Red) and NIR bands of satellite image.

Healthy vegetation will have high NDVI values ranging from +1 to -1. However, no green leaves give a value close to zero. A zero means no vegetation and close to 1 (0.8-0.9) means the highest possible density of green leaves. Bare soil and rock reflect similar levels of NIR and Red and so will have high NDVI values near zero. Clouds snow and vegetation are the opposite of vegetation in that they reflect more visible energy than infrared energy, and so they reflect negative NDVI values (Lillisad, 2004 ; ENVI help).

To produce vegetation density of the study area, the NDVI image was classified using the supervised method of image classification using the maximum likelihood algorithm

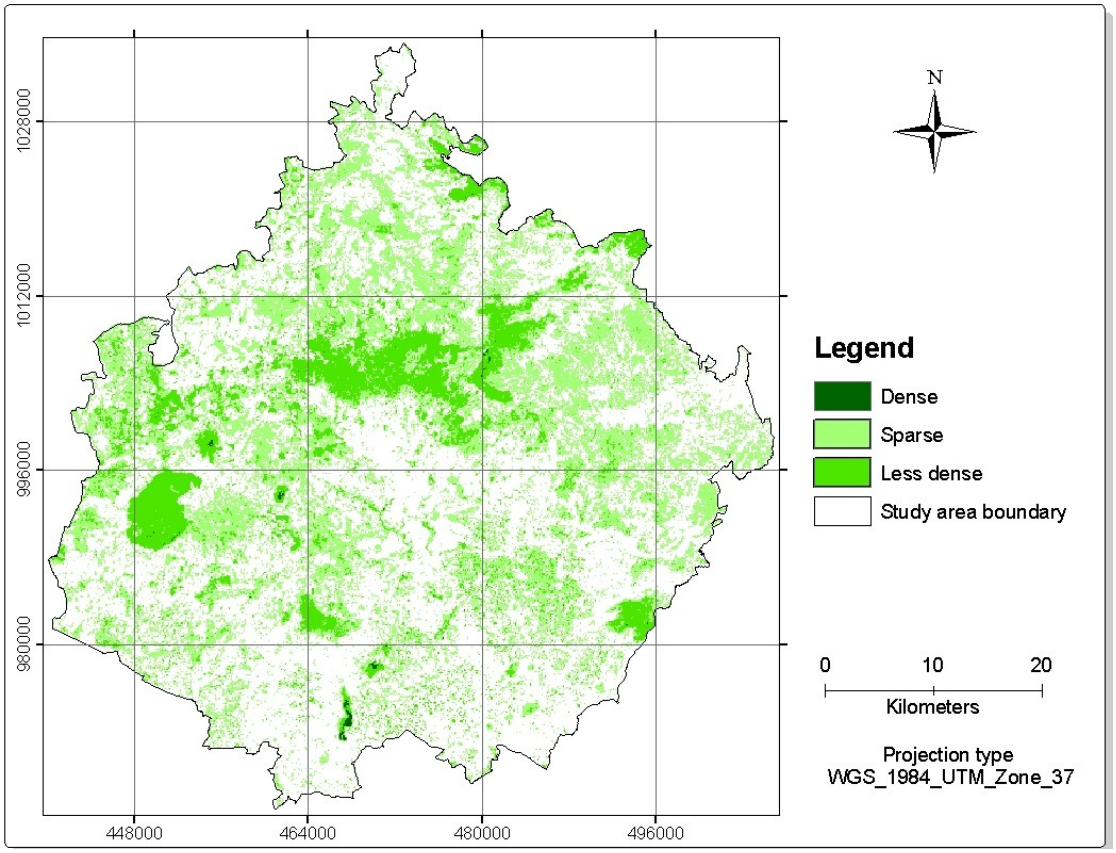


Figure 18: Vegetation density map

Table 8: Percentage share of vegetation density

No	Vegetation Density type	NDVI value	Area in KM^2	Percentage Share
1	Dense vegetation	0.50 and above	4.00	0.35
2	Less Dense vegetation	0.25 – 0.50	292.00	25.41
3	Sparse vegetation	0.10 – 0.25	853.00	74.24

About 43 percent of the study area is covered by vegetation. Vegetation in this sense indicates all plant communities (Eucalyptus, Scattered trees, Shrub, Rangelands, Wetlands etc,) in the land scape that share similar characteristics. As it is indicated in figure 18 and table 9, sparse vegetation accounts the largest share which is 74.24 percent followed by less dense vegetation that accounts for 25.41 percent. Dense vegetation, on the other hand, accounts for a minor percentage share which is 0.35 percent.

4.5.3. Soil

Soil is the natural medium for the growth of plants. It is also a major supportive system of human life and welfare. Most of the lands biodiversity also live in the soil. The study area has ten types of soils in which vertisols are the most dominant.

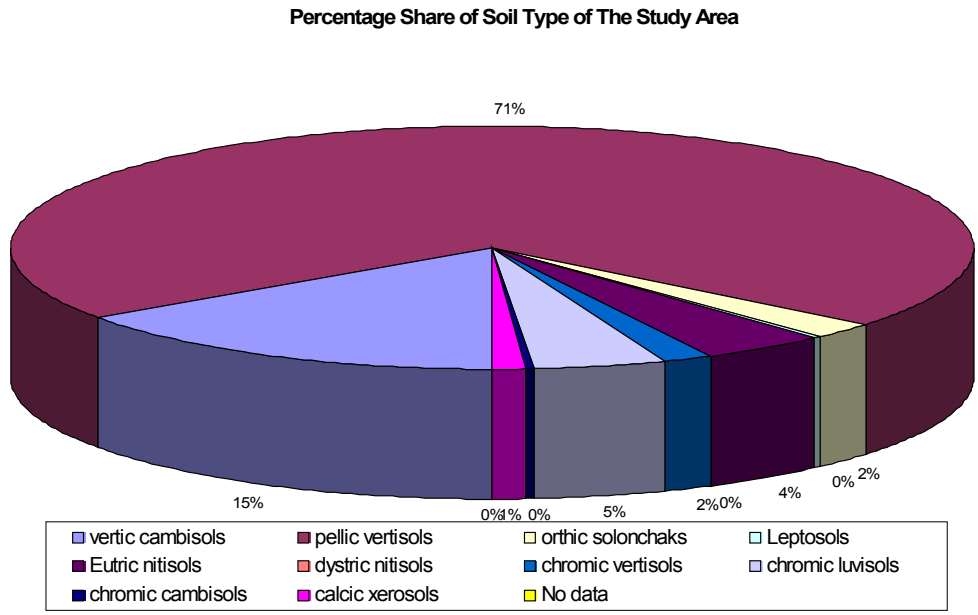


Figure 19: Percentage share of soil type.

As it is indicated in figure 19, the dominant soil type in the study area is pellic vertisols which accounts for 71 percent of the total soil type. It is then followed by vertic cambisols which accounts for 15 percent of the total soil type. All other soil types, on the other hand, accounts for a minor percentage share which varies between 5 percent for chromic luvisols and about one percent for luvisols. Figure 20 depictes the soil type of the study area.

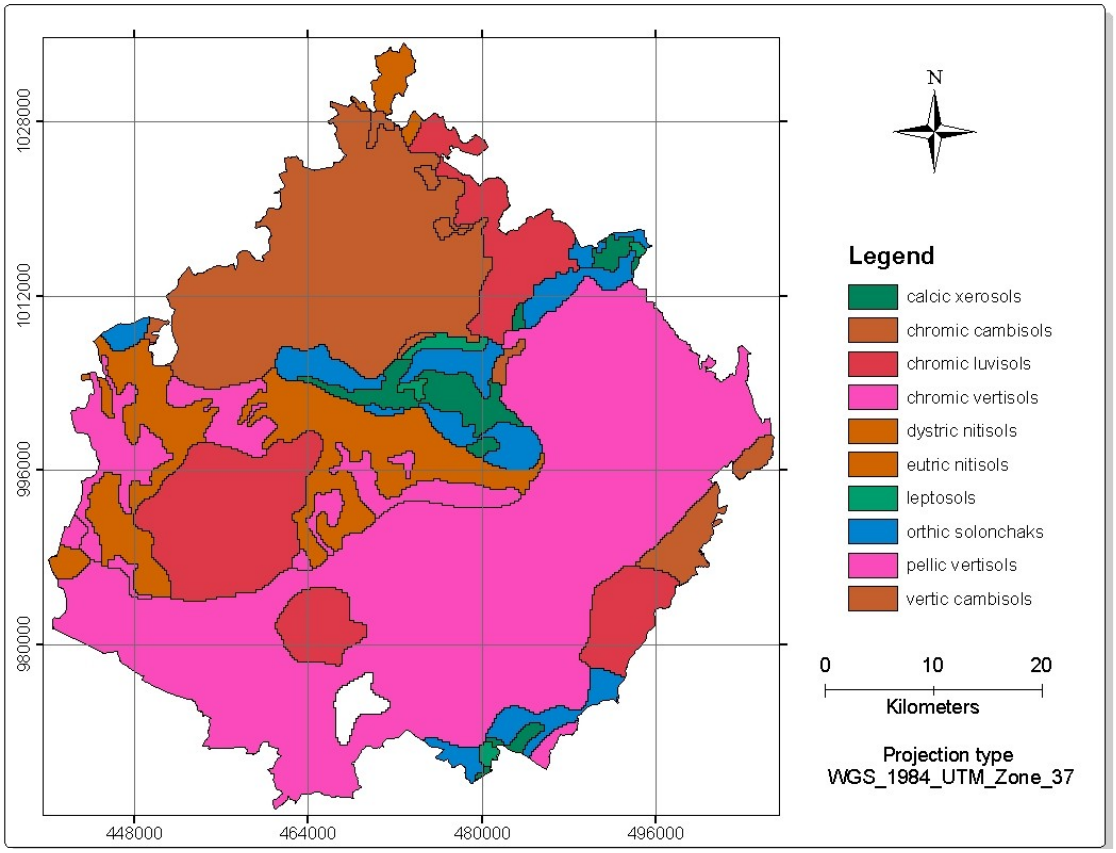


Figure 20: Soil type map

4.5.4. Weather Condition

State of weather condition in terms of Temperature and Rainfall is analyzed for different stations found with in and around the study area. For rainfall estimation, eleven stations that fall within the study area were considered. For temperature estimation, on the other hand, six stations that fall within the study area and six stations that fall outside of the study area were considered. Moreover, Monthly average rainfall, monthly maximum and minimum average temperatures were collected from the NMA services for a period of 30 years. From this mean annual rainfall and mean annual temperatures were computed for all stations. These mean annual rainfall and mean annual temperature was interpolated using the Inverse Distance Weighted of ArcGIS Spatial Analyst.

Interpolation predicts values for cells in a raster from a limited number of sample data points. The Inverse Distance Weight is one of the interpolation techniques that estimate cell values by averaging the values of sample data points in the vicinity of each cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process. This method assumes that the variable being mapped decreases in influence with distance from its sampled location (McCoy and Johnston, 2002).

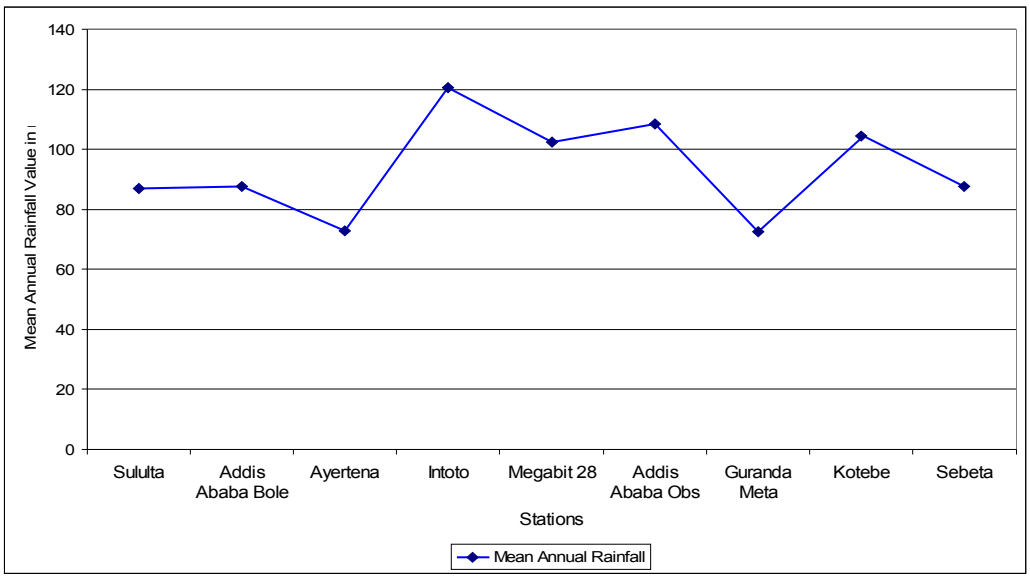


Figure 21: Mean Annual Rainfall

As it is indicated in figure 21, there is a variation of mean annual rainfall value among the observed stations. As a result, highest and lowest mean annual rainfall is recorded with in Addis Ababa city in Intoto and Ayertena, respectively.

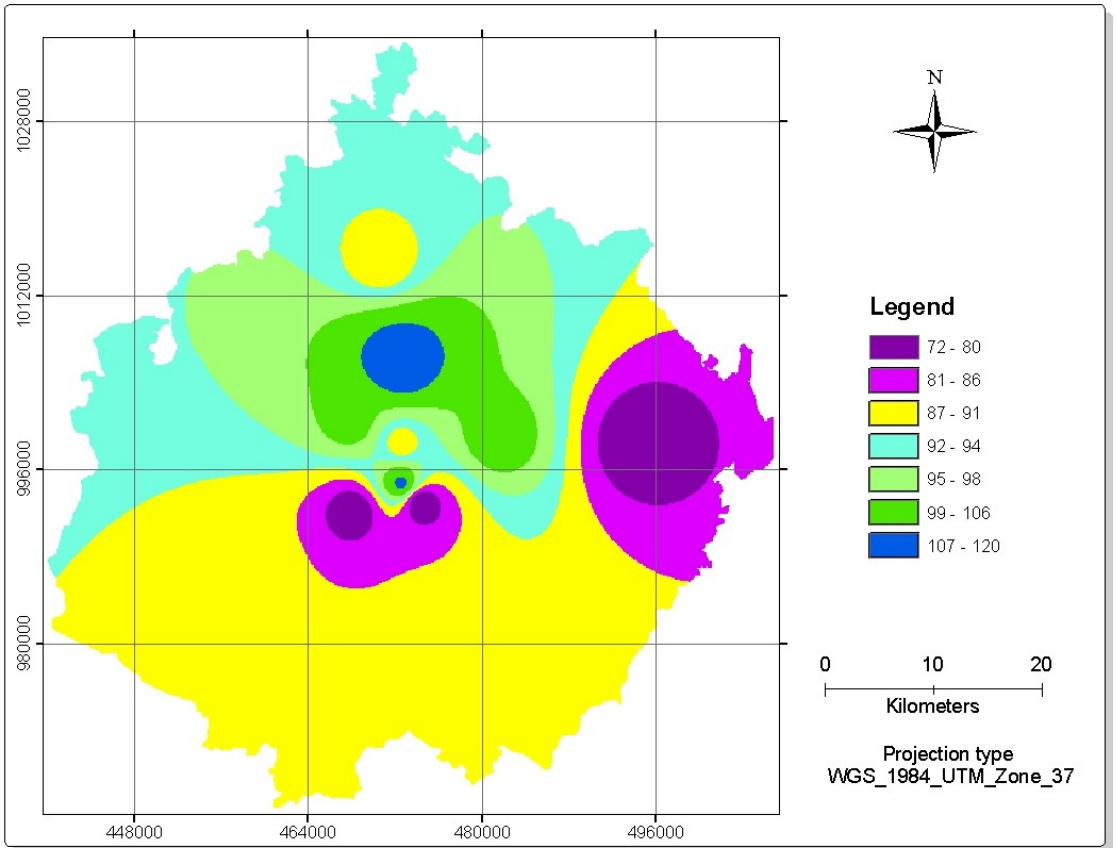


Figure 22: Mean Annual Rainfall map in mm

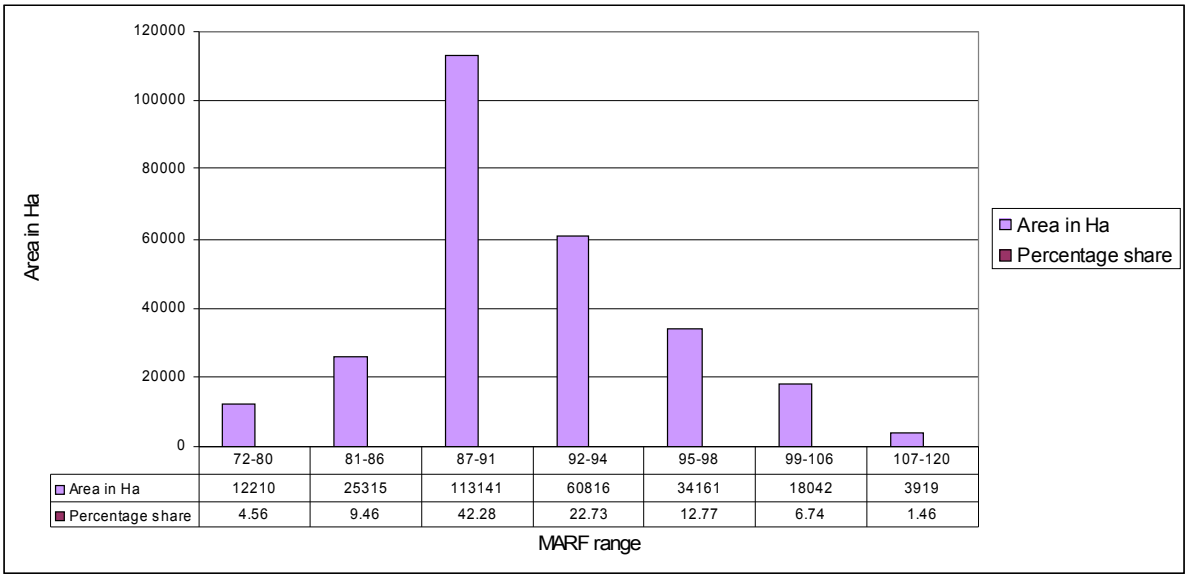


Figure 23: Rainfall distribution par area

Figure 22 and figure 23 indicates that the areas that receive MARF between 87 and 91 mm accounts for the largest share, which is 42.28 percent. On the other hand, areas that receive MARF between 92 and 94, and between 95 and 98 accounts for 22.73 and 12.77, respectively. The highest and lowest MARF ranges, which is between 107 and 120, and between 72 and 80 accounts for the smallest area proportion, which is 1.46 and 4.56 percent, respectively.

To estimate Temperature of the study area, stations found within and outside of the study area was considered. Similar to that of rainfall, temperature data was collected from the NMA for a period of 30 years for most stations. Few stations, however, have a data record of five, six or ten years. Irrespective of this, Mean Annual Temperature was computed for all stations from the Maximum and Minimum Monthly temperature records.

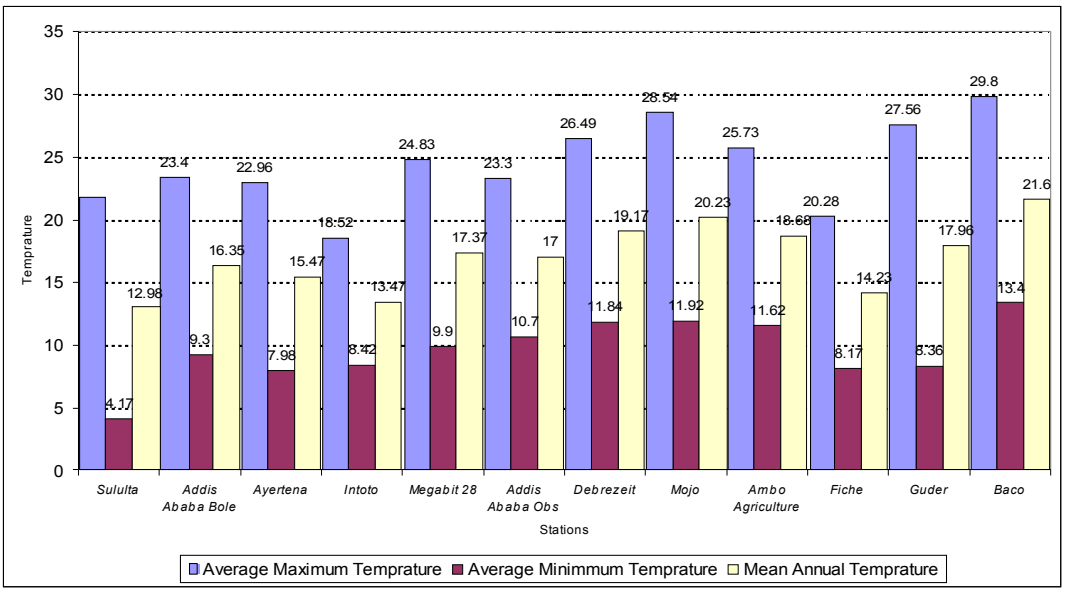


Figure 24: Average Maximum, Minimum and Mean Annual Temperatures.

Figure 24 reveals that highest average maximum monthly temperature and highest average minimum temperature was recorded in Baco. On the other hand, lowest average maximum monthly temperature and lowest average minimum temperature was recorded in Intoto and Sululta, respectively. Thus, highest and lowest Mean Annual Temperature was, respectively, recorded in Baco and Sululta.

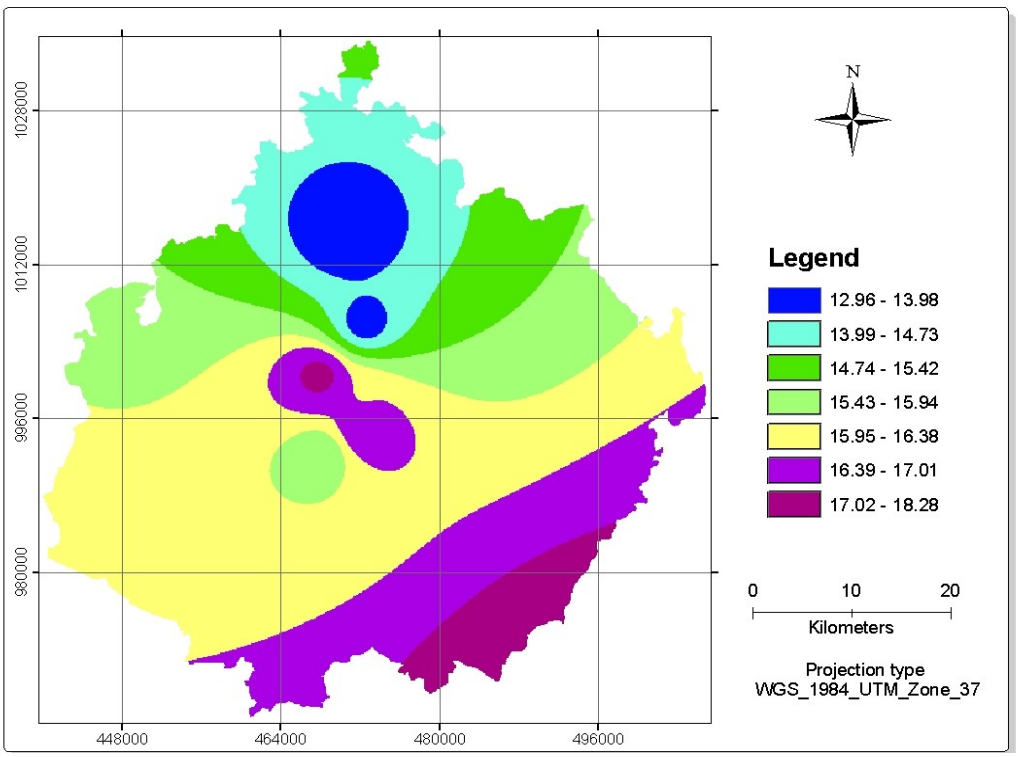


Figure 25: Mean Annual Temperature map in degrees

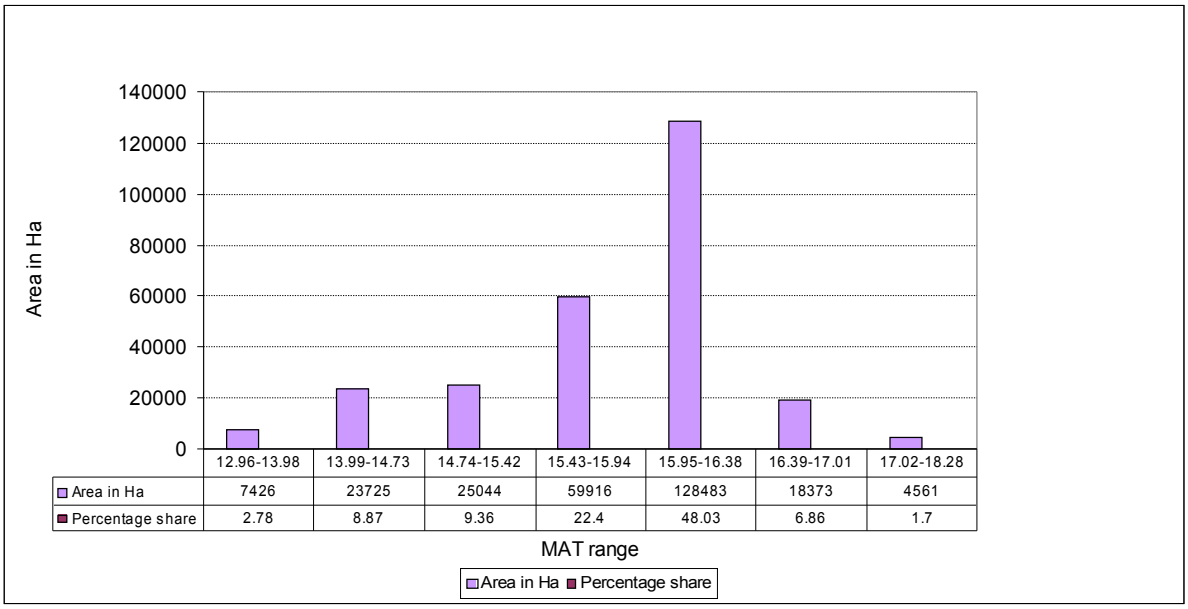


Figure 26: Distribution of Mean Annual Temperature

Figure 25 and figure 26 indicates that MAT range between 15.95 and 16.38 covers the largest area, which accounts for 48.03 percent; it is then followed by MAT range between 15.43 and 15.94 that accounts for 22.4 percent. The lowest MAT range (between 12.96 and 13.98) and highest MAT range (between 17.02 and 18.28), on the other hand, accounts the lowest percentage share which is 2.78 and 1.70 percent, respectively.

4.5.5. Relief

Relief is the differences in altitude and surface structure of any part of the earth. It also refers to various landforms (physical features) which represent the external shape of a place.

4.6.5.1. Elevation

Elevation, also called, altitude is the height of a place above (or below) a reference level, such as mean sea level. Altitude, like latitude, acts through climatic conditions to exert a major influence upon the distribution and abundance of living things (Kuchler, 1967). Topography influences plants in several fundamental and many subtle ways.

The Elevation of the study area is generated from a DEM. DEMs are scaled models of topography. Different types of DEMs exist such as TIN, CONTOUR and GRIDDED. Square Gridded DEMs, however, become the most common format of DEM in use, owing to their ease of computer representation and manipulation (Huggeth and Cheesman, 2002).

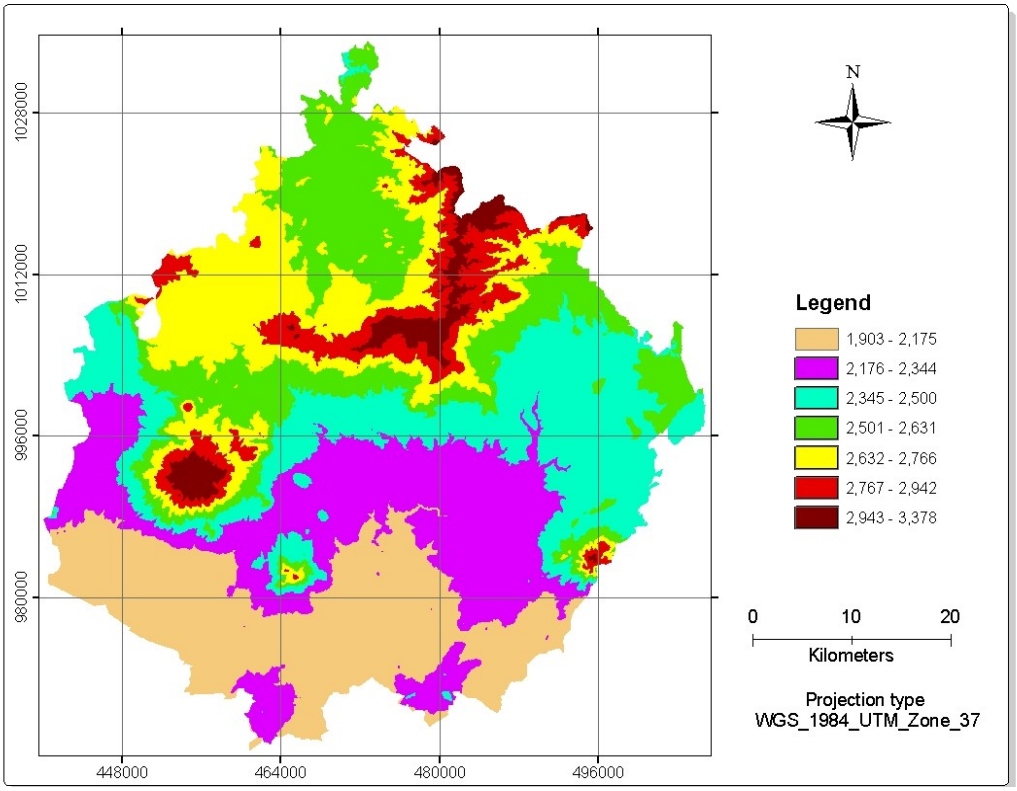


Figure 27: Elevation map in meters

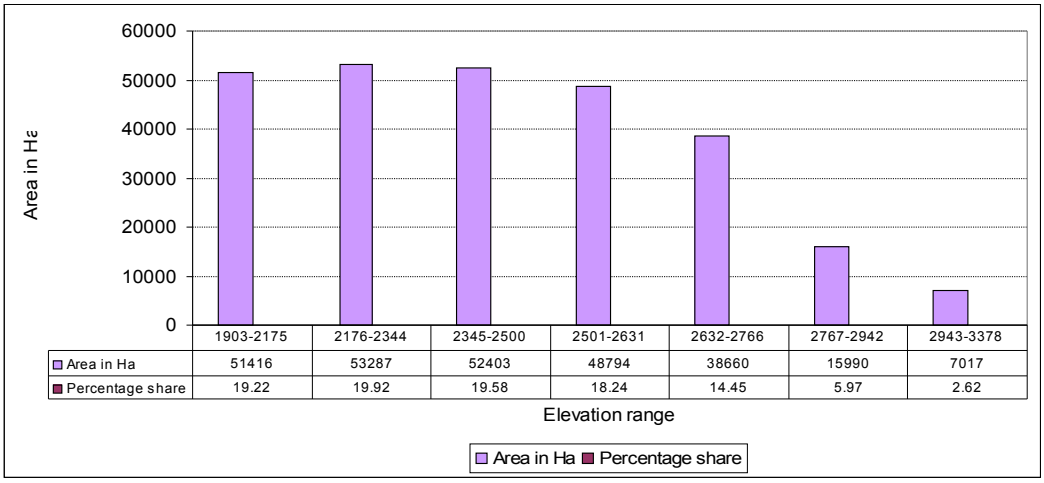


Figure 28: Distribution of elevation per area

According to figure 27 and figure 28, elevation range between 1903 and 2175, between 2176 and 2344, and between 2345 and 2500 have similar percentage share, which is 19.22, 19.92 and 19.58, respectively. On the other hand, when elevation increases its proportionate area shows a percentage decrease. Elevation range between 2632 and 2766, and between 2767 and 2942, for example, accounts for 14.45 and 5.97 percent, respectively. Similarly, the highest elevation range, which is between 2943 and 3378 accounts for the smallest percentage share which is 2.62 percent.

4.5.5.2. Slope

Slope represents the gradient of an area expressed either in percent or in degree. It is computed as the vertical increase divided by horizontal increase. Slope can also be classified as gentle and steep slopes. Those experiencing little variation are gentle slopes and those experiencing extreme variations are steep slopes.

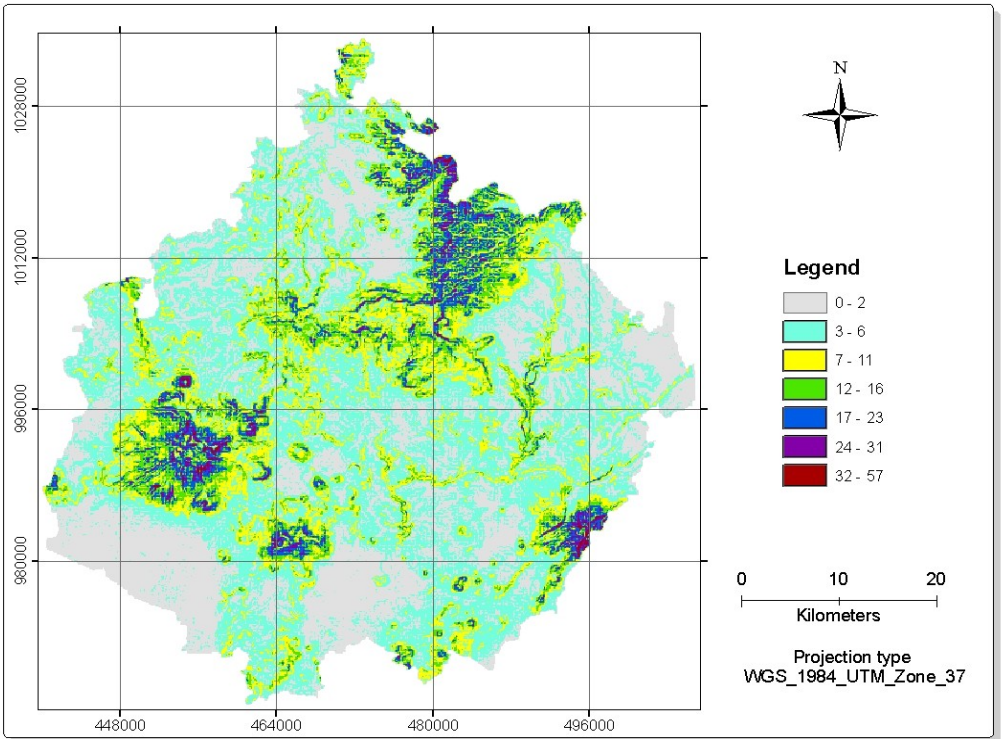


Figure 29: Slope map in degrees

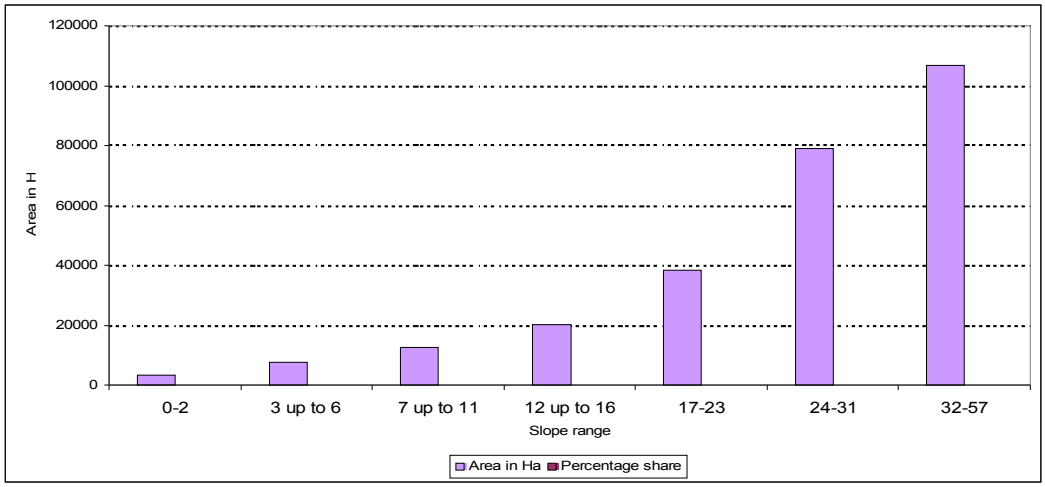


Figure 30: Distribution of slope value per area

It is indicated in figure 29 and figure 30 that with increase in slope value there is an increase in area percentage share. The lowest slope range has the lowest percentage share value where as the highest percentage share has the highest percentage share. For example, slope

range between 0 and 2 accounts for 1.2 percent whereas slope range between 32 and 57 accounts for 39.92 percent. This indicates the existence of spectacular features in the study area.

4.6. Decision rule and Multi-Criteria Evaluation

A decision is a choice between alternative criteria's. A criteria, on the other hand, is a basis for a decision that can be measured and evaluated. Criteria can be of two kinds: factors and constraints. A factor is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration. It is therefore most commonly measured on a continuous scale. A constraint, on the other hand, serves to limit the alternatives under consideration.

Decision rule is a procedure by which criteria are selected and combined to arrive at a particular evaluation, and by which evaluations are compared and acted upon. Decision rules typically contain procedures for combining criteria in to a single composite index and a statement of how alternatives are to be compared using this index.

4.7. Multi-Criteria Evaluation

A procedure of evaluating several criteria's is called multi-criteria evaluation. Multi-criteria evaluation can be achieved through either Boolean overlay operations or weighted linear combination. In Boolean overlay operations, all criteria are reduced to logical statements of suitability and then combined by means of weighted average. In weighted linear combination, however, continuous criteria (factors) are standardized to a common numeric range, and then combined by means of a weighted average.

While these two procedures are well established in GIS, they frequently lead to different results, and they make very different statements about how criteria should be evaluated. In the case of Boolean operation, an extreme form of decision-making is used. If the criteria are combined with a logical AND (the intersection operator), a location must meet every criterion for it to be included in the decision set. If even a single criterion fails to be met, the location will be excluded. 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. On the other hand, if a logical OR

(union) is used, the opposite applies- a location will be included in the decision set even if only a single criterion passes the test. This is thus a very gambling strategy, with (presumably) substantial risk involved.

Weighted linear combination, however, used to tradeoff their qualities. A very poor quality can be compensated for by having a number of very favorable qualities. The operator represents neither an AND nor an OR- it lies somewhere in between these extremes. It is neither risk averse nor risk taking.

To evaluate ecotourism suitability, seven factor maps namely, Land use land cover map, Soil map, Elevation map. Slope map, Vegetation density map, Temperature map and Rainfall map were considered. These factors were first reclassified and then ranked based on literatures and questionnaires prepared for these purpose. The questionnaire was distributed to experts working on Tourism, Environmental issues and Agriculture. Accordingly, questionnaire was distributed to Addis Ababa City Administration and the neighboring wereda offices including Burayu special zone office. Then ranking and criteria weighting for Land use Land cover, Relief, parks, Weather condition and forests was computed based on the statistics derived from the results of the questionnaire. Ranking and Criteria weighting for vegetation density and soil was made based on literatures.

A total of 120 questionnaires were distributed to different offices. However, because of different reasons only 75 percent of them were collected.

The questionnaire was arranged in such away that respondents could rank ecotourism attractions found in their respective areas. Most attractive sites were given least value whereas least attractive sites were given highest value. To evaluate the questionnaire a matrix was developed in which the column matrix indicates the value of rank and the raw matrix indicates list of ecotourism attractions. Values given to each attraction sites were then multiplied by the total number of respondents to that attraction site and these were aggregated for all lists of ranks. To determine the final value of rank of each attraction site, the aggregate value of each attraction site was divided by the number of respondents to that attraction site.

In table 10 the symbol * Stands for Land use land cover and its average score is 3.5; ** stands for vegetation and its average score is 3.6; *** stands for slope and its average score

is 3.7; **** stands for elevation and its average score is 4.0; finally, ***** stands for weather condition and its average score is 6.7. As a result, based on the above matrix and by considering the importance of soil in to account, the value of rank for Land use land cover, soil, Slope, Elevation, Vegetation density and weather condition is 1, 2, 3, 4, 5 and 6 respectively.

Table 9: Matrix to evaluate questionnaires

Feature	Rank														Total weight	Average weight	Rank
	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
*** Forest	20	10	10	-	10	-	-	2	2	2	1	1	1	1	224	3.6	3
* Lakes	15	8	7	6	2	1	-	-	-	-	-	-	-	-	92	2.3	1
* Rivers	4	-	-	6		4	-	-	3	-	-	1	-	-	91	5.0	8
Parks	9	5	-	-	5	-	2	3	-	-	-	-	-	-	84	3.5	2
Reserves	2	-	1	-	-	-	-	1	1	-	-	-	-	2	50	7.1	12
Protected Areas	-	-	-	-	1	-	1	-	-	1	-	-	-	-	22	7.3	13
Wild life	1	-	-	-	-	1	-	-	-	-	1	-	-	-	17	5.6	9
** Unique land-scapes	10	4	7	-	-	-	-	-	1	1	1	1	1	-	94	3.7	4
*****Weather condition	4	6	10	-	-	4	5	-	5	1	1	5	6	1	323	6.7	11
Wet lands	-	1	-	-	1	-	-	1	-	1	-	-	-	-	25	6.3	10
* Grass lands	10	5	-	20	-	5	-	-	1	1	1	1	1	1	196	4.2	6
**** Mo untains	30	22	2	2	1	2	1	3	-	3	1	-	1	-	190	4.0	5
* Open land	25	2	4	10	7	3	8	6	1	1	2	3	1	1	320	4.5	7
* Farm land	5	1	10	1	10		5	-	5	-	1	-	1	-	195	5.0	8

4.7.1. Reclassified Land use land cover map

Ranking of land use land cover types was done based up on the above questionnaire. Accordingly, the score of water is 1; forest, 2; scattered trees, 3; scrub, 4; eucalyptus, 5; grassland, 6; bare soil, 7; farm land, 8; built up, 9; and bare soil (stony), 10. Figure 31 shows reclassified land use land cover map of the study area.

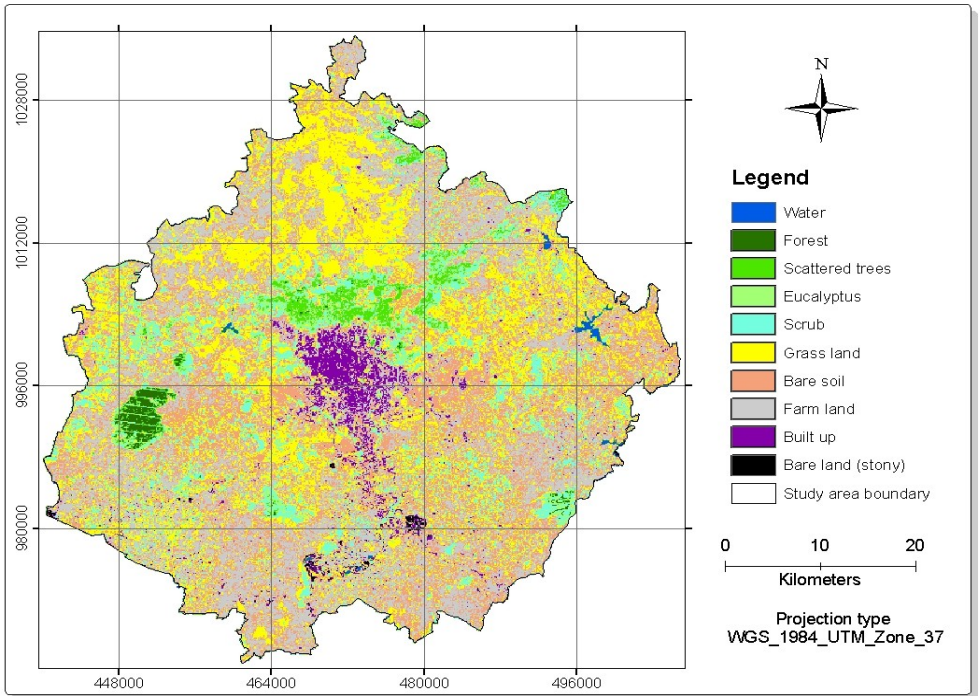


Figure 31: Reclassified land use land cover map

4.7.2. Reclassified soil map

According to the WRB soil report, soils of the study area have the following characteristics. Accordingly, they are ranked based on their characteristics and their degree of importance to the sustenance and growth of vegetation. Figure 32 depicts reclassified soil map of the study area, whereas table 11 shows values assigned to each soil type in order to rank them.

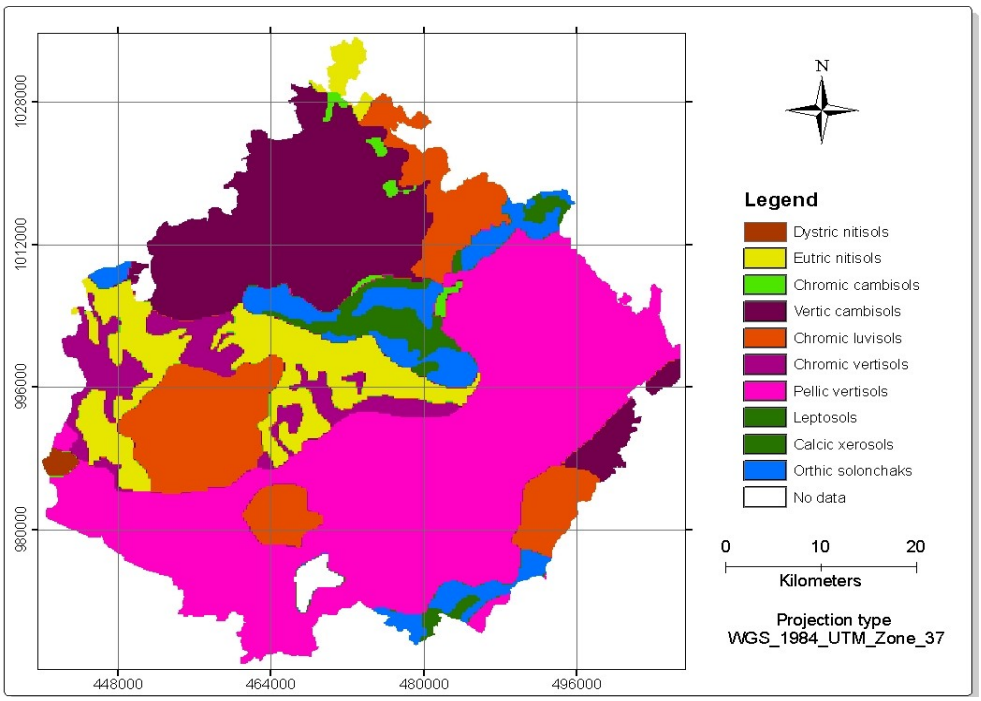


Figure 32: Reclassified soil map

Table 10: characteristics of soil type

Soil type	Characteristics	Sub types		Rank
Cambisols	- Characterized by Absence of appreciable quantities of illuvial clay, organic matter, Al and Fe compounds - They make good agricultural land and they are applied in a wide range of vegetation types. - cambisols with high base saturation in the temperate zone are among the most productive soils on earth - more acid cambisols, although less fertile; are used for mixed arable farming and as grazing and forest land - cambisols on steep slopes are best kept under forest; particularly in highlands.	Chromic cambisols	- They are cambisols having a base saturation of less than 50% (by NH4OAC) at least in some part of the B horizon.	3
		Vertic cambisols	- Other soils which after the upper 20 cm are mixed, have 30% or more clay in all horizons to at least 50 cm from the surface.	4
Calcic xerosols	- They are soils with substantial secondary accumulation of gypsum ($CaSo_4$ $2H_2O$), light olored surface horizon, accumulation of calcium sulphate, with or with out carbonates in the sub-soil -Natural vegetation is sparse and dominated by xerophytic shrubs and trees and/or ephemeral grasses - large areas with gypsisols are in use for extensive grazing			9
Leptosols	- They are very shallow soils developed over continuous rock and they are soils that are extremely gravelly and/or stonny - They develop on mostly land at high or medium altitude and with strongly dissected topography - Have a resource potential for wet-season grazing and as forest land -the excessive internal drainage and the shallowness of many leptosols can cause drought even in a humid environment			8

Chromic luvisols	- Soils that have a higher clay content in the subsoil than in the topsoil as a result of pedogenetic processes - Have high-activity clays throughout the argic horizon and a high base saturation at certain depths - Most common in flat or gently sloping land in cool temperate regions - Most luvisols are fertile soils and suitable for a wide range of agricultural uses - Luvisols in the temperate zone are widely grown to small grains, sugar beet and fodder, in sloping areas, they are used for orchards, forests and/or grazing			5
Nitisols	- They are deep, well-drained, red tropical soils with diffuse horizon boundaries and a sub-surface horizon with more than 30% clay and moderate to strong angular blocky structure elements that easily fall apart into characteristic shiny, polyhedric (nutty) elements - They are red or reddish brown clay soils with a nitic subsurface horizon of high aggregate stability. Nitisols are rich in Fe and have little water dispersible clay. -The deep and porous solum and the stable soil structure of nitiosols permit deep rooting and make these soils quite resistant to erosion -The good workability of nitisols', their good internal drainage and fair water holding properties are complemented by chemical (fertility) properties that compare favorably with those of most other tropical soils -Nitisols have relatively high contents of weathering minerals, and surface soils may contain several percent of organic matter, in particular under forest or tree crops. -They are amongst the most productive soils of the humid tropics	Eutric nitisols	Eutri-Soils having a base saturation of 50% (by NH4OAC) or more to a depth of 125 from the surface.	2
		Dystric nitisols	Other types of soils having a base saturation of less than 50% (by NH4OAC) in at least a part of the B horizon with in 125 cm of the surface.	1

Orthic solonchaks	- They are saline soils and have high concentration of soluble salts at some time in the year - They are confined to the arid and semi-arid climate zones. Notably in areas where ascending groundwater reaches the solum, with vegetation of grasses and/or halophytic herbs, and inadequately managed irrigation areas - Excessive accumulation of salts in soil affects plant growth in two ways: i. The salts aggravate drought stress because dissolved electrolytes create an osmotic potential that affects water uptake by Plants ii. The salts upset the balance of ions in the soil solution because nutrients are proportionately less available			10
Vertisols	-They are churning, heavy clay soils with a high proportion of swelling clays - The climate vegetation is savannah, natural grassland and/or woodland	Pellic vertisols	Vertisols having moist chromas of less than 1.5 cm dominant in the soil matrix throughout the upper 30 cm	7
	-These soils have considerable agricultural potential, but adapted management is a precondition for sustained production -Tree crops are generally less successful because tree roots find it difficult to establish themselves in the subsoil and are damaged as the soil shrinks and swells to establish themselves in the sub-soil and are damaged as the soil shrinks and swells.	Chromic vertisols	Vertisols having a moist value of more than 3 and a chroma of more than 2 dominant in the soil matrix throughout upper 30 cm.	6

4.7.3. Reclassified vegetation density

Vegetation density of the study area is categorized in to three as dense, less dense and sparse vegetation. For ecotourism suitability highest vegetation density is preferable. Accordingly, highest vegetation density is assigned the highest possible rank, and lowest vegetation density is assigned the lowest possible rank. Dense vegetation is ranked as 1; less dense vegetation as 2; and, sparse vegetation as 3. Figure 33 depicts reclassified vegetation density map of the study area.

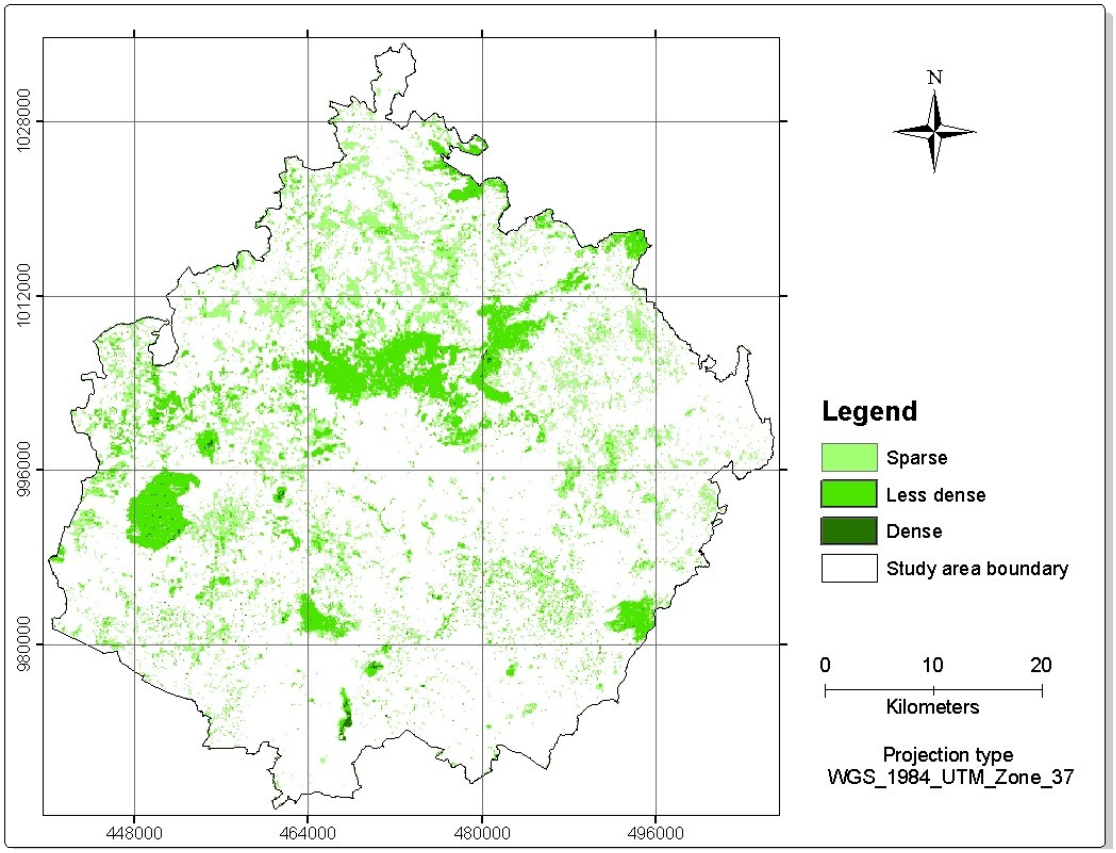


Figure 33: Reclassified vegetation density map

4.7.4. Reclassified Elevation

Elevation represents the height of land surface features above mean sea level. Elevation value of the study area ranges from 1903 to 3378m. For ecotourism suitability highest elevation is preferable. Accordingly, highest rank was assigned to highest elevation, and vise versa. Elevation value between 1903 and 2278 is ranked as 4; between 2279 and 2525 as 3; between 2526 and 2773 as 2; and, between 2774 and 3378 as 1. Figure 34 depicts reclassified elevation map of the study area.

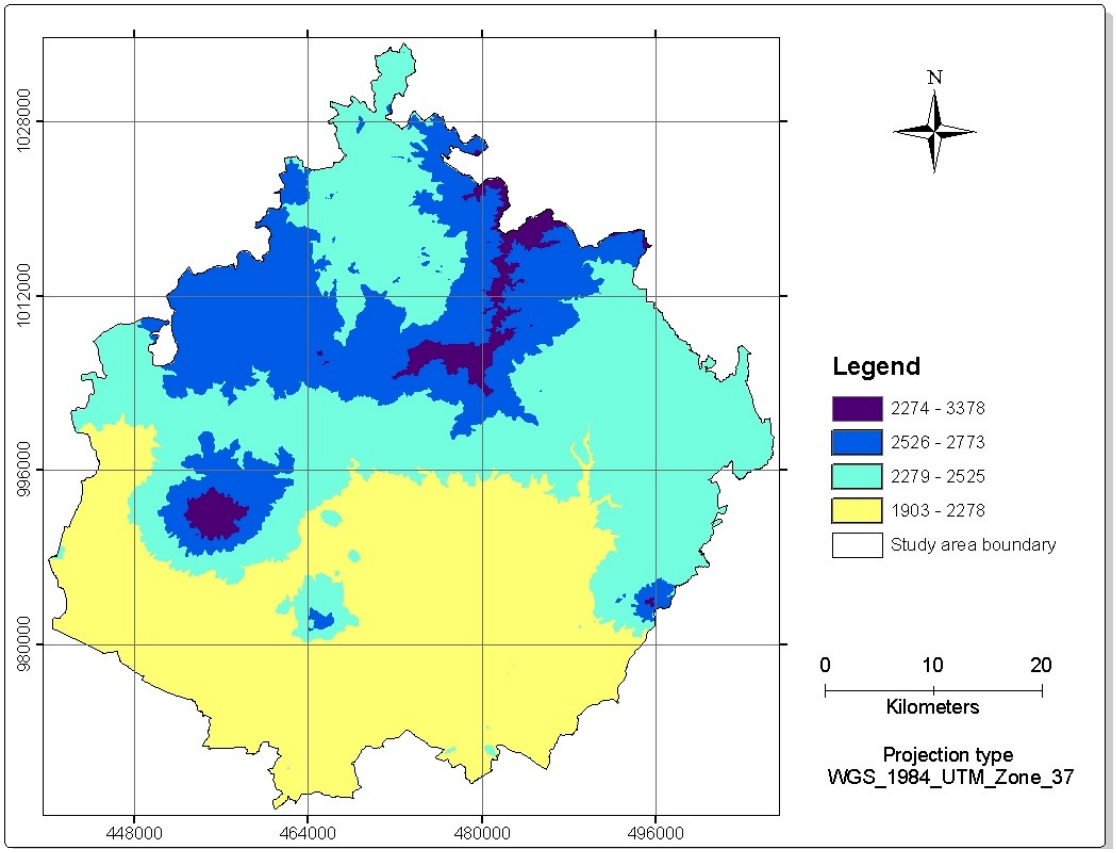


Figure 34: Reclassified elevation map in meters

4.7.5. Reclassified slope

Slope represents the steepness of terrain features and it is calculated as the ratio of vertical distance to horizontal distance. Slope is important for ecotourism because all terrain features are derived from a complex landmasses. Steep slopes are more suitable for ecotourism than gentle slopes. As a result, highest rank is assigned to highest slope values and lowest rank is given to lowest slope value. A slope value between 0 and 4.19 is ranked as 4; between 4.20 and 11.27 as 3; between 11.28 and 22.10 as 2; and, between 22.11 and 56.57 as 1. Figure 35 shows reclassified slope map of the study area.

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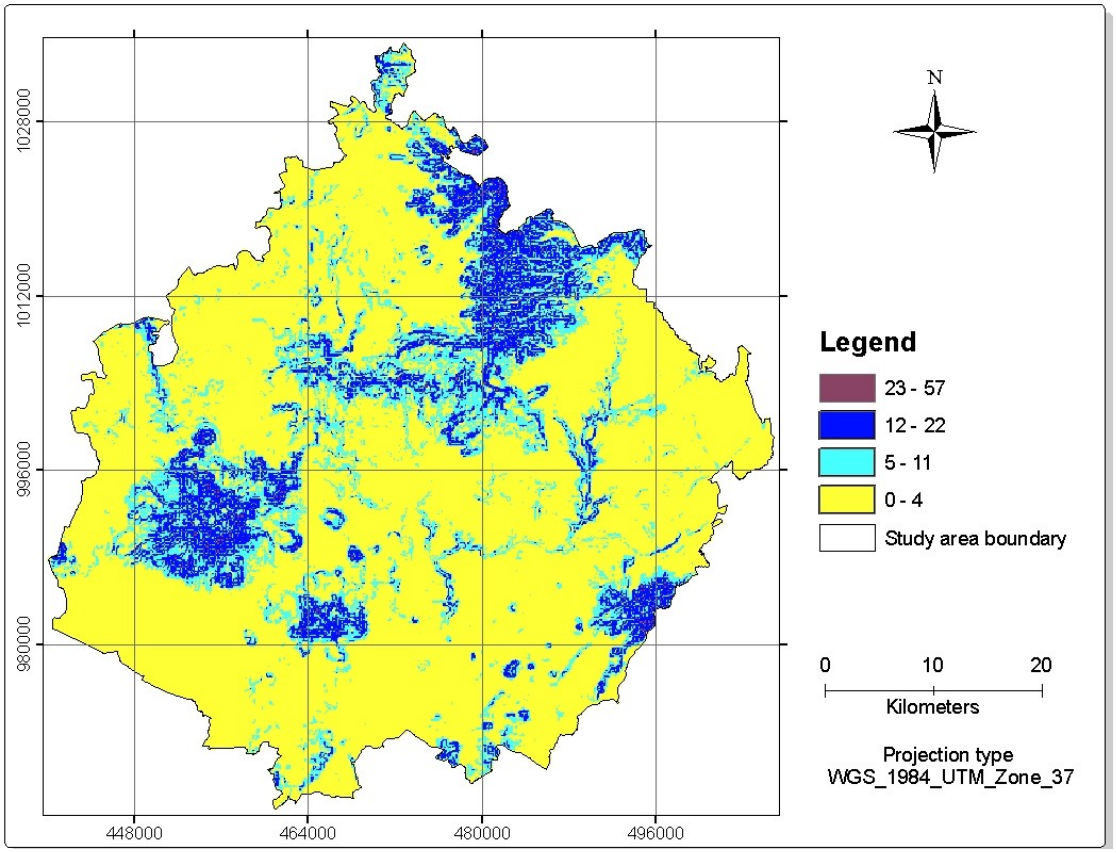

Figure 35: Reclassified slope map in degrees

4.7.6. Reclassified Mean Annual rainfall

Rainfall is highly associated with the growth of vegetation. The availability of surface and ground water is also directly or indirectly dependent up on the availability and amount of rainfall. Moreover, it highly modifies the state of weather condition of a certain area. There fore, high amount of rainfall of a certain area is more suitable for ecotourism sites than less amount of rainfall. The mean annual rainfall of the study area ranges between 72 and 120 mm. Mean Annual Rainfall value between 72 and 85 is ranked as 4; between 86 and 91 as 3; between 92 and 98 as 2; and, between 99 and 120 as 1. Figure 36 shows reclassified man annual rainfal map of the study area.

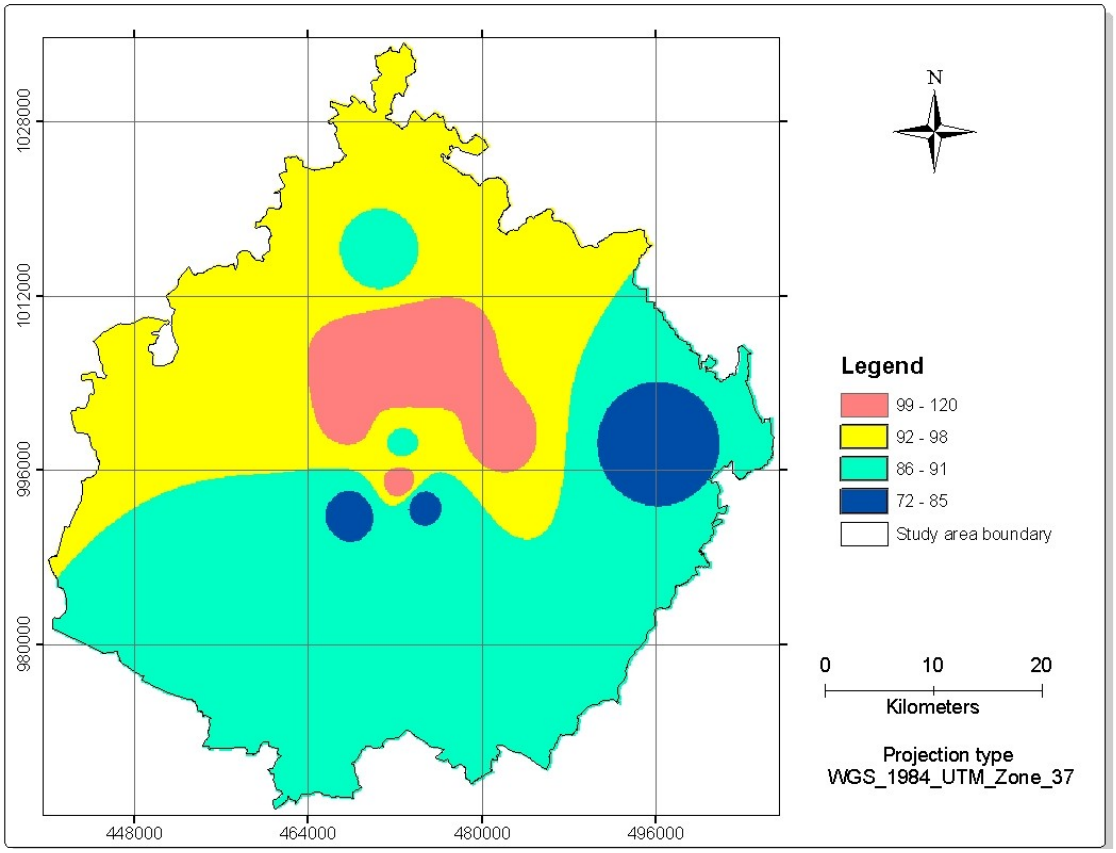

Figure 36: Reclassified mean annual rainfall in mm

4.7.7. Reclassified Mean Annual Temperature

The sate of weather condition of an area is also determined by the temperature of that area. The availability and distribution of vegetation is also affected by the temperature of that area. Suitable environment for human recreation is also determined by the temperature of that area. Generally, lowest temperature is considered suitable for ecotourism, as most humans prefer low temperature area for existence and recreation. Most living things also survive in low temperature area as compared to high temperature area. Mean Annual Temperature of the study area varies between 12.96^0c and 14.70^0c. Lowest temperature value is, therefore, assigned the highest possible rank and highest temperature value is assigned the lowest possible rank. Temperature values between 12.96^0c and 14.70^0c is ranked as 1; between 14.71^0c and 15.72^0c is ranked as 2; between 15.73^0c and 16.57^0c is ranked as 3; between 16.58^0c and 18.28^0c is ranked as 4. Figure 37 shows reclassified mean annual temperature map of the study area.

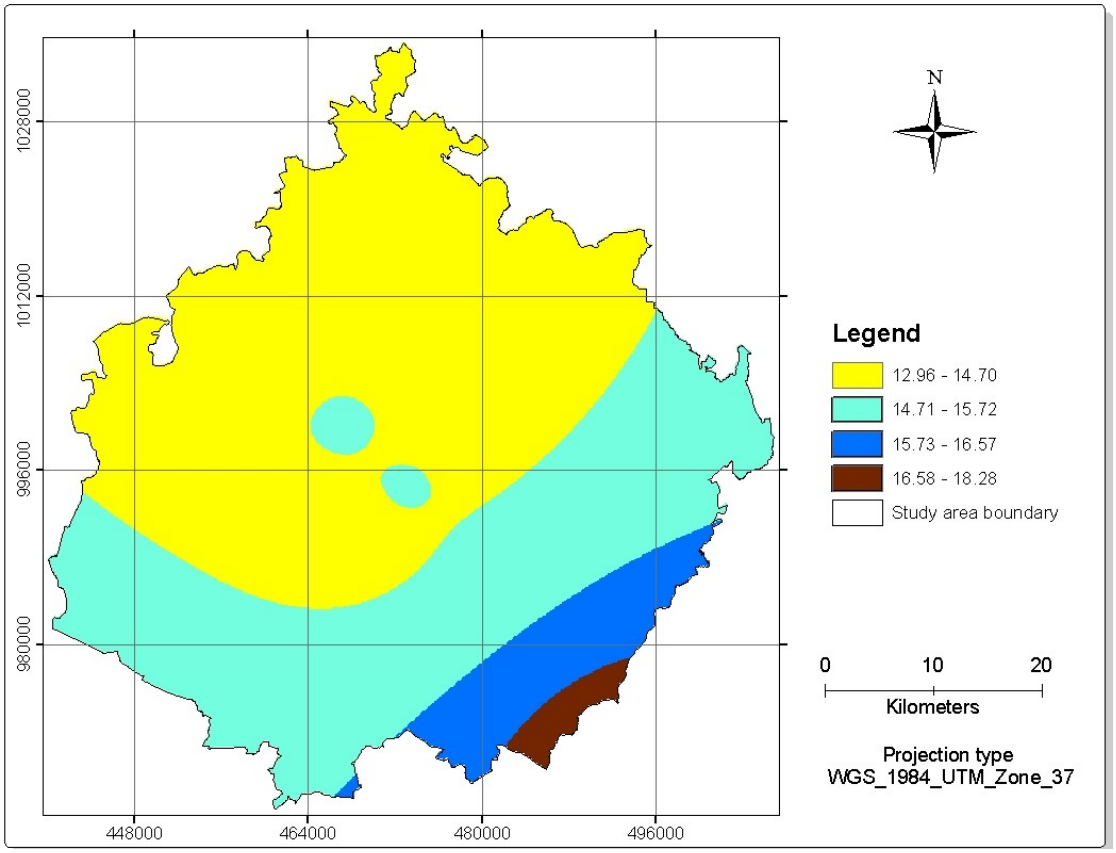

Figure 37: Reclassified mean annual temperature map in degrees

4.8. Weighting, Evaluation and suitability Analysis

Suitability evaluation is the actual process of applying multi-criteria evaluation to different criteria's or factors in order to arrive at certain decision. For ecotourism suitability, seven factor maps were produced and reclassified according to their degree of importance that they have to ecotourism and environmental sustainability.

Weight for each factor maps was assigned based on the questionnaire developed and distributed to different experts. According to this questionnaire, the prioritizing of factor maps (or simply factors or criterion) from highest to lowest is as follows: Land use land cover map, soil map, slope map, elevation map, vegetation density map and weather condition (Temperature and Rainfall map).

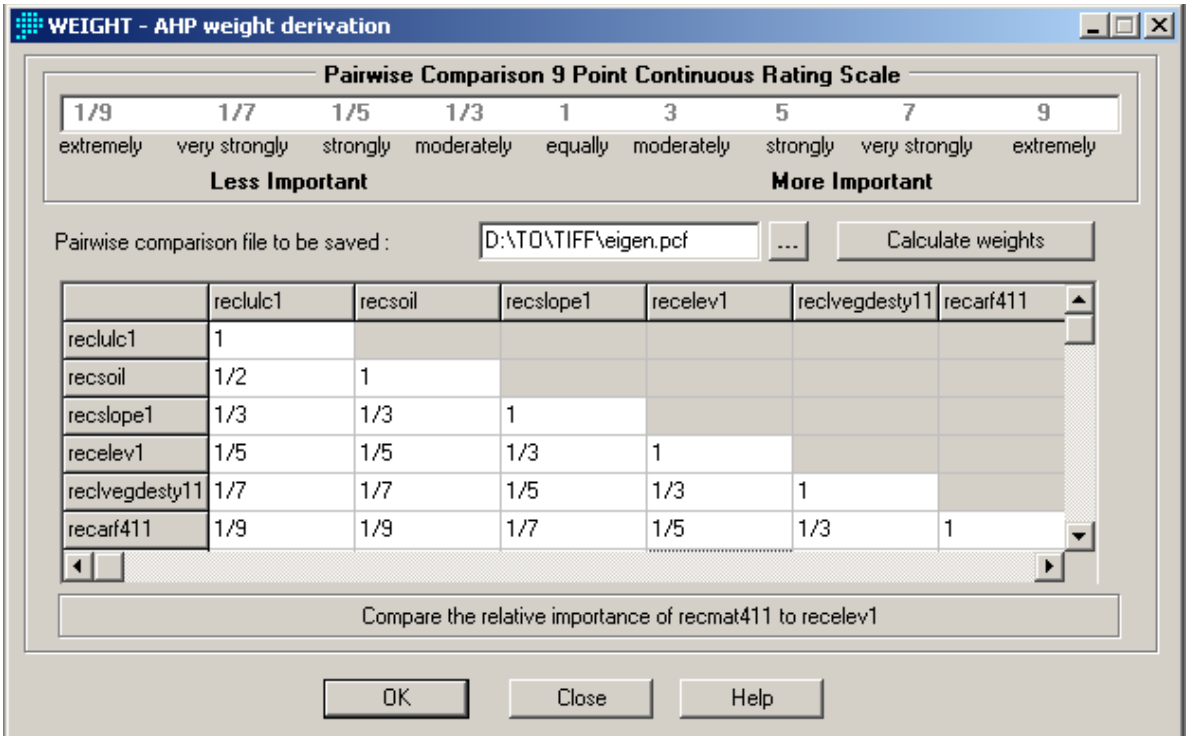

Plate 4: Pairwise comparison of factor maps

The above matrix can be summarized in table 12 as follows:

Table 11: pairwise comparison matrix

	Reclassified land use land cover	*Reclassified soil*	*Reclassified slope*	*Reclassified elevation*	*Reclassified vegetation density*	*Reclassified mean annual rainfall*	*Reclassified mean annual temperature*
Reclassified land use land cover	*1*						
Reclassified soil	*1/2*	*1*					
Reclassified slope	*1/3*	*1/3*	*1*				
Reclassified elevation	*1/5*	*1/5*	*1/3*	*1*			
Reclassified vegetation density	*1/7*	*1/7*	*1/5*	*1/3*	*1*		
Reclassified mean annual rainfall	*1/9*	*1/9*	*1/7*	*1/5*	*1/3*	*1*	
Reclassified mean annual temperature	*1/9*	*1/9*	*1/7*	*1/5*	*1/3*	*1*	*1*

As it is indicated in table 12, soil is very less moderately important than vegetation; Slope is less moderately important than land use land cover and soil. Elevation is strongly less

important than land use land cover and soil, but moderately less important than slope. Vegetation density, on the other hand, is very strongly less important than land use-land cover and soil, and strongly less important than slope, but moderately less important than elevation. Finally, mean annual rainfall and mean annual temperature are extremely less important than land use-land cover and soil, and they are very strongly less important than slope; strongly less important than elevation; moderately less important than vegetation density, but equally important to each other.

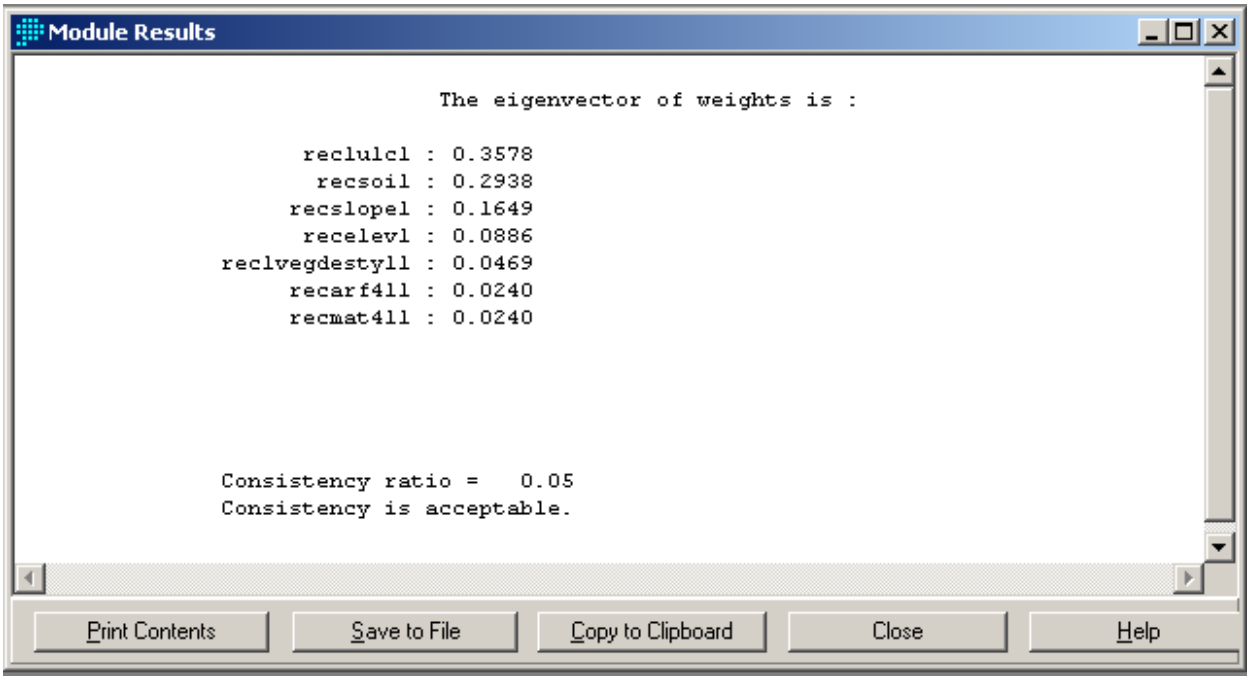

Plate 5: Eigen vector of factor map weights

The eigenvector of weights for land use-land cover, soil, slope, elevation, vegetation density, mean annual rainfall and mean annual temperature is 0.3579, 0.2939, 0.1649, 0.0886, 0.0469, 0.0240 and 0.0240, respectively. Out put evaluation was then computed by multiplying each factor map by these eigenvector weight values.

Suitability Map = *0.3579 (Land use-land cover map) + 0.2939(Soil map) + 0.1649 (Slope map) + 0.0886 (Elevation map) + 0.0469 (Vegetation density map) + 0.0240 (Mean annual rainfall map) + 0.0240 (Mean annual temperature map)*

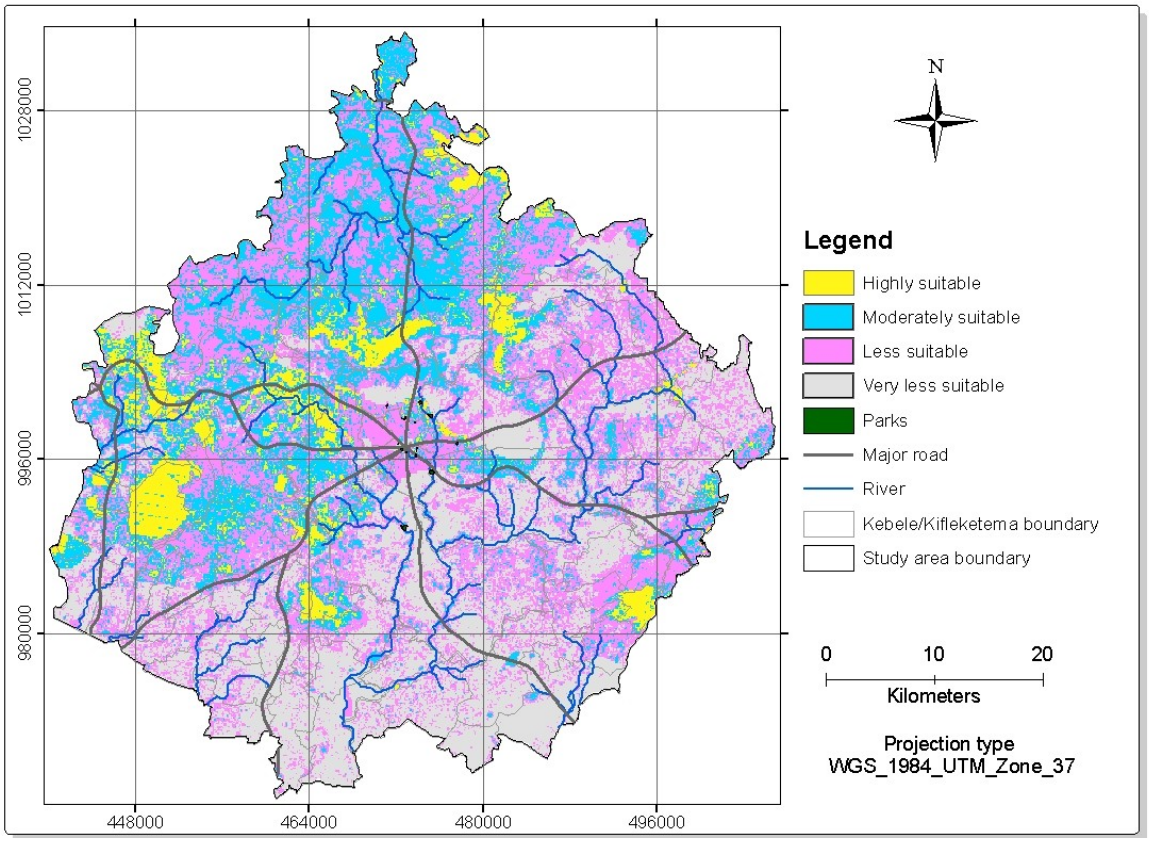

Figure 38: Ecotourism suitability map

As it is indicated in figure 38, large part of the highly suitable area lies in the Northern and western part of the study area. Small part of the highly suitable area, on the other hand, lies in the extreme part of the southeastern part of the study area. For the moderately suitable areas, except, few that are found in the southern part of the study area, all the rest and large part are found nearby the highly suitable areas. The least suitable areas are found dispersilly in all part of the study area. Very least suitable areas, however, are rare in the Northern, North western and southwestern part of the study area. The southern part of the study area is dominated by very least suitable areas.

Specifically, the most suitable areas include 'Suba Menagesha Yemengist Den', Wolmera Goro, area around Menagesh town, Menagesha Medhanealem Suba and Elala Gojo which are located in Wolmera Woreda. Few part of Gullele and Intoto in Addis Ababa and Weserbi Gutu in Sululta Woreda; Legedadi in Bereh Woreda; Mount Yerer in South East part of the study area; Mount Furi and Repi in the southern part of the study area are among the highly suitable areas.

Moderately suitable sites include major part of the Kebele's selected in Mulano Sululta Woreda, Mount Wochecha and large part of Kebele's selected in Wolmera Woreda. And areas surrounding the highly suitable sites.

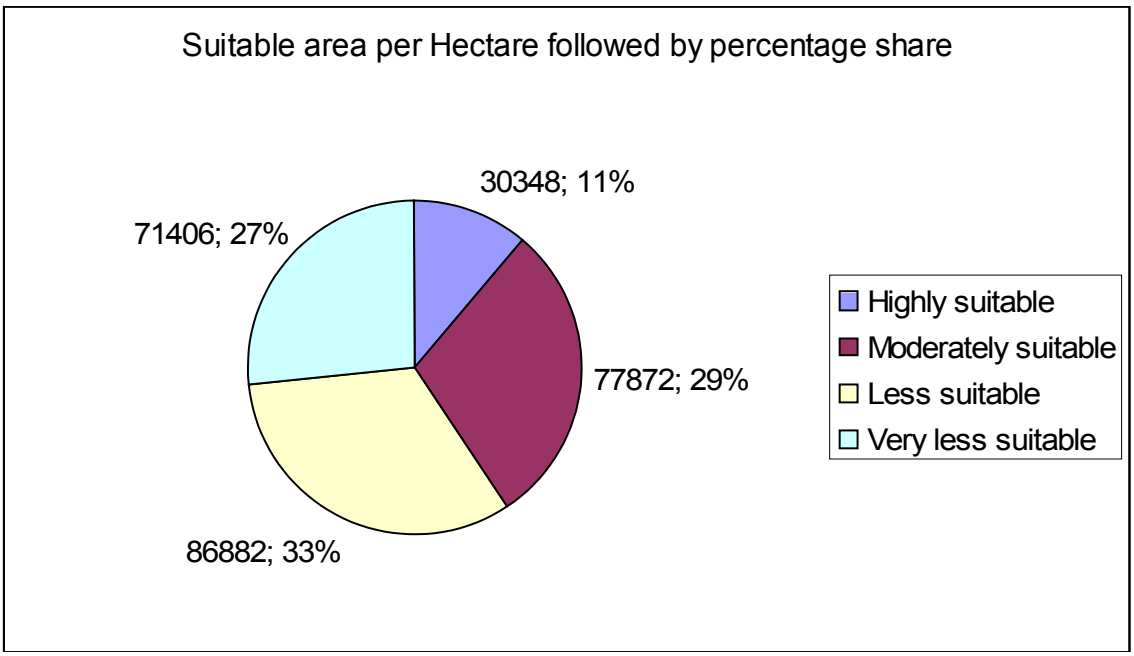

Figure 39: Ecotourism suitability per Area.

It is indicated in figure 39 that highly suitable area accounts for 11 percent, Moderately suitable area for 29 percent, less suitable and very less suitable area, on the other hand, accounts for 33 and 27 percent, respectively. Thus, largest area is dominated by less suitable sites whereas least area is found to be highly suitable site.

4.9 Discussion

This work is one of the few that has been done concerning ecotourism in Ethiopia. However, the application of Remote Sensing and GIS methods for ecotourism site selection in Ethiopia is a new one. In other parts of the world, however, there are different works done in identifying suitable sites for ecotourism using GIS and Remote-Sensing. Some countries, for example like India, give emphasis to factors such as vegetation density, land use-land cover and soil. Other countries, for example those that are found in mountainous regions give emphasis to mountains (landscapes) and its biota. Countries found nearby shorelines give emphasis to water and its biota. Even the application of ecotourism ranges to urban areas. In such cases, more emphasis is given to infrastructures and urban ecosystems. For example, articles produced in England indicated that how people, knowingly or unknowingly, practice ecotourism in urban areas. Areas having Parks, reserves, protected areas, wildlife and migratory birds

are also highly preferred for ecotourism sites. Thus, site selection for ecotourism is contextual to different countries in the sense that it depends up on their natural ecosystem as well as cultural landscapes.

In this paper, the writer tried to include more factors to determine ecotourism suitability. As a result seven factors namely land use-land cover, soil, vegetation density, elevation, slope, temperature and rainfall were considered. These factors are similar to the works mentioned above. Though the applied method can have limitations due to time and basic information, it has shown that it can be extended to other areas. Mapping of ecotourism potential sites helps to develop the sites for economic purposes, to protect them from human threats and therefore to conserve them.

The suitability model shows that 11 percent of the study area is highly suitable for ecotourism. This implies that the area is very significantly important for conservation, maintaining equitable environment and environmental sustainability. In terms of ecotourism activities Adventurers, Hikers and Walkers can practice and enjoy the area. 29 percent of the study area is moderately suitable for ecotourism and this implies that the area is significantly important for conservation and environmental sustainability. Riders, Hikers and Walkers can entertain ecotourism activities in these areas. 33 and 27 percent respectively represents less and very less suitable sites for ecotourism. This indicates the area is less important for environmental sustainability and ecotourism activities. Thus, it requires impact assessment and environmental management. Ease ecotourism activities such as walking, bicycling, horse riding, car camping can be entertained in this area. Moreover, the area can serve for infrastructure development.

5. Conclusion and Recommendation

5.1. Conclusion

The aim of this paper is to produce potential ecotourism sites in Addis Ababa city and its surrounding environs. The study area covers an approximate area of 2676 sq kms. Addis Ababa is found at the centre of the study area. Surrounding Addis Ababa City, there are kebele's selected from each of the five Woredas surrounding the city. The selection of these kebele's was made based on the proximity they have to the city. Thus, Kebele's nearby the city are included in the study area whereas those far away are not included.

- ✓ Although ambigous, ecotourism in this paper is defined as a form of alternative tourism which gives more emphasis to environmental sustainability and to the natural environment, but also considers cultural and educative components. Generally, it is agreed that tourism that considers low impact up on the environment and conserves the natural environment, promotes cultural and educational issues as well as benefits the local population is considered as ecotourism.

- ✓ Accuracy assessment for land use land cover was done using 375 GCPs. The result, then, indicated that 84.96 overall accuracy and 0.82 overall kappa statistics.

- ✓ Vegetation density of the study area reveals 74.24% sparse vegetation, 25.41% less dense vegetation and 0.35 dense vegetation.

- ✓ The dominant soil type of the study area is pellic vertisols which accounts for 71%.

- ✓ Mean annual rainfall range between 87 and 91 covers largest part of the study area which accounts for 42.28%. Whereas mean annual rainfall range between 107 and 120 covers least part of the study area which accounts for 1.46%.

- ✓ Mean annual temperature range between 15.95 and 16.38 covers largest part of the study area which accounts for 48.03%. Mean annual temperature range between 17.02 and 18.28, on the other hand, covers least part of the study area which accounts for 1.7%.

- ✓ Elevation range between 1903 and 2175, 2176 and 2344, 2345 and 2500, and 2501 and 2631 covers proportionate areas which is about 19% of each. Elevation range between 2943 and 3378, on the other hand, covers 2.62% of the total area coverage. Slope showed a remarkable increase with area. Thus, largest area is covered by the steepest slope.

- ✓ The result of the questionnaire reveals that the value of rank of the factor maps. Accordingly, land use land cover, soil, slope, elevation, vegetation density, temperature and rainfall are ranked as 1, 2, 3, 4, 5, 6 and 6, respectively.

- ✓ The final out put indicates 11 percent of highly suitable areas and 29 percent of moderately suitable area, majority of which is located in the Northern and Southwestern part of the study area. Less and very less suitable areas, on the other hand, accounts for 33 and 27 percent, respectively, of which majority is located in the Southern and Southeastern part of the study area.

5.2. Recommendation

- ✓ In this paper more emphasis is given to the natural component of ecotourism, hence it is necessary again to map the cultural aspects of ecotourism. Accordingly, sites of cultural heritage and other man made features should be mapped. Moreover, as the marketing of such cultural features is again the concern of ecotourism it should be given more emphasis.

- ✓ Accommodation sites, which are suitable to the maintenance and sustainability of the natural environment, should be established. In areas where such establishment is difficult or impossible, it should be well managed and conserved.

- ✓ More factors such as Noise impact in urban areas and land use impact in rural areas should be studied in detail. Moreover, Vegetation, Rangelands and Wetlands should be assessed and their impact to the cultural and natural environment should be studied.

- ✓ Surface water features such as the Aba Samuel Dam are under threat, it is again recommended that such surface water features should regularly cleaned and managed as their contribution to the local population and the local environment is high.

- ✓ The writer has also observed that a Forest area such as the 'Suba Menagesha Yemengist Den' is under environmental stress, it is again recommended that health of vegetation and in particular, that of forests should be assessed.

- ✓ Wild life and birds should be well studied and their location and distribution should be mapped because their benefit as an ecotourist attraction is high.

- ✓ Areas that are found as high suitable sites should be advertised to both local and foreign tourists so that local people can entertain economic activities. Educational awareness concerning their utilization, management and conservation should be given hand in hand. Concerned governmental and non-governmental organizations should again give greater concern to the maintenance and sustainability of this ecosystem.

- ✓ Areas that are found to be very less suitable for ecotourism again be can utilized for

the establishment of resorts and recreational sites by planting vegetation types suitable for the environment.

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APPENDIX

Annex 1: Questionnaire

QUESTIONNAIRE

The aim of this questionnaire is to gather information, from Addis Ababa City and its Surrounding environs', regarding ecotourism attractions and it also aims to determine their degree of attractiveness. Since your response is valuable for the mentioned objective, the writer politely requests you to give your answers to the stated questions as much as possible as you can.

1. Is there any tourism attraction in your area?

A. Yes B. No

2. If your answer is yes, from the possible attractions which are listed in the table below

A. Put a 'thick mark' on the tourist attractions that exist in your area (Wereda or Kebelle)

B. 'Rank' these attractions according to their degree of attractiveness (give least number- for example 1- to the most attractive site, and highest number to the least attractive site)

C. List the 'Names' of existing attractions

D. Mention the area (Wereda or Kebelle) that these attractions are found

No	List of possible attractions	Does it exist in your area? If yes put '✓'	Rank	Name	Location
a	Forests				
b	Lakes				
c	Rivers				
d	Parks				
e	Reserves				
f	Protected areas				
g	Wild life				
h	Unique species				
i	Unique landscape				
j	Weather condition				
k	Migratory birds				
l	Wetlands				
m	Grazing lands				
n	Mountains				
o	Open land				
p	Farm land				

Annex 2: Ground Control Points

OID	latitude	Longitude		49	456552	1008395
0	446121	997722		50	457212	1009588
1	446092	997670		51	457728	1011403
2	446134	997859		52	457287	1009787
3	446299	997316		53	456577	1008451
4	446753	997372		54	456214	1007380
5	446153	991727		55	457843	1000298
6	447086	990879		56	459982	998732
7	448399	990710		57	465643	998669
8	448101	990255		58	469410	998998
9	447859	990161		59	468652	998585
10	447616	989308		60	470452	998592
11	447867	989802		61	471194	998657
13	447856	989702		63	472675	997860
15	448916	990979		64	473014	996761
16	446175	991644		65	476790	998059
17	446145	993005		66	479404	997208
18	446882	994101		67	480281	998088
19	446882	994101		68	481247	998881
20	446636	994161		69	482799	999103
21	446491	994064		70	483805	999144
22	446699	994919		71	484678	999370
23	445184	999606		72	485380	999543
24	444988	1001560		73	486626	1001158
25	444912	1002564		74	486582	999872
26	445736	1003986		75	486613	998190
27	447144	1004797		76	486692	998312
28	447907	1004760		77	486698	997605
29	447779	1002336		78	486527	997242
30	450863	1001256		79	485534	995748
31	452222	1000735		80	483918	995005
32	451105	1000007		81	483702	995005
33	451214	999897		82	484331	992749
34	451440	1000324		83	484279	992381
35	452969	1001130		84	484251	991601
36	457820	1002989		85	484554	991362
37	458720	1003125		86	483582	992003
38	458362	1003710		87	482096	993266
39	458509	1004131		88	480674	994452
40	457842	1004433		89	479764	995294
41	458690	1004424		90	479534	994923
42	457100	1004737		91	479322	994264
43	457142	1005832		92	478479	994303
45	456748	1006770		93	478025	993616
46	456475	1007036		94	476972	994041
47	456212	1007337		96	476988	993558
48	455832	1007642		97	476963	993592
98	475232	992731		147	458187	984885

99	475124	992154		148	452260	985131
100	475599	991336		149	451967	985234
101	476565	991092		150	451452	985469
103	476317	990147		151	450547	985660
104	475785	989361		152	449852	985774
105	474739	988717		153	451128	985506
106	474459	987747		154	451583	985424
107	474196	986485		155	451964	985333
108	474093	984830		156	452385	985119
109	474593	983643		157	454527	984555
110	475462	982004		158	454761	984141
111	476324	981135		159	454153	983333
112	476494	981943		160	453152	982777
113	476359	982847		161	452676	982517
114	474512	983768		162	451801	982033
115	473969	985647		163	451066	981625
116	474234	986529		164	450418	981270
117	474864	988136		165	450017	981041
118	474677	990453		166	449381	980651
119	475279	989975		167	448898	980436
120	474725	990628		168	448972	980274
121	474614	990452		169	453210	982802
122	474975	988273		170	454653	983599
123	476136	989122		171	455202	983903
124	476128	989122		172	455452	984040
125	476617	988499		173	455817	984240
126	476541	988564		174	470801	997258
127	476323	988815		175	471222	996718
128	475864	988171		176	471967	997621
129	476092	988505		177	471543	997814
130	472517	987425		178	472809	998333
131	471423	987890		179	477282	996765
132	471667	989372		180	477937	996603
133	472419	988946		181	479766	996993
134	470253	990969		182	482426	998266
135	467371	992313		183	484391	998944
136	467991	993443		184	485110	999328
137	467966	994632		185	485587	999733
138	467852	995445		186	487167	987167
139	468309	995579		187	488563	1002860
140	468970	995508		188	489092	1003303
141	468900	994041		189	493189	1004980
142	469482	996136		190	493945	1005062
143	470439	996171		191	494484	1005176
144	470820	996290		192	494962	1005381
145	471323	996260		193	495532	1005631
146	471934	996543		194	495847	1005725
195	496455	1005679		244	485895	978994
196	496860	1005918		245	486094	979471
197	497307	1006141		246	486555	979610
198	498477	1006862		247	487303	979330
199	499227	1008236		248	487535	979423
200	499765	1008940		249	487753	979850

201	505330	1000300		250	487303	979330
202	505192	1000057		251	487535	979423
203	490825	1004669		252	487753	979850
204	505233	999358		253	488007	979907
205	505384	1000011		254	489290	980660
206	494894	1005302		255	489577	980421
207	494411	1005173		256	489989	980081
208	493910	1005125		257	490039	979899
209	493425	1004982		258	487154	979393
210	492185	1004542		259	485917	979485
211	491941	1004520		260	485453	979536
212	490825	1004669		261	485404	976210
213	487452	1002549		262	485773	978729
214	489130	1003324		263	485400	977753
215	488148	1002539		264	485310	977045
216	487450	1002550		265	483703	976003
217	486687	1003943		266	482251	976261
218	490344	1004287		267	482278	975949
219	494983	1004222		268	482291	975751
220	495132	1003681		269	482490	975119
221	495555	1002773		270	482618	975258
222	495722	1002063		271	482504	975119
223	495537	1002476		272	481990	976540
224	495874	1001914		273	480953	977267
225	496156	1001827		274	477449	979476
226	496386	1001860		275	476677	980214
227	488476	972886		276	476766	980667
228	487335	974442		277	476118	980081
229	487569	974532		278	475939	979409
230	488015	974724		279	476046	978932
231	488195	974889		280	476045	978169
232	488488	974779		281	475843	977147
233	488591	974733		282	475573	976940
234	488562	974551		283	475412	976607
235	487961	974712		284	474726	975845
236	486553	974701		285	474216	975525
237	484598	971719		286	473798	975215
238	484711	976007		287	472458	974045
239	485017	976548		288	472100	973746
240	485333	976927		289	469247	972108
241	485359	977525		290	468823	971929
242	485325	977991		291	468119	971760
243	485384	978433		292	467783	971515
293	467610	971320		341	473069	1012195
294	467677	971366		342	473701	1011958
295	467823	971433		343	473324	1011974
296	473780	975271		344	473106	1010184
297	473191	974827		345	471631	1009327
298	473332	975182		346	469401	1007330
299	474987	976055		347	468806	1005316
300	475457	976704		348	469413	1004293
301	475412	976720		349	472754	997353
302	476763	980400		350	473081	994785

303	476774	980994		351	472790	995334
304	474082	984941		352	475322	998444
305	474000	989716		353	463427	1002812
306	473566	992526		354	463962	1003561
307	473603	993444		355	464573	1003159
308	473567	994124		356	466318	1002150
309	473478	994655		357	467171	1001627
310	473528	995760		358	468324	1001239
311	475421	998503		359	468554	1001141
312	471462	1009179		360	471189	1000206
313	473905	1029551		361	471671	1000131
314	473559	1029762		362	496726	1002345
315	472706	1026879		363	497068	1002687
316	473331	1025823		364	497211	1002886
317	473243	1025809		365	460360	1002088
318	473167	1025812		366	460304	1002089
319	474047	1023827		367	459306	1002573
320	473775	1023254		368	450842	991886
321	473785	1023405		369	449445	992456
322	472981	1021468		370	450386	993368
323	472985	1021514		371	450899	993995
324	473151	1021190		372	479741	1003514
325	473056	1018933		373	470632	1003365
326	473098	1018135		374	474839	1006392
327	473369	1017849		375	483959	989549
328	474038	1017633				
329	474377	1017531				
330	473095	1017368				
331	473673	1017253				
332	473545	1015387				
333	472664	1013044				
334	472094	1012917				
335	471678	1012898				
336	471485	1012868				
337	471117	1012926				
338	471143	1012843				
339	472259	1013226				
340	472193	1013218				

DECLARATION

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

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