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GEOSPATIAL APPROACH FOR ECOTOURISM DEVELOPMENT: A CASE OF BALE MOUNTAINS NATIONAL PARK, ETHIOPIA

A THESIS SUBMITED TO ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES DEPARTMENT OF EARTH SCIENCE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN GIS AND REMOTE SENSING

By

TEWODROS KEBEDE TOLA

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

MASTER OF SCIENCE

In

Remote Sensing and Geographical Information Systems (GIS) of Addis Ababa University, Addis Ababa, Ethiopia

By
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Under the guidance of

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Addis Ababa University, Faculty of Natural Science, Department of Earth Sciences

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"Praise be to God for what he has given, which words have no power to say" 2Corinthians 9:15

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Acronyms

AHP	Analytic Hierarchy Process
a.s.l	above sea level
BMNP	Bale Mountains National Park
DEM	Digital Elevation Model
ETM	Enhanced Thematic Mapper
EWCO	Ethiopian Wildlife Conservation Organization
FAO	Food Agriculture Organization
FCC	False Color Composition
GIS	Geographic Information System
MCDM	Multi Criteria Decesion Making
MCE	Multi Criteria Evaluation
SRTM	Shuttle Radar Topography Mission
STEP	Sustainable Tourism and Elimination of Poverty
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WTO	World Tourism Organization

Abstract

Naturebased tourism is increasing throughout the world. Ecotourism has attracted increasing attention in recent years, not only as an alternative to mass tourism, but also as a means of economic development and environmental conservation. Being a naturebased tourism it takes into account the natural ecological attraction, their conservation and development. Most is based in national parks and restricted areas. The need for a sustainable approach in tourism development is very often addressed among the academia, the authorities and the stakeholders, as well as the apparent need for tools, which will guide in evaluation and planning. This study apply Geographical Information System (GIS) in multi-criterion decision-making framework in solving a spatial multi-objective problem of selecting suitable site for lodge establishing and map the scenic potential for ecotourism development and produce land use land cover map for BMNP ETM+ image has been used. Accordingly six land use land cover types were obtained: grassland, forest, erica, woodland, bareland and alpine. Seven criteria were defined to evaluate suitable sites for lodge: these are land use land cover; proximity to river, settlement and wilderness camp sites; geological, elevation (altitude) and slope suitability. To map the scenic potential map, four criteria were used from the previous seven factors: river availability, land use land cover, elevation and slope scenic. These criteria were ranked using the pairwise comparison technique of multi criteria analysis (MCA) and the results integrated into GIS weighted in hierarchical order using the MCE approach and produce lodge suitability and scenic potential maps. This study represents an important contribution to effective decision-making and environmental friendly infrastructure planning for ecotourism tourism development. Geospatial approach is necessary and effective for ecotourism components.

Key words: *Criteria (factor), Ecotourism, GIS, Multi-criteria evaluation, Suitability*

1. Introduction

1.1 Background

Tourism can be defined as the act of travel for the purpose of recreation and business, and the provision of services for this act. Tourists are people who are “traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited” (WTO, 2006). Tourism contributes to economic and social development of a country and has emerging potential. Traditional methods of disseminate tourism-related spatial information are inadequate. However, Geographic Information System (GIS) is providing new tools for advanced ecotourism management. So, it is helpful for decision maker and users to reach the decision and information easily.

Ecotourism is one of the fastest growing sectors in the tourism industry at present. Its development took place among the western society to experience wilderness. It started in 1872 in the United States with Yellowstone Park, in 1879 in Australia with Royal Park and in 1885 in Canada with Banff Park and Niagara Falls to set aside natural areas for protection and recreation in the form of national parks. There is a worldwide system of thousands of protected areas in all parts of the globe now. Since 1970, globally the number of protected areas has increased by 185%. The market for nature holidays is certainly a growing one. In 1993, the World Tourism Organization (WTO) has estimated that nature tourism generates 7% of all international travel expenditure, where the total annual global earning from tourism is nearly $3 trillion and 212 million people are employed (Eagle, 1997 cited in Ryngnga, 2008). The year 2002 declared as International Year of Ecotourism (IYE) by the United Nations as an encouragement for intensified cooperative efforts by governments and international and regional organizations, as well as non-governmental organizations in promoting development and the protection of the environment (Hari, 2010).

Ecotourism has attracted increasing attention in recent years, not only as an alternative to mass tourism, but also as a means of economic development and environmental conservation. Being naturebased tourism; it takes into account the natural ecological attraction, their conservation and development. Its main aim is to safeguard the environment, making it beneficial to the local people by generating revenue and education and pleasure for the tourist.

Tourism in Ethiopia has always involved features of ecotourism. People who visit the Historic Route are, of course, primarily interested in the country's history and the unusual accomplishments of Ethiopians over the millennia: the great monuments of Aksum and other sites in the north; the monolithic churches of Lalibela; the island monasteries of Lake Tana. But they are also interested in the physical features of these areas and in the extent to which they are being protected. In recent years, visitors have increased to other areas of major environmental interest: the Semien Mountains, the Bale Mountains, the Rift Valley Lakes, especially to the Omo Valley and other parts of the southwest. Eco-lodge development in some regions of the country has begun. Some tour organizations are beginning to specialize in animal and bird-watching tours, tours to observe indigenous forests and unusual geologic features (Paul, 2000).

Tourism infrastructures are the base to promote ecotourism tourism markets and benefit for country economic development and helps raise funds for environmental protection, research and education through a variety of mechanisms, including park entrance fees, tour organization, hotel, airline, voluntary contributions. Businesses are creating camps and eco-lodges, and natural resource managers are designing trails and tours. Most of the popular eco-travel destinations have fragile eco-systems, however, so it is important to maintain a careful balance between preservation and promotion sustainable development in order to ensure the long-term health of both the eco-systems and the tourism economies.

The diverse interests in preservation, education and recreation in ecotourism development do require effective and objective means for designing zones for various objectives. Obviously, MCE techniques are important tools in handling multiple criteria and objectives for resource planning in ecotourism (Fung and Wong, 2007).

1.2 Problem statement

Bale Mountain National Park has wild alpine scenery that has around a dozen endemic birds living on the slopes, as well as the Ethiopian Wolf and a Mountain Nyala. The park is the most important component of the Ethiopian Highlands Biodiversity Hotspot as recognized by Conservation International. It is proposed as a World Heritage Site recognized by UNESCO and is currently on the tentative list pending final status (UNESCO World Heritage). Also Ethiopian government is listing it as one of conservation/protected vicinity of the country.

The Bale Mountains, which has incalculable international, national and regional value, is the best-kept secret of Ethiopia. Bale Mountains National Park gives us opportunities for unsurpassed mountain walking, horse trekking, scenic driving and the changes to view many of Ethiopia's endemic mammals, in particular Ethiopian Wolf (Semien Fox), Menelik's Bushbuck and Mountain Nyala. Increasing tourism is of importance to in-situ conservation in that it brings revenue to the community and area while establishing an interest in resources. In many protected areas, tourism is a major activity that occurs without much planning or preparation. But, it would require developments and improvements in different infrastructure facilities in the park for tourists. Ethiopia's expanding national parks are still at a very elementary stage of development. There is a need to develop tourist destination that can be managed scientifically and sustainable way to attract large number of international as well as domestic tourists.

There are good potentials to enjoy visitors of the Bale Mountain National Park; but for these to be widely enjoyed; lodges and other facilities will have to be provided. However, at present only a single lodge facility in the park i.e. located at the head quarter of the park. The construction of such facilities will has not affect the park ecosystem and to be at suitable location. In order to ensure effective long-term sustainable management of the park and the challenge is to provide the infrastructure that tourists need as well as to identify viable strategies for sustainable use and conservation of the natural resources.

Bale Mountains, with BMNP at its heart, are a unique natural heritage with outstanding beauty, diverse attractions and great tourism potential. Despite its wildlife, trekking, scenic, and other attractions, lack of tourism infrastructure, planning and marketing currently inhibit BMNP from fulfilling its tourism potential (BMNP, 2007). So This study attempt to provide alternatives of most favorable sites to lodge establishing for decision maker and identifies best possible landscape scenic attractive sites to facilitate the development of tourism infrastructure that minimizes negative impacts maximizes the benefits of ecotourism and tourism management in Bale Mountain National Park.

1.3 Objectives of the study

1.3.1 General objective

To produce an ecotourism map for Bale Mountain National Park that facilitate for ecotourism resource utilization and development in the park.

1.3.2 Specific objectives

- To select suitable sites for new lodge establishment in Bale Mountain National Park
- To map Bale Mountain National Park scenery (landscape) attractiveness potential for the benefit of ecotourism

2. Literature Review

2.1 Concepts and Definitions of Tourism

Today, tourism is recognized as one of the world's huge industries that influence economical, cultural, social and environmental sections of human life. Many researchers believe tourism is an independent section and they are defining the principles of tourism based on an industrial structure (Eslami and Roshani, 2009). Currently, travel and tourism account for more than $3 trillion in spending annually and creating source of revenue for about 7.6% of the world's total employment. The United Nations World Tourism Organization forecasts that international travel will double by 2020 (USA Embassy, 2008).

It is changing rapidly as nature, heritage, and recreational destinations become more important, and as conventional tourism is forced to meet tougher environmental requirements. This presents a challenge to government and private enterprises to develop new approaches to the tourism market (Hari, 2010). However, it is one of the fastest growing sectors of the global economy and developing countries are attempting to react on this expanding industry; make an effort to boost foreign investment and financial reserves (Mike, 1999).

2.1.1 Eco-tourism

The concept of ecotourism is one of ambiguity and dispute. There is no universal definition for ecotourism, nor is there a certifying agency. The term ecotourism was coined by Héctor Ceballos-Lascuràin in 1983 (cited in Hari, 2010), and was initially used to describe nature-based travel to relatively undisturbed areas with an emphasis on education. The concept has, however, developed to a scientifically based approach to the planning, management and development of sustainable tourism products and activities. A common misconception is that ecotourism is just nature based tourism, the act of surrounding yourself with natures little wonders. The truth is far more complex. Ecotourism has to be both ecologically and socially conscious. Its goal is to minimize the impact that tourism has on an area through cooperation and management and in some case it even encourages travelers to have a positive impact on their new surroundings. A walk through the rainforest is not eco-tourism unless that particular walk somehow benefits that environment and the people who live there (Mike, 1999).

2.1.2 Ecotourism development

Ecotourism is considered the fastest growing market in the tourism industry, according to the World Tourism Organization with an annual growth rate of 5% worldwide and representing 6% of the world gross domestic product, 11.4% of all consumer spending - not a market to be taken lightly (Hari, 2010). The growth of ecotourism primarily involves travel by Europeans and North Americans to all parts of the world. Eagles *et al.* (1994) found that Canadian eco-tour companies visited fifty different countries in 1992. The number of eco-destinations expands with the increase in park numbers. There is now a worldwide nature travel market, with tourists from many countries traveling to destinations in many other countries (Zurick, 1992). It is a growing industry in many developing countries, particularly in tropical regions which contain a diversity of flora and fauna not available in the U.S. and Europe. Ecotourism has the additional appeal of promoting environmental responsibility and education by enabling the tourists to enjoy the beauties of sensitive areas, as well as giving opportunities to tourists to assist in preservation activities (Fatima *et al.*, 1996).

In the two last decades, ecotourism has been located in the center of attention for many experts, since people are traveling to original and natural regions and enjoy from landscapes, wild animals and plants, which these actions had insignificant impact on the environment and natural resources and play role in the protection and survival of various specious of plants and natural sources. They will be introduced as good income source for natives, if it is applied using appropriate advertisement and education (Eslami and Roshani, 2009).

Ecotourism as a kind of tourism, which includes wide range of activities related to natural resources e.g., visiting of national parks and protect areas, original natural area, watching of birds, tours in the natural environments, mountain climbing, visiting of natural caves, study of flora or fauna, conducting of field studies on wildlife and similar activities. It is also an increasingly popular form of tourism in which tourists seek out wild and scenic areas such as rainforests or mountains for an active and educational trip. Ecotourism has also become popular among people interested in both environmental conservation and sustainable development (Educational Web Adventures, 1996).

2.1.3 Tourism in Ethiopia

Ethiopia is a country of contrasts and extremes, from the cool Semien Mountains peaking at over 4600m to the low-lying Danakil Depression 120 m below sea level and the hottest place on earth. Situated in northeast Africa with Sudan, Eritrea, Djibouti, Somalia and Kenya as neighbors, Ethiopia is old beyond imagination. Its culture and traditions date back 3000 years, but hominid fossil finds dated at 4.4 million years show Ethiopia to be the earliest known home of humankind. Tourists visiting the country can enjoy unusual and diverse attractions from rare wildlife such as the highly endangered Ethiopian wolf, to ancient history in the rock-hewn churches of the north, and languid Rift Valley Lakes. Importantly, Ethiopia is not yet spoilt by mass tourism (Keri, 2010).

Tourism in Ethiopia has always involved features of ecotourism. People who visit the Historic Route are, of course, primarily interested in the country's history and the unusual accomplishments of Ethiopians over the millennia: the great monuments of Aksum and other sites in the north; the monolithic churches of Lalibela and the island monasteries of Lake Tana. But, they are also interested in the physical features of these areas and in the extent to which they are being protected (Paul, 2007).

2.1.4 Ecotourism in Ethiopia

Wildlife and its habitats in developing countries are becoming increasingly popular attractions for international tourism (Mike, 1999). However, Ecotourism is still in its infancy in Ethiopia, but it holds significant potential for growth. The country’s biodiversity is quite unique compared to neighboring countries, some of which are famous safari destinations. Ethiopia’s Protected Area (PA), which includes national parks, game reserves, wildlife sanctuaries and controlled hunting grounds, covers about 14% of the country. The protected areas offer ecotourism and leisure activities such as wildlife viewing, trekking, mountaineering and bird watching (Euromonitor International, 2010).

Ethiopia is really a place for outdoor lovers, as the choice attractions throughout the country are open air. For the energetic walking and trekking, pony trekking and mountain climbing in the Semein Mountains in the north and Bale Mountains in the south. However, the concept of ecotourism is still relatively new to Ethiopia and developers and policy makers still need some convincing but the Ethiopian Tourism Commission is aware of the benefits and has incorporated the development and promotion of ecotourism in its planning for the first time.

In 2008 the United States Agency for International Development (USAID) launched its new multimillion dollar ecotourism program, which will contribute to the development of Ethiopia’s unique and potentially very lucrative ecotourism sector. This Ethiopia Ecotourism

Development Program will protect natural resources and cultural heritage sites, as well as improve the livelihoods and quality of life of local communities (USA Embassy, 2008). In addition, the World Tourism Organization (WTO) has chosen Ethiopia as one of the first countries to be targeted by its Sustainable Tourism and Elimination of Poverty (STEP) initiative.

National park is an area set aside for the purpose of conserving and protecting wildlife and objects of aesthetic, ecological and scientific interest. Inside the park activities like felling trees or exploiting natural resources prohibited in any manner unless these activities are for the development and management of the park. There are nine national parks in Ethiopia where are listed in the Table 1, and three proposed (Maze and Chabara-Churchura in Gamogofa and Dawuro respectively and Alatish Park in Gondar bordering Sudan). Only Semein and Awash National parks have been legally gazetted (Spring Ethiopia Tours, 2010).

Table 1. List of the National Parks in Ethiopia

Name of park	Charismatic species	Species Recorded	
		Mammals	Birds
Awash	Beisa Oryx	81	453
Simen Mountain	Walia Ibex	21	180
OMO	Common Enland	75	325
Abijatta-Shalla Lakes	White Pelican	76	436
Bale Mountains	Mountain Nyala	77	260
Nechisar	Burchell`s Zebra	84	342
Yangudi/Rassa	African Wild Ass	36	230
Mago	African Buffalo	81	257

Source: Spring Ethiopia Tours (2010)

2.2 GIS and Tourism

Even though GIS is rarely discussed in the context of tourism, its wider use by planners concerned with environmental issues and resource management is now well established (Berry, 1991; Robinson, 1992 cited in Mansir, 2007). GIS has a number of advantages for supporting decision-making and planning for sustainable tourism. Tourism is an activity which strongly implies the geographical dimension for all, the users (the tourists), the providers and the planners. GIS is the technology specifically developed for the management and study of spatial phenomena (Farsari and Prastacos, 2009).

Geographic Information Systems (GIS) and tourism share a common characteristic, that is, both cross the boundaries of disciplines and application areas. GIS has been applied in many disciplines including geography, forestry, urban planning, and environmental studies. Similarly, tourism has been a subject of interests to geographers, economists, business, environmental planners, anthropologists, and archaeologists. As such, the potential for GIS applications in tourism is significant (Colak and Aydinoglu, 2006). Since 1980, the use of GIS has grown radically from relative obscurity to become a vital tool in most countries' decision-making processes concerning environmental management and planning, as well as many other diverse applications (Daniel, *et al.*, 2009)

Nowadays GIS is equally useful in tourism as in other applications involving management and planning, since tourism consists of a wide variety of elements including facilities, activities, services, and industries which combine to deliver travel experiences. They point out that the growing interest in tourism and recreation studies will be able to benefit from GIS technology by developing more useful and efficient applications. In light of this GIS may play a key role in documenting natural conditions, developments and documenting the suitability of resources for tourism, exposing conflicts, and revealing cause-effect relationships (Dye and Shaw 2007 cited in Rannveig and Micael, 2009).

2.3 Concepts of Multi Criteria Evaluation

In Decision theory, multi-criteria evaluation is the process in which several criteria are evaluated in order to meet a specific objective. Taking several criteria into account in an evaluation can be achieved. A decision is a choice between alternatives. The basis for a decision is known as a criterion. In a multi-criteria evaluation, an attempt is made to combine a set of criteria to achieve a single composite basis for a decision according to a specific objective (Ronald, 2006).

Multi-criteria Evaluation (MCE), also known as multi-criteria decision; is a means of simplifying complex decision-making tasks which may involve many stakeholders, a diversity of possible outcomes and many and sometimes intangible criteria by which to assess the outcomes. MCE is an effective technique in which to identify trade-offs in the decision-making process with the ultimate goal of achieving compromise. It is also an important means by which structure and transparency can be imposed upon the decision-making process. In recent years it has gained popularity as a tool for making decisions involving complex environmental, economic and social issues (Wendy and Martin, 2003).

Multiple criteria evaluation (MCE) aims at evaluating several criteria to meet a specific objective (Malczewski 1999 cited in Fung and Wong, 2007). It has been integrated with GIS for a wide range of applications. Based on either Boolean operations or weighted linear combinations, MCE can help provide results in the form of suitability maps (results of weighted linear combination) pertinent to the specific objective. Jiang and Eastman (2000) used fuzzy measures to provide a theoretical basis for the standardization of factors.

A Multi-criteria Evaluation seeks to make explicit the logical thought process that is implicitly carried out by an individual when coming to a decision. In complex decision-making tasks, which sometimes involve many objectives and many decision-makers, this structured process may be lost in the complexity of the issues. In general, a MCE seeks to identify the alternatives or options that are to be investigated in coming to a decision, a set of criteria by which to rank these alternatives, the preferences or weights the stakeholders assign to the various criteria and an aggregation procedure by which the criteria-specific rank orders are aggregated into a single 'compromise' rank order (Wendy and Martin, 2003).

GIS has good capabilities of handling spatial problems, and as such can be used to support spatial decision-making. Solving a complex multiple criteria problem without spatial analytical and visualization tools would be computationally difficult, if not impossible. Multi-criteria decision making techniques, as stand alone tools, have been computerized and nowadays there is much software to use. However, it is not common that such software is capable to handle spatial problem in the form of maps (Mansir, 2007). GIS technology was considered as the appropriate platform for tourism because it can integrate both qualitative and quantitative information, it can provide a visual display of results thus permitting an easy and efficient appraisal of results, and can communicate information to all interested parties becoming thus a participatory and exploratory tool.

2.3.1 Multi criteria evaluation

A decision is a choice between alternatives (such as alternative actions, land allocations). The basis for a decision is known as a criterion. In a Multi-Criteria Evaluation, an attempt is made to combine a set of criteria to achieve a single composite basis for a decision according to a specific objective. For example, a decision may need to be made about what areas are the most suitable for industrial development. Criteria might include proximity to roads, slope gradient and exclusion of reserved lands. Through a Multi-Criteria Evaluation, these criteria images representing suitability combined to form a single suitability map from which the final choice will be made.

The integration of multi-source geo-referenced spatial data within a real spatial database, which allows a synergistic processing of a considerable amount of information, the standardization of data and the elaboration of digital maps that are the basis of decision-making. GIS-based decision-support systems strongly sustain a single decision-maker, or a group of decision-makers, in evaluating alternatives to enhance decisions and to achieve specific objectives (Looney, 2001). It is, however, the decision-maker who determines the criteria, factors and constraints that may reduce uncertainty in the decision rules, and in the end, makes the decisions. Therefore, decisions for resolving problems should be based on preliminary simulation on computer-based systems, thus necessitating the use of multi criteria evaluation method and GIS technology.

2.3.2 Spatial multi criteria decision making

Spatial multi criteria decision problems typically involve a set of geographically-defined alternatives (events) from which a choice of one or more alternatives is made with respect to a given set of evaluation criteria (Jankowski, 1995; Malczewski, 1996 cited in Mohamed, *et al.*, 2006). Spatial multi criteria analysis is vastly different from conventional MCDM techniques due to inclusion of an explicit geographic component. In contrast to conventional MCDM analysis, spatial multi criteria analysis requires information on criterion values and the geographical locations of alternatives in addition to the decision makers' preferences with respect to a set of evaluation criteria. This means analysis results depend not only on the geographical distribution of attributes, but also on the value judgments involved in the decision making process. Therefore, two considerations are of paramount importance for spatial multi criteria decision analysis: (1) the GIS component (data acquisition, storage, retrieval, manipulation, and analysis capability); and (2) the MCDM analysis component (aggregation of spatial data and decision makers' preferences into discrete decision alternatives)

2.3.3 The analytical hierarchy process

The most frequently raised problem in MCDM is how to establish weights for a set of activities according to importance. Location decisions such as the ranking of alternative communities are representative multi-criteria decisions that require prioritizing multiple criteria. Saaty (1980) has shown that this weighting of activities in MCDM can be dealt with using a theory of measurement in a hierarchical structure. The analytic hierarchy process (AHP) is a comprehensive, logical and structural framework, which allows improving the understanding of complex decisions by decomposing the problem in a hierarchical structure. The incorporation of all relevant decision criteria, and their pairwise comparison allows the decision maker to determine the trade-offs among objectives. Such multi criteria decision problems are typical for housing sites selection. The AHP allows decision-makers to model a complex problem in a hierarchical structure showing the relationship of the goal, objectives (criteria), sub-objectives, and alternatives. Uncertainties and other influencing factors can also be included. It is not only supports decision makers by enabling them to structure complexity and exercise judgment, but also allows them to incorporate both objective and subjective considerations in the decision process.

2.4 Land use land cover mapping

The terms land uses and land cover are often used interchangeably, their actual meanings are distinct yet closely linked characteristics of the Earth's surface. Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Land use refers to the purpose the land serves, for example, recreation, wildlife habitat, or agriculture. Land use applications involve both baseline mapping and subsequent monitoring, since timely information is required to know what current quantity of land is in what type of use and to identify the land use changes from year to year (Canada Center for Remote Sensing). The availability of spatial land use land cover data is important to plan the land resources.

Land use land cover mapping is the assessment of different land use land cover types over a certain geographic extent. There are many ways of doing this. Field workers can go into the field and actually take an inventory of species and draw a map showing what species occur in what areas. This is very time consuming and expensive. Aerial photographs are used to trace areas of certain species. This method has been used extensively in the past. It is much more cost effective and faster than field workers, but it still has its limitations. In recent years, we have had the benefit of satellite data and computers to help us better map the extent of various land cover types. Now, we can get larger areas mapped in less time with more consistency.

3. Materials and Methods

3.1 Study Area Description

3.1.1 Location

The Bale Mountains National Park (BMNP) at $6^0$30'-$7^0$00'N and $39^0$30'-$39^0$55'E on the south-east Ethiopian plateau, in Bale Zone of Oromiya National Regional State. It covers about 2,322 km^2 of mountains and forest (Figure 1). It was first proposed in the late 1960s to protect the afroalpine habitat and populations of the rare and endemic species of the Mountain Nyala (*Tragelaphus buxtoni*) and the Ethiopian Wolf (*Canis simensis*). It was established by the Ethiopian Wildlife Conservation Organization (EWCO) in 1971 with the primary objective of conserving the wildlife and other valuable natural resources in the area. The park headquarter is on the northern border at Dinsho, 400 km by road from Addis Ababa. Geographically the park boundary falls in four Weredas of Bale zone and one Wereda of West Arsi zone: Dinsho in the North, Goba in the East, Mena in South and South East, Harena in South and South West and Adaba in the West.

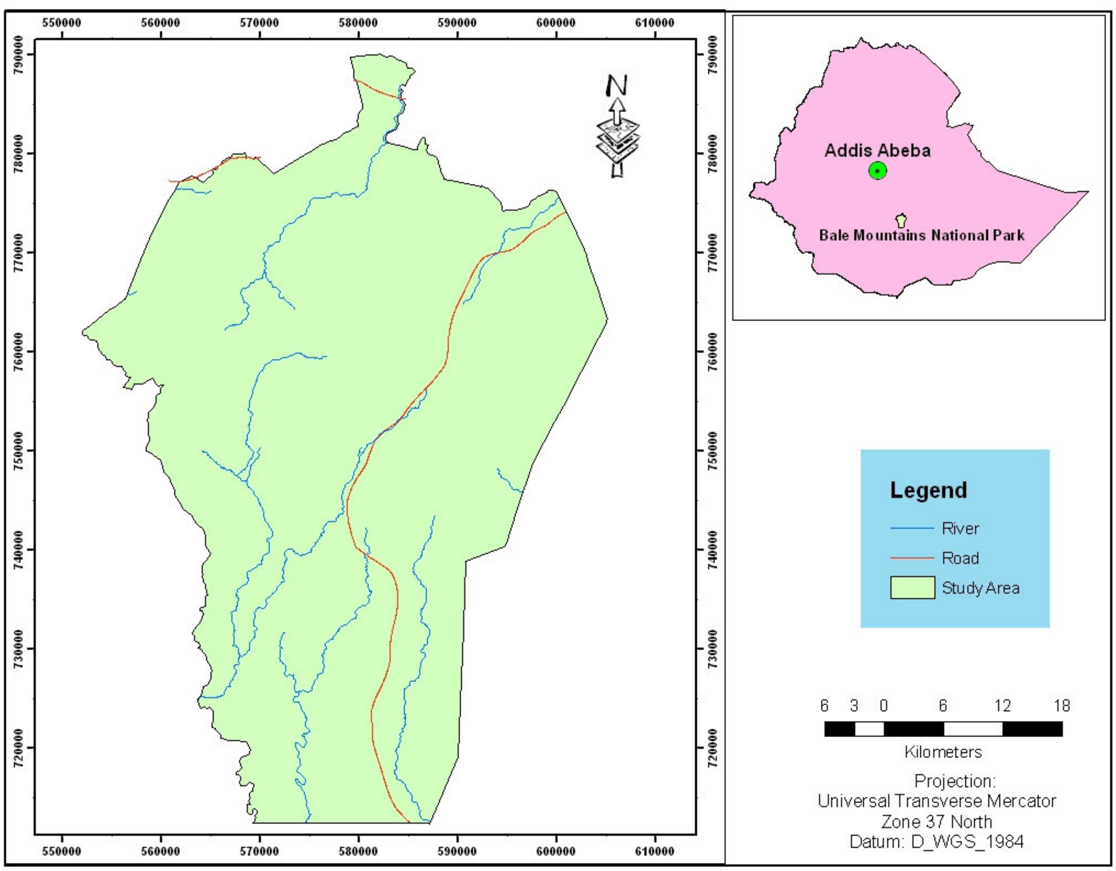

Figure 1. Study area map

The park is divided in to three subsections on the basis of land forms and altitude for ease of description (BMNP, 1986).

Northern Gaysay Area: This area of broad valleys and high ridges mainly lies between the altitude of 3000 and 3500m a.s.l, which is the upper limit for tree growth. This area comprises Juniper/Hagenia woodlands, broad grassy valleys and swamp areas. It is divided in to three small areas on the northern boundary, the largest of which is the Gaysay area.

Central peaks and Sanete Plateau: The most obvious part of the park is formed of the mountainous central peaks and plateau area.

The eastern side of the mountains, which lies above 4,000 m a.s.l is known as the Sanete plateau. From this plateau rise the highest peaks of the mountains- Tullu Dimtu, Batu, Kara Deem, Tullu Konteh, Worgona, Wasema, Archaah and Adola.

North of Sanete Plateau is highly dissected area, formed of valleys and intervening ridges of the Micha, Tegona, Kaficho, Shiya and Danka rivers. West of Sanete Plateau lays the lava flows area. This is the very broken rocky area of relatively recent lava flows, originating from a peak or peaks, on the Sanete Plateau, that flowed westwards and stopped on the edge of the present day upper Web Valley.

West of lava flows area is the upper Web Valley. Web river rises from the south east corner of the mountain part of the park, and flows north, north western in broad flat valley. This is walled to the east by the cliffs of lava flows, and to the west by the ridge that forms the north-western boundary of the park.

Southern Harenna Area: The largest sub-section of the park in area is that part immediately south of the mountains. The plateau falls away rapidly in altitude to the south, from the treeline at 3,500 m to 2,000 m a.s.l over a distance of 8 km is contain Harena Escarpment. The slope from there to the southern park boundary is gentler through the Harena Forest, from 2,000 m to 1,500 m a.s.l over a distance of 20 km.

3.1.2 Topography

Bale Mountain is a chain of mountains structure; to the west, north and east by an extensively formed plateau of about 2500 meter. They rise to a high altitude plateau the greater proportion of which is over 4000 meters and rapidly fall away to the south at the Harena Escarpment. The plateau is result of ancient volcanic rocks dissected by many rivers and streams that have cut deep gorges into the edges over the centuries. In some places this has resulted in scenic waterfalls. From the plateau rise several mountain massifs of rounded and craggy peaks, including Tullu Diimtu the second-highest mountain in Ethiopia at 4,377 m above sea level. A major part of the central peaks area is covered by a capping of more recent lava flows, still mainly unvegetated, and forming spectacular rock ripples and pillars. Many shallow depressions on the plateau are filled with water in the wet season, forming small lakes that mirror the surrounding scenery (Bird Life International, 2010).

3.1.3 Geology

The study area geology was three major groups forming a succession of basalts and trachytes: the Lower Stratoid Basalts (Microporphyritic Feldspar Basalt), the Reira Basalts and the Sanete Basalts and Batu Trachytes. The Lower Stratoid Basalts are some 10 to 150 m of weatherd aphyric basalts which rest directly on the Proterozoic basement. These are overlain by Damole Ignimbrites which are 200-250 m thick and composed of rhyolites and alkali rhyolites with welded and unwelded ashflow tuffs. The Reira basalts form a 600 m succession of aphyric, pyroxene and plagioclase-phyric basalts. The Sanete Basalts and Batu Trachytes are the latest shield volcanic rocks (Berhe, *et al.*, 1987).

3.1.4 Hydrology

The Bale Mountains massif is very important water catchments, as is evident from the pattern of rivers rising in them. The head water rivers that rise from the mountains are Wabe Shebele, Web, Dumal and Welmel (Table 2). Since the main part of the mountains is formed of a flat plateau, the watersheds are characterized by flat, swampy areas, and many small shallow lakes.

People numbering in the hundreds of thousands, their livestock and the environment in the south east of Ethiopia and further in to Somalia are dependent on the water that originates from the Bale Massif. The importance of the hydrological services that the area provides to south-eastern Ethiopia and parts of Somalia and Kenya have gradually been recognized over subsequent years and their conservation is now a primary purpose of the park.

Table 2. Rivers catchments in BMNP

No	Major Rivers	Tributaries
1	Wabe Shebele	Abasa, Arba, Baranda, Boko, Furunna, Gondadoh, Layleeso, Solay
2	Web	Albabo, Dalacha, Danka, Dimbeeba, Garano, Gaysay, Kabasha, Kaficho, Keyrensa, Lolla, Micha, Shaya, Shaya Gugesa, Tayanta, Togona, Toroshama, Walla, Wasama, Web and Zetegn Melka
3	Dumal	Six un-named tributaries
4	Welmel	Garemba, Rira, Shawe, Shisha, Welmel and Yadot

Source: BMNP (2007)

3.1.5 Climate

The climate of the study area is under the influence of altitude; temperature falls with increasing altitude. At the higher altitudes the lowest temperature occur at night in the clear skies of the dry season and the highest temperature during the day of the same season; the lowest recorded temperature at highest plateau of Bale (Sanete) was (-15ºC) during the night and maximum record was 26ºC during the day time. In contrast the rainy season is warmer and the temperature shows much less daily fluctuation. It rarely freezes during the rainy season but the temperature also rarely climbs over 20^0C. Orographic rainfall type is dominant which is characterized; by one eight month rainy season (March - October) with the greater bulk of the rain falling in April and then in August - October. From May to July there are showers, usually in the afternoon, but it is rarely incapacitating. The rainy season is followed by a four month dry season (November to February). Rainfall is well distributed through out the wet season, ranging from 1000 to1400mm annually (BMNP, 1986).

3.1.6 Vegetation

The high rainfall in the Bale Mountains together with the great variation in altitude and topography; result in rich diversity in the vegetation. Changes in the vegetation with altitude are clearly seen, this zonation being a result of increasing then decreasing rainfall as you ascend, generally decreasing temperatures, and increased exposure of rock and resulting poorer soils. The mountains are surrounded to the northwest and northeast by fertile plains at 2,500 m that are heavily utilized for agriculture mainly wheat growing. This is succeeded by remnants of beautiful juniper and Kosso (Hagenia abyssinica) forest belt that reaches up to about 3,300 m altitude, which is the upper limit of the tree zone, apart from a few isolated trees in protected valleys. Above the tree line the heather moorlands begin, reaching to about 3,600 m altitudes on gently sloping ground, and as high as 3,800 m on steep rocky slopes.

Above this are various forms of Afro-Alpine moorland, dominated by different plants depending on slope, drainage and rodent activity. The tops of most of the high peaks are either bare rocks, or exposed soil with very small hardy tussock herbs or grasses. To the south, the land falls away far more, through rich and varied forest below the heather, containing bamboo and giant Podocarpus trees, and dry short-tree wooded grasslands at 1,600 m on the southern boundary of the Park (BMNP, 1986).

3.1.7 Fauna

Bale Mountains National Park encompasses a broad range of habitats between 1,500 and 4,377 m altitude. These provide a large number of niches for animals, and as a result there is great variety in the fauna. Much of the original stimulus for making a National Park in the Bale Mountains was the plights of the endemic Mountain Nyala and Ethiopian Wolf. There are, in-fact, at least 46 mammal species from other animal orders-reptiles and amphibians that all have a part in the complex ecosystem that have evolved in this remarkable area.

A large proportion of the Bale Mountains fauna is endemic. The variety of species and high rate of endemic is due to the wide variety of habitats conserved in BMNP and to the isolation of the highland areas of Ethiopia from other similar highlands in Eastern Africa, by the surrounding hot dry lowlands. Ethiopia as a whole has a large number of endemic species.

Table 3. Endemic Animals in the Bale Mountains National Park

	Animals				
	Mammals	**Birds**	**Snakes**	**Lizard**	**Frogs**
Bale Mountains					
Total Species	46	161	2	3	8
No of endemics	11	14	0	0	7
% total	23.9	8.7	0	0	87.5
Ethiopia					
Total Species	239	850	77	-	55
No of endemics	21	23	3	-	20
% total	8.8	2.7	3.9	-	36.4
% Ethiopian endemics found in Bale	52.4	60.9	-	-	35.0

Source: BMNP (1986)3.2 Method

3.2. Method

3.2.1 Data Source

Software's used for this study were: ARC GIS 9.2 for map making and GIS analysis; ERDAS IMAGINE 9.1 for satellite image processing; IDRSI Andes for multi criteria analysis; 3DEM Visualization for processing SRTM data and Global positioning system for ground control points.

Input data for this study are collected and derived from different sources. River shape file, digital elevation model and slope of the study area were extracted from 30m SRTM data. Road map is digitized from Toposheet map (1:50000) scale. Moreover, settlement, wilderness campsites points and a shape file showing the official boundary of the study area were received from Bale Mountain National Park head quarter. Geology map is obtained from FAO 1997 classification for East Africa because; it is acquired in digital data. Finally, Multi temporal 2005 Landsat ETM+ imagery accessed from GIS and Remote sensing laboratory of Addis Ababa University.

3.2.2 Lodge site and scenic suitability analysis

The term lodge used in this study with the context of provisional place to stay, meals and other basic facilities are providing for the tourists who stay in the park for visiting and other related activities. Scenic suitability is the visual beauty of the landscapes. The process of suitability analysis and mapping is based on evaluation criteria. Criterions are selected from available data on the basis of different related reviewed literatures, discussion with related experts and depending on related previous works. The selected criterions are operational (have some relation with activity), complete (full information about the input data), measurable in one or more of the scales, variable (non uniform) in the area, and it is not repeated (non redundant). The criterions used for lodge site suitability analysis include: land use land cover, geology, elevation and slope suitability; settlement, wilderness campsite and river proximity; and accessibility by either road or trekking routes. The lodge suitable sites mapping was done using MCE. To carry out the MCE, each of the criteria with its associated attribute data is digitally encoded in GIS data base. A geo database consisting of all factor layers was created in ArcGIS 9.2 software then point and line features are changed in to raster data. Each layer was subjected to undergo reclassification process and weight influence was calculated through IDRSI Andes software. Then the overly analysis was conducted using

ArcGIS 9.2 spatial analyst extension. Finally, the lodge suitability map was produced. Using similar procedures, scenic suitability maps produced using availability of river, vegetation type (land use land cover), slope and altitude characteristic which all are significant contribution for the scenic. The general methodology of study is displayed by flow chart in Figure 2.

3.2.3 Mapping criterions

From the collected data, relevant criterions which are used for lodge suitable site identification and the scenic potential mapping were prepared. All factor maps are arranged in continuous raster feature format to make compatible and standardize. River, settlement points and wilderness campsites are changed into raster using distance calculator tool. Then, factors are reclassified in to five classes and value of suitability is assigned to each class and ranked. Lodge site suitability is used all the seven criterion maps. Landscape scenic is used four of them criterions (factor) maps namely: land use land cover, elevation, slope and river maps. The reclassified factor maps are exported in to IDRSI and through pairwise comparison the weight of the factors are obtained. On running weight overlay modeler using the derived weight on IDRSI; suitability raster map were produced. Detail of their relevance for mapping is described in Table 4 and 5.

Table 4. Lodge site suitability mapping criteria and their use in analysis

No	Criteria/Map	Relevance for lodge site suitability map
1	Land use land cover	To consider ecological risk from infrastructure development
2	Settlement	To determine sites that are distance from settlement
3	Wilderness campsite	To determine sites that are distance from campsites which are giving services and potentials
4	Geology	To stratify the lithology suitability for foundation
5	Slope	To determine areas which is easily accessible
6	Elevation	To stratify elevation suitability for human survive and preferred
7	River	To determine distance from water sources which is the basic need of life for different purposes

Table 5. Scenic mapping criteria and their use in analysis

No	Criteri/Map	Relevance for scenic map
1	Land use land cover	To determine vegetation cover and their attraction
2	Slope	To examine surface undulation
3	Elevation	To determine surface topography
4	River	To identify the presence of river which is create aesthetic value of landscape

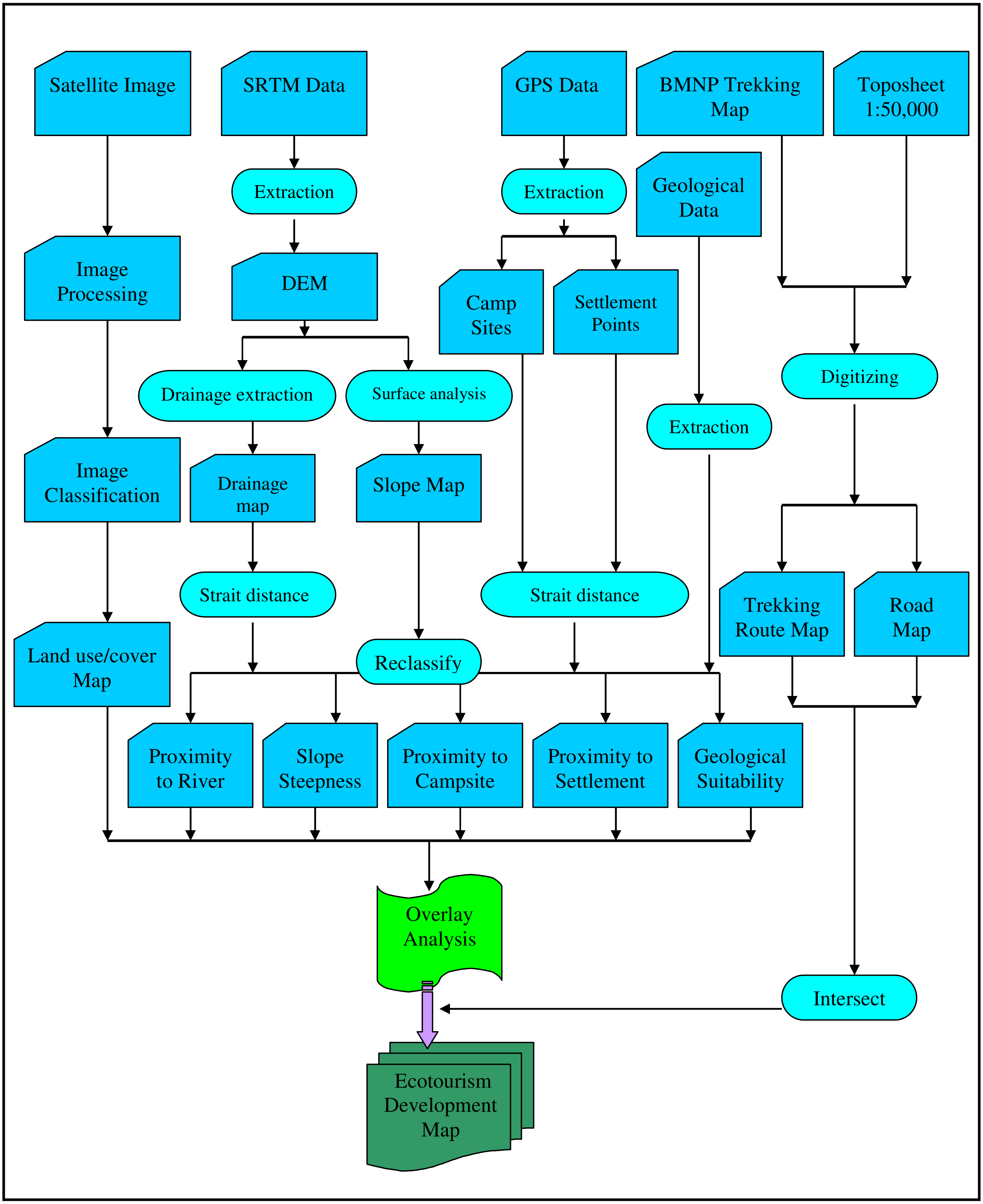

Figure 2. Research methodology flow chart

3.2.4 Land use land cover mapping

The terms land use land cover has been combined as one entity for the description of the landscape within the area of study. Landsat ETM+ satellite image of the year 2005 was classified using a supervised classification method. Figure 3 is show the Landsat ETM+ imagery in false color composition of the study area in 2005.

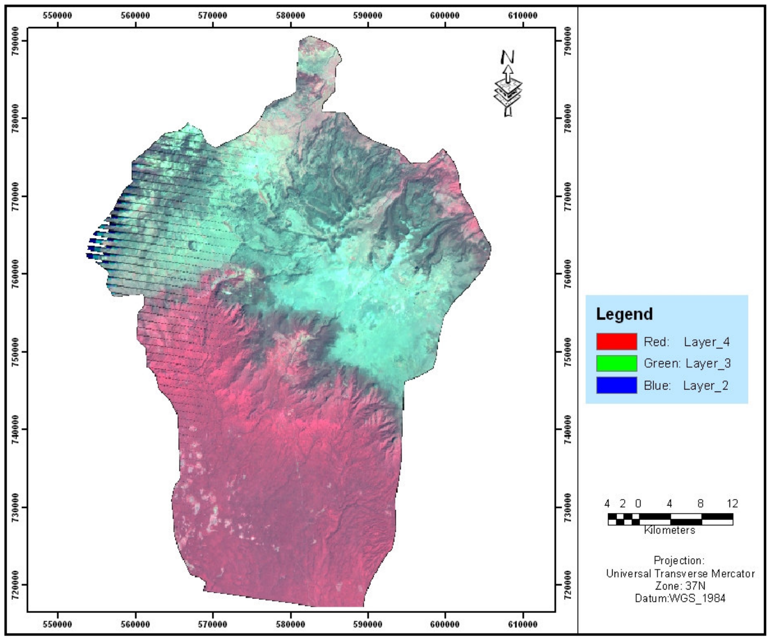

Figure 3. Landsat ETM+ satellite imagery in FCC

A total of 6 land use land cover classes were identified: alpine, bareland, erica, grassland, harena forest and woodland (Figure 4). The description of each land use land cover types are:

Alpine: vegetation type found in high altitude. On higher in altitude in the park a plant species is found, the smaller the growth form is likely to as a protection against wind and frost. Vegetation types of the class are Helichrysum citrispinum and Helichrysum splendidum

Bareland: bareland is the land which is devoid of vegetation and lava flow areas. Many places on the Sanete plateau looks as though they have been ploughed.

Erica: erica is type forest found in BMNP mainly occur on the tree line of harena forest escarpment and north eastern part of the park. It contains two types of erica: erica forest and erica shrub. Vegetations included are erica arborea trees and erica trimera

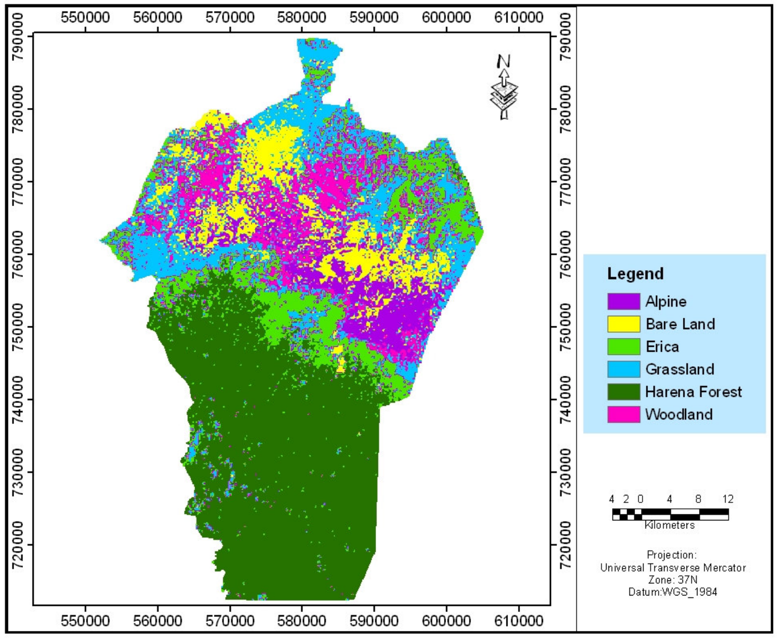

Figure 4. Land use land cover map of BMNP (2005)

Grassland: grassland mainly occurs in northern, northestern and western part of the park.

Harena forest: harena forest covers almost half of the park in area and is magnificent example of unspoiled moist tropical forest. It extends over a wide range of altitude. The tree cover is very high and dense. It is home to high levels of biodiversity and endemism, including many threatened species.

Woodland: tree cover is sparse with incomplete canopy, a high inter-tree distance and only a single canopy layer for the most part.

Forest is the leading by its area coverage while alpine and woodland the lowest area coverage in Bale Mountain National Park. Area coverage of each land use land cover class is shown in Figure 5 by km^2. As show in figure 5; harena forest is occupy 41% of land cover, erica 14%, grassland 17%, bareland 10%, alpine and woodland 9% cover respectively.

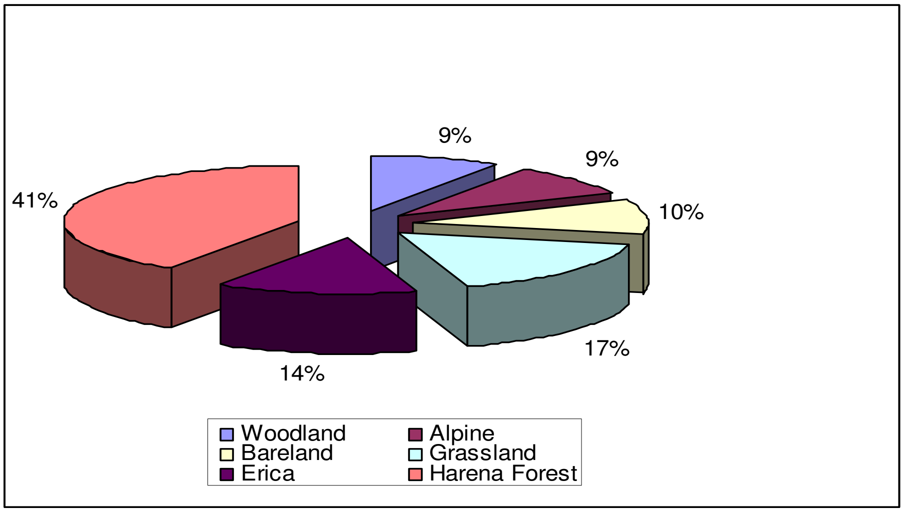

Figure 5. Percentage share of land use land cover

3.3 Decision Rule and Multi Criteria Evaluation

A geographical information system (GIS) is an information system technology that is used to store and retrieve geographical data, and provides the tools that used to manipulate, analyze and present geographical data (Rigaux *et al*., 2001 cited in Chhetri and Arrowsmith, 2008). In recent years, it have made a contribution to various facets of tourism resource management and planning. These contributions range from a simple resource inventory to building a spatial decision support system. The development of geospatial-based inventories has introduced flexibility, objectivity and efficiency in managing the spatial database of tourism resources. It provides procedures and tools for acquiring spatial information as well as making data more accessible, repeatable and useable.

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 different criteria in to a single composite index and a statement of how alternatives are to be compared using this index.

Base map over the study area were created and used to produce several criterion maps. Each criterion is represented at a map as a layer. Every map represents one criterion and it is called a thematic layer or data layer. They represent in what way the attributes are distributed in space and how they fulfill the achieving of the objective. In other words, a layer represents a set of alternative locations for a decision.

3.4 Criterions Used for Lodge Site Suitability Analysis

A criterion (factor) is basis for a decision that can be measured and evaluated. It is the evidence upon which a decision is based. Selecting/formulating criteria that need to be fulfilled in order to make the right decision is one of the difficulties in multi-criteria evaluation. For the last three decades, geographic information system (GIS), and multi criteria evaluation techniques have been used in solving site selection problems (Chhetri and Arrowsmith, 2008).

The site suitability analysis for lodge establishing and finding of possible topographic scenic attractive map of the study area achieved based on various interrelated components of the environment. Based on literature search, previous works, and interviews with tourism experts; the following criterions are identified.

3.4.1 Land use and Land cover

The entire study area Landsat ETM+ image was classified into 6 classes of land use land covers: afro alpine, bareland, erica, grassland, forest and woodland. Moreover, the land use land cover was reclassified in to six suitability classes in order of ecology susceptibility and forest vulnerability if lodge sites is their.

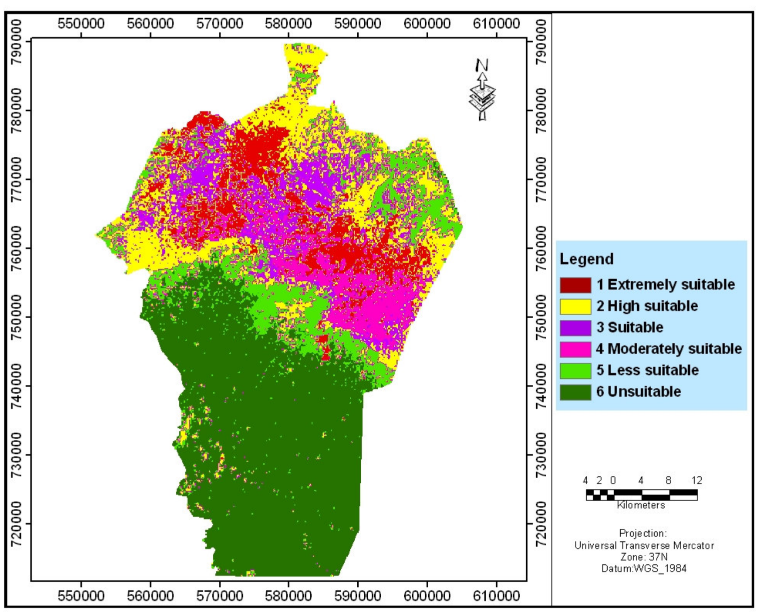

Figure 6. Reclassified land use land cover map (2005)

Due it high and diverse ecology carry potential of forest; forest land use/cover is considered as unsuitable or the least suitable for lodge site. Lodge infrastructure establishing is needed open space for foundation and other activities. As a result the forest and vegetation on the site is removed; this disturbs or damages the ecosystem on the site. Still the proximity of the loge site to forest increase vulnerability of forest when number of tourists increasing over time. To avoid such problems forest land use/cover assigned as unsuitable for lodge site.

Therefore the least rank 6 were given to forest cover, erica forest was given rank of 5, alpine rank 4, woodland rank 3, grassland rank 2 and the highest suitability 1 rank was given to for Bareland. The result for reclassified land use land cover map is shown on Figure 6.

3.4.2 Proximity to settlement

The settlement in the Bale Mountain National Park is a type of hamlet; it has not such big size a cluster of houses. Settlements areas collected using GPS receiver in the form of point feature data Figure 7.

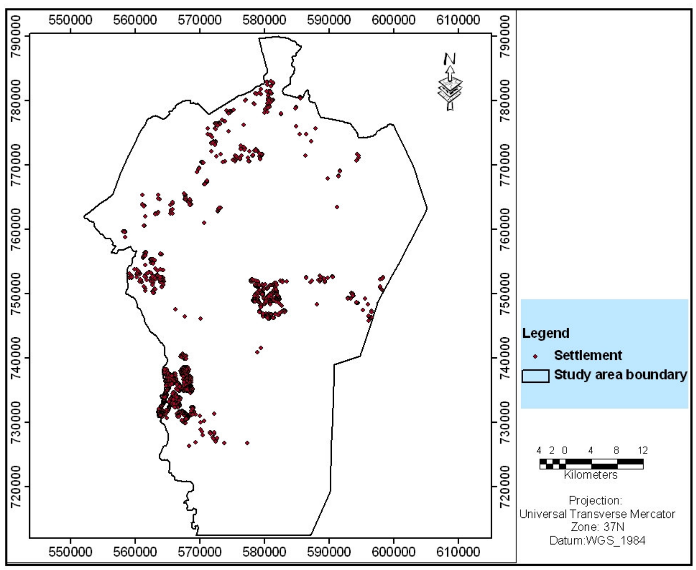

Figure 7. Settlement distribution map

So this had changed in to raster format to make continuous surface and standardized to be compatible for MCE. Settlement point feature data are changed to raster using strait distance method of spatial analysis tool. Though the raster data is reclassified in to five classes based on distance from settlement points is depict in Figure 8. The nearby distance to settlement area is ranked as high suitability for lodge site. The highest suitability value was given rank of 1 which is up to 2.7 km the nearby distance to settlement; a distance 2.7 – 5.3 km is ranked as 2; 5.3 – 8 km is ranked as 3; 8 – 10.7 km is ranked as 4 and the unsuitability rank was given 5 for far away distances (10.7 – 13.3 km) from the settlement.

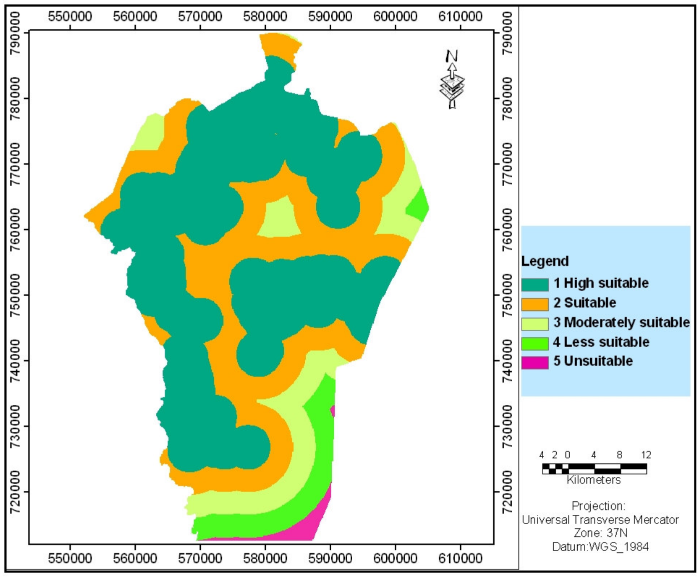

Figure 8. Reclassified settlement map

3.4.3 Proximity to wilderness campsites

Wilderness campsites are now served for tourists those visit the park but, no camping facilities whatsoever are provided. The tourists must carry all water, food, and shelter with them by rucksack or horse. You pitch a tent in the middle of the woods or open space and completely fend for yourself. In other words, its caveman camping: sleep outside (personal shelter), get your own food, pee in the woods, and connect with nature.

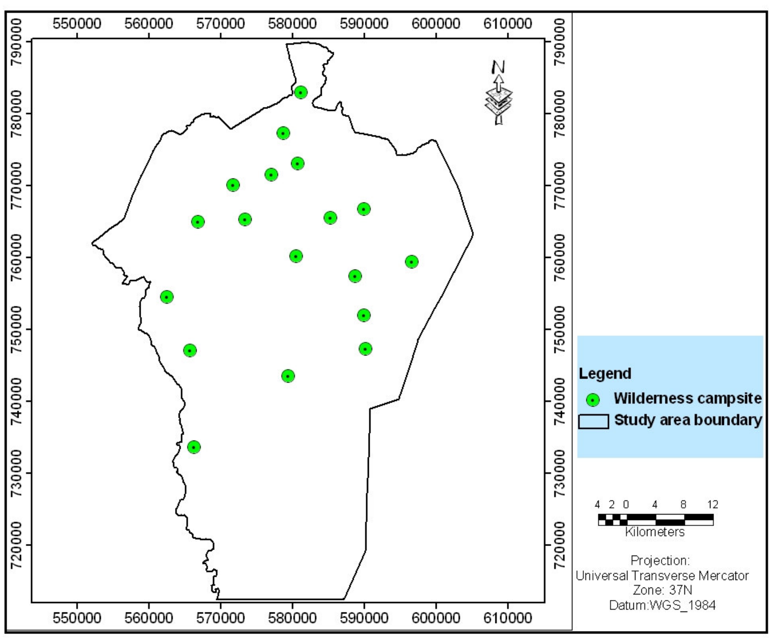

Figure 9. Wilderness campsite map

Wilderness campsites are taken as high suitability for lodge because currently under utilization and potential. However, they are selected on the basis of time taken to move from one campsite to another campsite during trekking and tourists personal interest. The campsites locations areas collected using GPS receiver and transferred in to GIS environment as point feature data set is shown in Figure 9.

Currently the park has 18 wilderness campsites. These point features of campsites are changed in to raster data set using strait distance method of spatial analyst tool and reclassified in to six classes using equal interval technique to get distance from wilderness campsites are displayed in Figure 10. Result of reclassified distance from wilderness campsites is 0–6 km, 6-12 km, 12-18 km, 18-24 km and above 24 km were computed. The highest value for suitability was given rank of 1 which is in close proximity to the campsite (up to 6 km) and lowest suitability value was give rank 6 to remote areas from wilderness campsites (above 24 km).

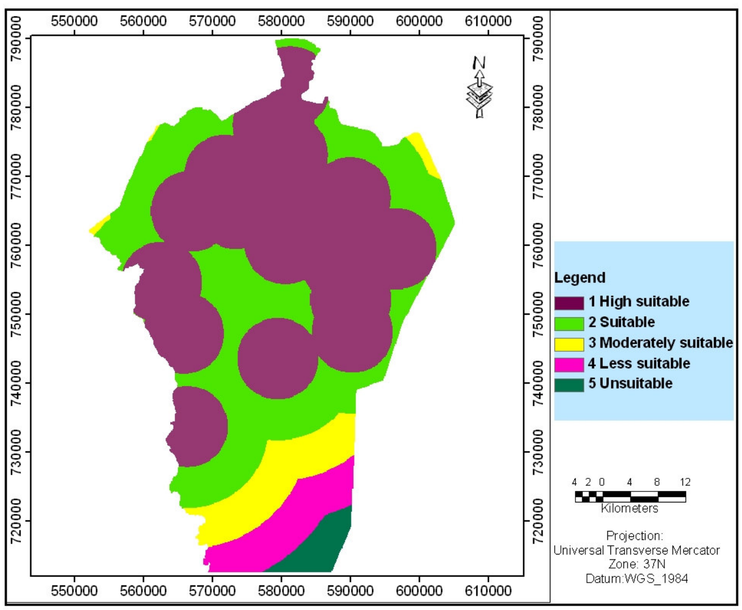

Figure 10. Reclassified wilderness campsite map

3.4.4 Geological suitability

Geology map of the study area has been prepared on the basis of geology map of Ethiopia prepared by FAO for east Africa in 1997. In analysis of FAO classification the park has three geological rock types; Pyroclastic rock, Ultrabasic rock and igneous rock. Figure 11 shows the three rock types are ranked into three classes of suitability based on geologist opinion;

Ultrabasic rock ranked as 1 high suitability for foundation, Igneous rock was given rank 2, medium suitability; and Payroclastic rock was given rank 3, low suitability for base foundation.

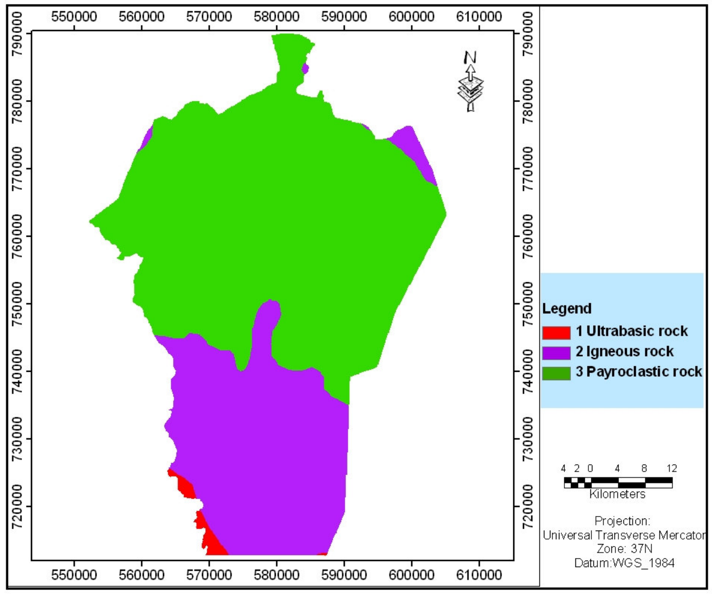

Figure 11. Reclassified geology map (FAO, 1997)

3.4.5 Topography

Topography describes the surface shape and relief of the land. It refers to various landforms (physical features) which represent the external shape of the earth.

3.4.5.1 Elevation suitability

Elevation, also called altitude is the height of place above or below a reference level such as mean sea level. Since altitude is one of the climate determinant factor of the area, recognized as one important factor in the lodge site suitability analysis. Usually temperature is fall as the altitude increase. Climate of BMNP is highly under influence of altitude. Temperature is drop in to negative on the high altitude especially above 3400 m a.s.l during night time in the park. This is not suitable to stay their and a risky for people come from high temperature areas.

Elevation map of the study area is generated from digital elevation model. The digital elevation model (DEM) is a raster based digital dataset of the topography of the Earth. The pixels of the dataset are each assigned an elevation value, and a header portion of the dataset defines the area of coverage, the units each pixel covers, and the units of elevation.

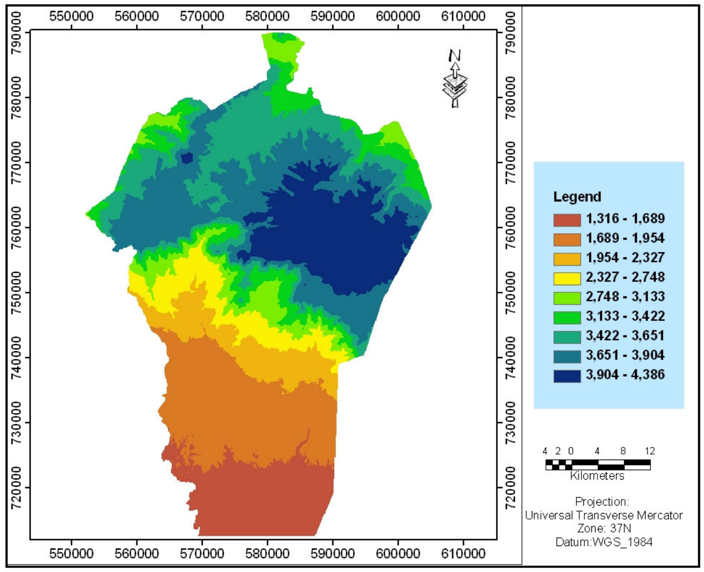

Figure 12. Elevation map in meter

To generate the study are digital elevation model; the raw SRTM data is patched on 3D Visualization software in order to fill the missing data and exported into Arc map environment. While this vector elevation map was converted into raster grid format using ArcGIS conversion tool extension of DEM to raster module, which applies the spatial resolution value stored in the DEM. Then study area DEM is extracted by masking of study area shape file with help of extraction tool; the resulting raster had elevation value which is revealed in Figure 12. The elevation of the park is increase from south (Harena forest) 1,316 m to north part (Sanete plateau) of the park reach up to 4,386 m a.s.l i.e. Mount Batu.

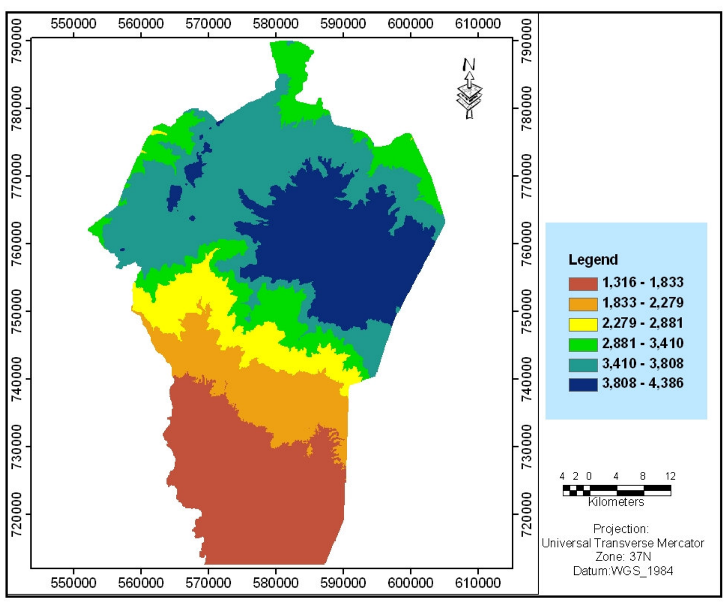

Figure 13. Reclassified elevation map in meter

As depicted in Figure 13, elevation map derived from DEM data was reclassified based on altitude using natural breaks (jenks) technique to rank elevation suitability for human to stay. The layer was reclassified in to six classes and new values were assigned to each class and based on this classification 1, 2, 3 and 4, values were given to elevation ranges of 3,410–3,808 m, 2881–3410 m, 2,279–2,881 m, and 1,833–2,279 m respectively. The highest elevation class is from 3,808 to 5,386 m a.s.l was given rank of 4, because this range of elevation is not having suitable environment for a lot human being due to low temperature. The lower elevation class from 1316 to 1833 m a.s.l was give 6 rank.

3.4.5.2 Slope suitability

Slope is a safety indicator implying the gentler the slope, the higher the safety factor and vice versa. Topography and slope should be considered when selecting site plan for any construction project. Consideration of the slope of the land is important to reduce construction cost and minimize risk from natural danger. In areas with very steep slopes, access may be difficult there is also an increased risk of landslide in high slope areas.

The slope raster was derived from the DEM using the ArcGIS Spatial Analyst extension of surface module, which enabled to classify the area according to the steepness and the gentleness of the terrain. The lower the slope value, the flatter the terrain and the higher the slope value the steeper the terrain. Slope of the terrain surface can be explained by degree or percent for change of slope. The slope of the study area is explained by degree measurement unit is shown in Figure 14. Most parts of the Harena forest and Sanete plateaus are characterized by gentle slope. Where as the Central, North East and North West part of the park is experience steep slopes. The lowest slope of Bale Mountain National Park is 0^0 indicates flat land and the highest slope value recoded is 72^0 which is near to cliff land form.

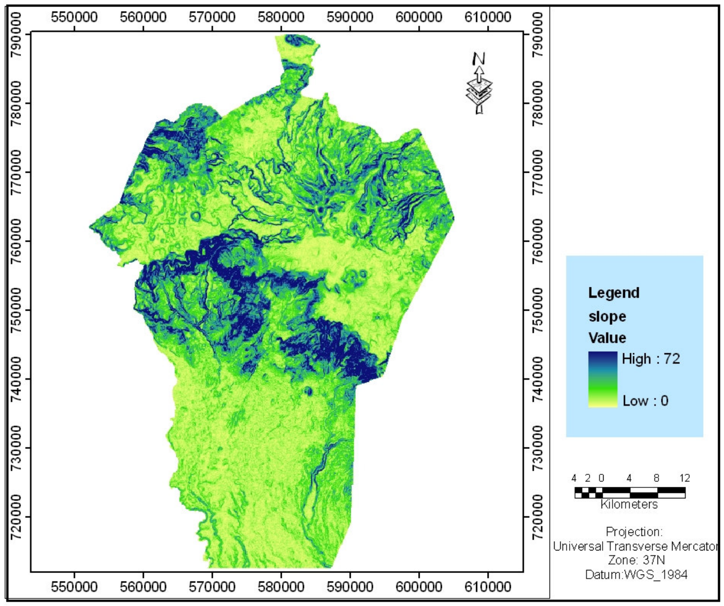

Figure 14. Slope map in degree

The slope raster map was reclassified in to five slope class based on its natural break is explained in Figure 15. The reclassified slope was given 4 class of suitability for lodge establishment; the higher rank value of 1 (0-5^0) shows flat (gentle) slope, resulting high suitability for lodge site; slope from 6-12^0 ranked 2; slope from 13-20^0 rank 3; slope from 21-30^0 rank 4 and slope from 31-72^0 is not suitable for lodge establishing due to steep slope restricted in weighting evaluation.

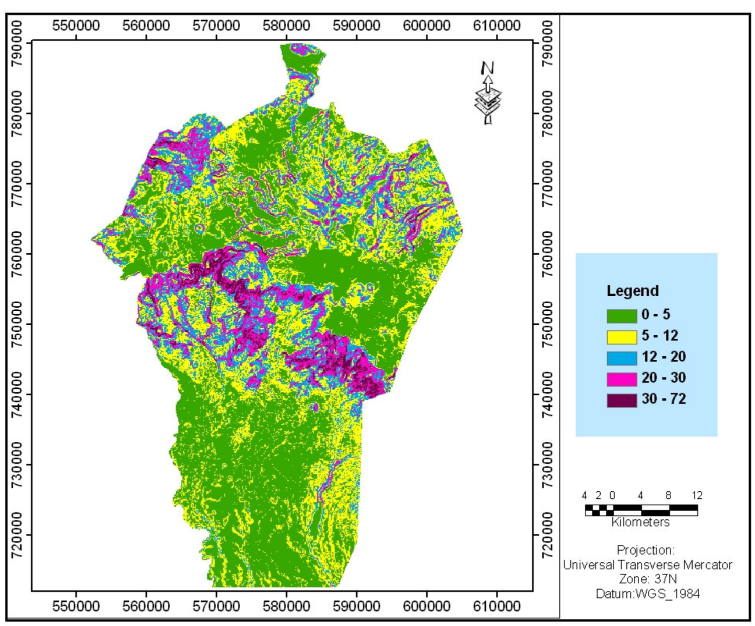

Figure 15. Reclassified slope map in degree

3.4.6 Proximity to river

Water is the basic necessity for any living thing. So river as source of water supply for human being is very important. Availability of water in near by distance is necessary for many purposes like drinking, cooking and sanitation. As result river is taken to as one of the factor for lode site suitability analysis.

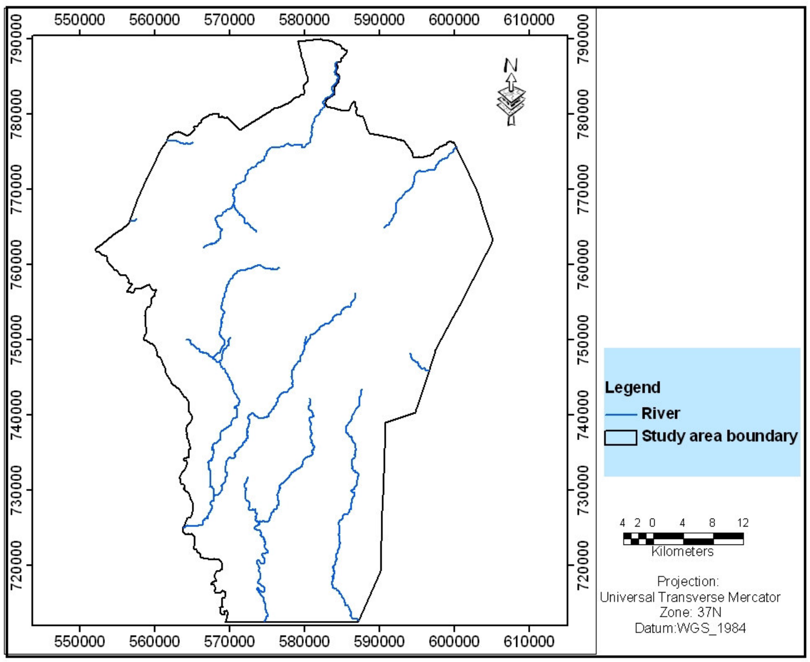

Figure 16. River map

Figure 16 is shows river map of the study area resulting from SRTM 30 m resolution satellite data. To produce river map, SRTM data is patched for missing data with help of 3D Visualization and saved in DEM format. In Arc GIS 9.2 the result is displayed and processed by Hydrology tool in the spatial analysis extension tool to generate the stream order. The result was generating seven stream orders. However, the lowest order of the stream (1-4) avoided because their influence is not much significant and only the higher order of streams (5, 6 and 7) are taken for this study analysis.

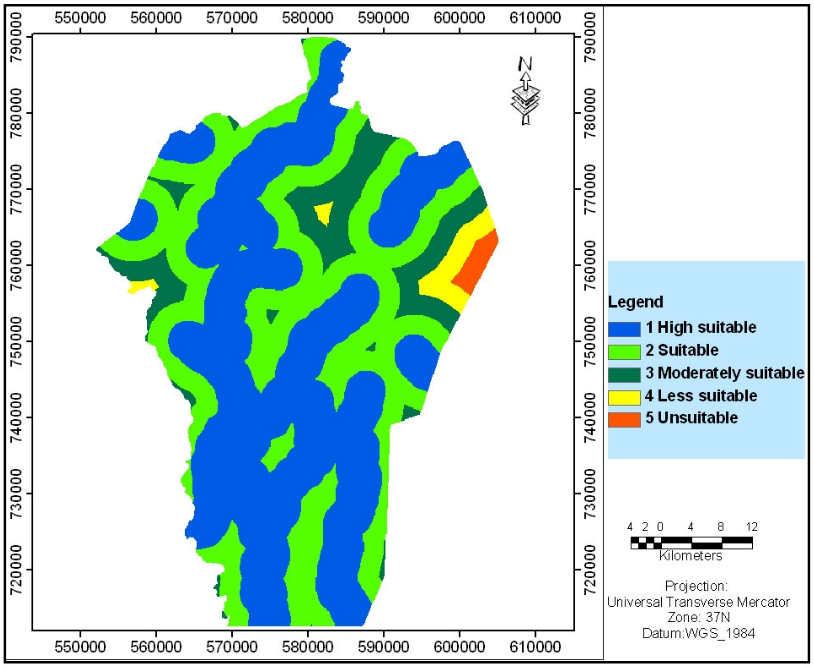

Figure 17. Reclassified river map

River map is represented by line feature isn't compatible for MCE. Firstly the line feature was converted in to raster feature and reclassified in to five classes based on the distance from the river (Figure 17). The area near to water source (river) less than 2.67 km is ranked as high suitability for lodge represented by value 1, since it is easily accessible for water need; rank 2 for distance from 2.67-5.33 km; rank 3 for distance from 5.33-8 km; rank 4 for distance from 8-10.67 km and rank 5 was given for distance far from river (10.67-13.34 km) is unsuitability for lodge.

3.5 Criterions Used For Landscape Scenic Potential Mapping

The scenic beauty potential of landscape is the sum of many factors that it holds for its scenic attractiveness. Factors included in this study are: elevation, slope steepness, river and land cover map of the study area. These components are assigned weights according to their importance in contributing to landscape value.

3.5.1 River

The presence of water in a vivid or distinctive form in landscape, for example, a waterfall or a rapid, increases the aesthetic value of landscape and generates a state of appreciation among visitors. A network of streams in a landscape may not only develop numerous visually attractive geomorphologic features, but also generates variety and diversity that is interest to many visitors. River feature map of the study area was converted in to raster and a distance function was used to calculate the distances of every cell in the study area to its nearest river. The derived distance values were reclassified into four classes of suitability. For the nearest distance to river, the higher suitability value of rank 1 is given and the far distance from river is given lower suitability rank of 4. The result of reclassified river is depicted on Figure 18.

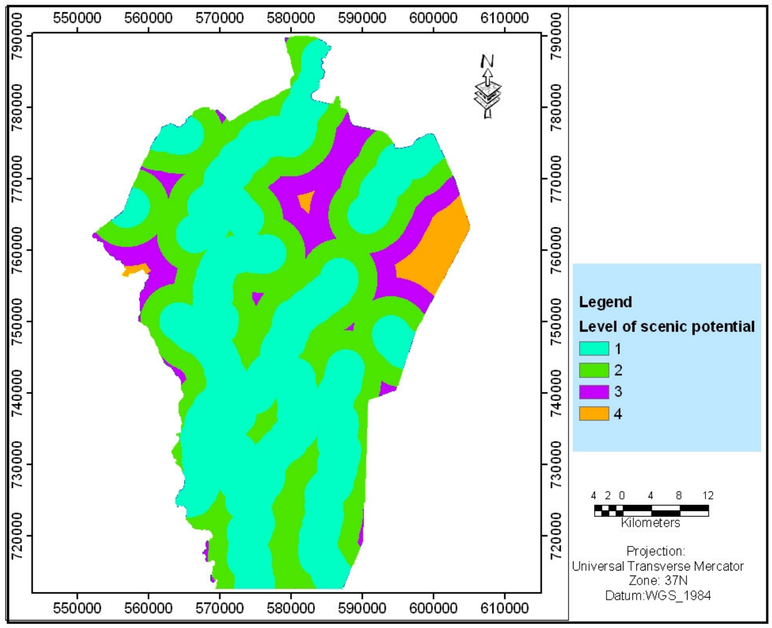

Figure 18. Reclassified river map

3.5.2 Land use land cover

Landscape attractiveness is increase with vegetation cover. More variety in plant species enhances biodiversity and consequently increases the health in habitat. Healthy ecosystems are generally believed to be more visually attractive. Diversity in vegetative communities in the landscape can produce spatial patterns that may carry higher scenic values for a visitor. Land use land cover map of the study area was reclassified and ranked in to 5 classes on the basis of its visual attraction potential. High rank of visual attraction potential with landscape was given to forest cover and erica; rank 2 for alpine vegetation cover; rank 3 given to woodland; rank 4 given to grassland and the lowest suitability rank 5 was given to bareland (Figure 19).

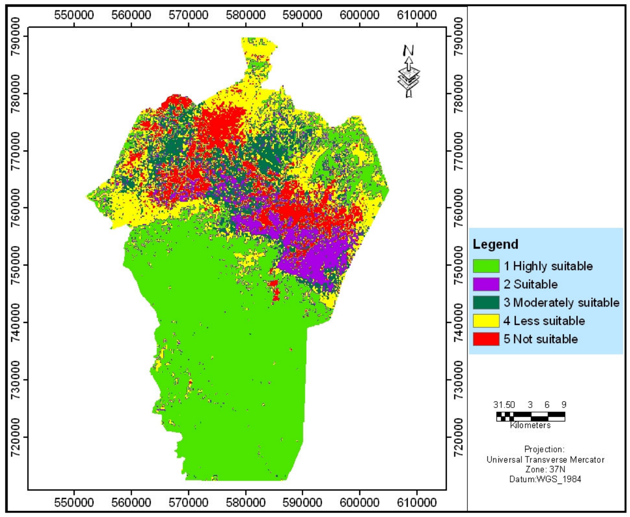

Figure 19. Reclassified land use land cover map

3.5.3 Elevation

Earlier studies suggest that topography is one of the most important dimensions of attractiveness in landscape, as it enables patterns and form for many other landform and land cover features to be determined (Linton 1968; Bishop and Hulse 1994; Miller *et al.,* 1994 cited in Prem and Colin, 2008). Elevation of the study area is reclassified in to 5 classes of scenic potential. Result of reclassified elevation range were 1316-2047 m, 2047-2731 m, 2731-3342 m, 3342-3774 m and above 3774 m, new values were assigned to each class were 5, 4, 3, 2 and 1 respectively. The higher elevation range was given higher suitability value 1 for scenic attraction because such type of land feature is not found everyplace and it is attractive for most of human visual. Lower elevation (1316-2047 m a.s.l) is given low suitability value 5 (Figure 20).

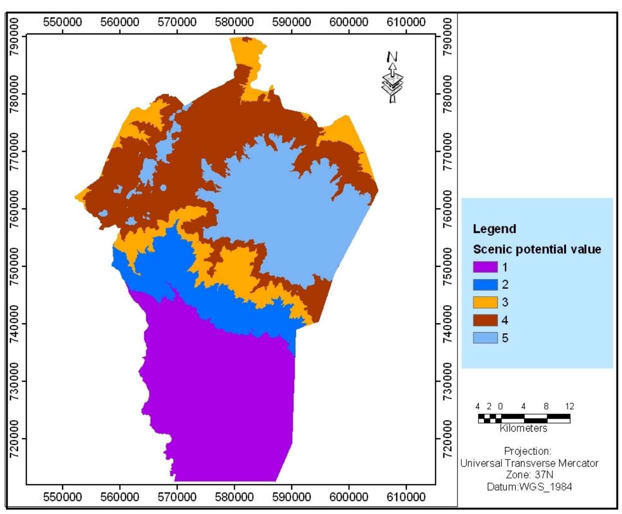

Figure 20. Reclassified elevation map

3.5.4 Slope

Terrain properties such as convexity and concavity generate undulation in slope profile that appears visually attractive to observers across a wider geographical area. Slope of the study area was reclassified in to 5 classes for the scenic potential mapping on the basis of its degree. New classes are 0-5 degree, 5-13 degree, 13-21 degree, 21-30 degree and above 30 degree were computed and assigned values of 5, 4, 3, 2 and 1 respectively. Then, each class shown in Figure 21, beginning from the class with a gentle slope was given rank 5 which is less attraction value and value 1 was given for steep slops (above 30 degree). Cliff and hanging wall landscape is result of steep slopes that create good scenic beauty.

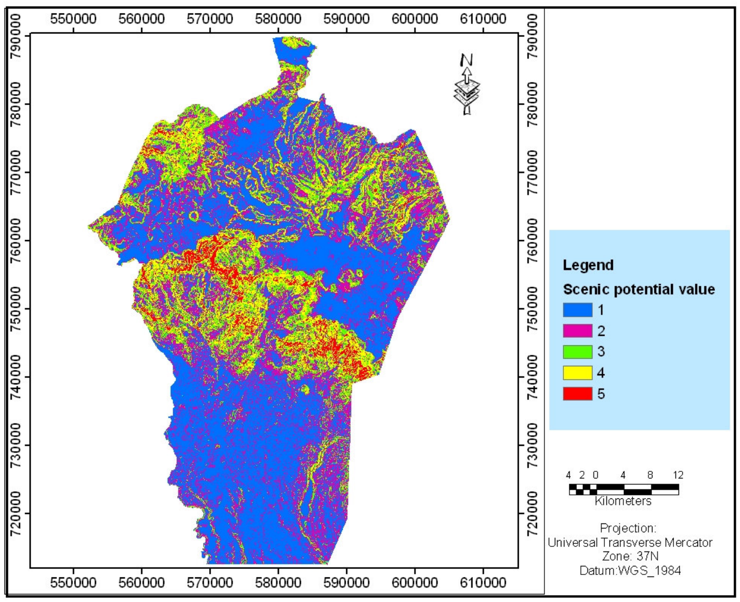

Figure 21. Reclassified slope map

3.6 Weighting, Evaluation and Suitability Analysis

Weight is used to develop a set of relative weights for all factors in a multi criteria evaluation. Criterion weights were used to prepare ratio values assigned to each criterion for suitability analysis. The result was determining the relative importance of one criterion over another. The task of assigning weights (deciding the importance of each factor) is performed outside GIS software on IDRSI.

Weight overlay technique, is based on the standardized criterion scores, which are compared and added. Criterion maps have different scales of measurement; they can not be compared by their raw scores. In order to allow comparability, which is essential to multi criteria evaluation, the criterion maps are standardized. Standardization allows comparison of criterion scores within one alternative, to come into some kind of trade-off when poor performance of the alternative under one criterion can be compensated by a high performance under another criterion. In order to make standardize and compatible raster features of all factors are reclassified by reclassify tool and the point features data were converted in to raster format using strait distance tool in spatial analyst. Total score for suitability is achieved by multiplying criterion score with its appropriate weight and adding all weighted scores.

The loose coupling multi-criteria decision making method relies on a file exchange mechanism which enables communication between two software's ArsGIS and IDRSI. Separate tasks are performed in either of software. GIS is used for performing land suitability analysis, the selected and reclassified or standardize raster files with their scores were exported in GEOTIFF/TIFF format to IDRSI. Thus imported on IDRSI and changed into IDRSI raster format. The decision support module is used for executing multi-criteria evaluation using pairwise method for all criteria/factors. Pairwise comparisons were analyzed to produce a set of weights for each criteria map.

3.6.1 Lodge site suitability analysis

One of the problems in decision theory of multi-parameter analysis is the determination of the relative importance of each factor. There are several techniques for assigning criterion weights; Analytical Hierarchy Process (AHP) was proposed by Saaty (1980) uses pairwise comparison method for criterion weighting. Suitable site selection for tourist lodge establishment involves pairwise comparison of seven criterion maps namely: land use land cover map, settlement map, wilderness campsite map, geology map, altitude map, slope map and river map of the study area. In developing the weights, every possible pairing was compared and the ratings have been recorded into a pair-wise comparison matrix (Figure 22 and Table 6). As the matrix is symmetrical, only the lower triangular half was to be filled in. The remaining cells were the reciprocals of the lower triangular half.

Pairwise Comparison files are stored in ASCII format. The first line contains the number of factors being compared, then each factor name follows, one per line, in the order they appear in the matrix. Each column and row is labeled with the name of the variables (in the same order across the columns as down the rows). In each cell one considers the relative importance of the row variable to its corresponding column variable. Fractions are entered in to the pairwise matrix to create comparisons also decimals is possible (i.e., entering 1/2 is the same as entering 0.5).

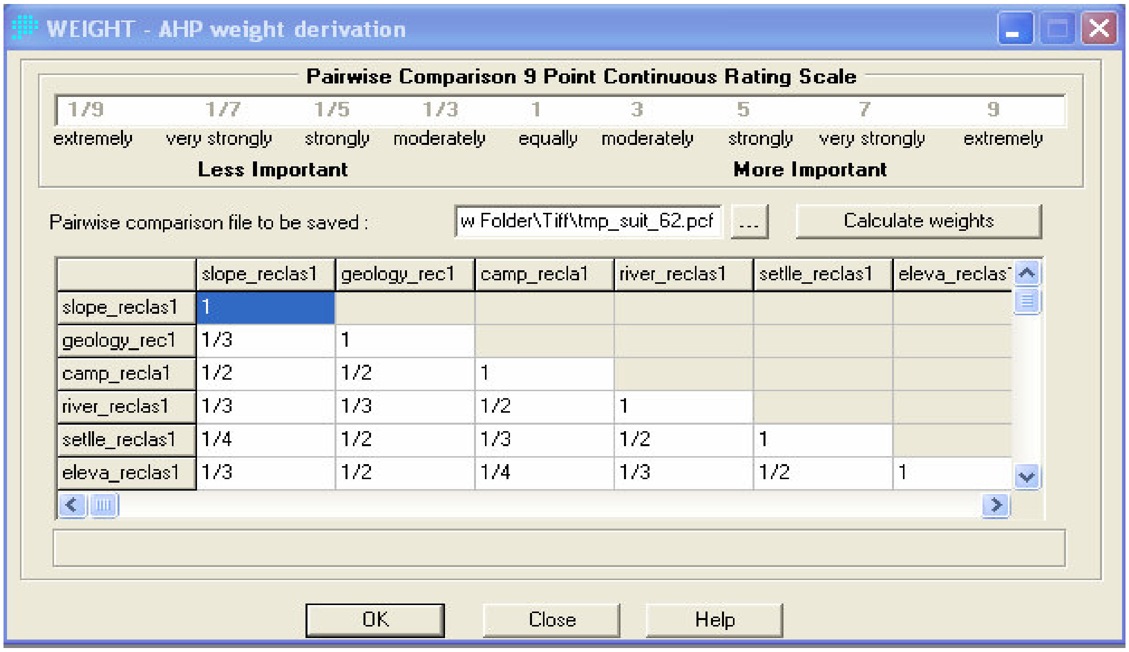

Figure 22. Pairwise comparison of factor maps

The software executed judgments were synthesized by summing the columns of the matrix, and the matrix normalized by dividing each column entry by the columns sum.. Then the arithmetic average of each row in the normalized matrix was computed. Because individual's judgment will never agree perfectly, the degree of consistency achieved in the ratings was measured by a consistency ratio (CR) indicating the probability the matrix ratings were randomly generated. The rule is that a CR less than or equal to 0.10 indicates an acceptable. In this study, the calculated consistency ratio result was 0.07, which is acceptable.

Table 6. Pair-wise comparison matrix for lodge suitability

	Slope	Geology	Wilderness campsite	River	Settlement	Elevation	Land use land cover
Slope	1						
Geology	1/3	1					
Wilderness campsite	1/2	1/2	1				
River	1/3	1/3	1/2	1			
Settlement	1/4	1/2	1/3	1/2	1		
Elevation	1/3	1/2	1/4	1/3	1/2	1	
Land use land cover	1/5	1/2	1/3	1/4	1/3	1	1

3.6.2 The scenic potential mapping analysis

Natural environments provide a range of recreational opportunities that is harnessed for ecotourism development. Ecotourism destinations are natural environments wherein recreational forms and structures evolve and develop around natural attractions. The potential of ecotourism destination to attract tourists is determined by location-specific characteristics of the environment of which landscape scenic attractions is one (Figure 21). Tourists usually visit particular locations because of some attraction or series of attractions. These attractions are either embedded in the geographical characteristics of localities in terms of their scenic qualities or else are socially constructed as discrete attractions. However, levels of landscape scenic attractiveness for these tourist attractions may vary according to an individual's gender, perception, cultural and ethnic background, socio-economic status, educational level, family situation, health, disability and/or age (Chhetri and Arrowsmith, 2008). Despite this fact this study predicts areas with good landscape scenic attractiveness potential based on various factors.

Derivation of predictors of scenic attractiveness using the biophysical characteristics of the geographical location is to be expected. To identify potential suitable sites for landscape scenic, four different criteria are identified namely, altitude, slope, land use land cover and river attractions.

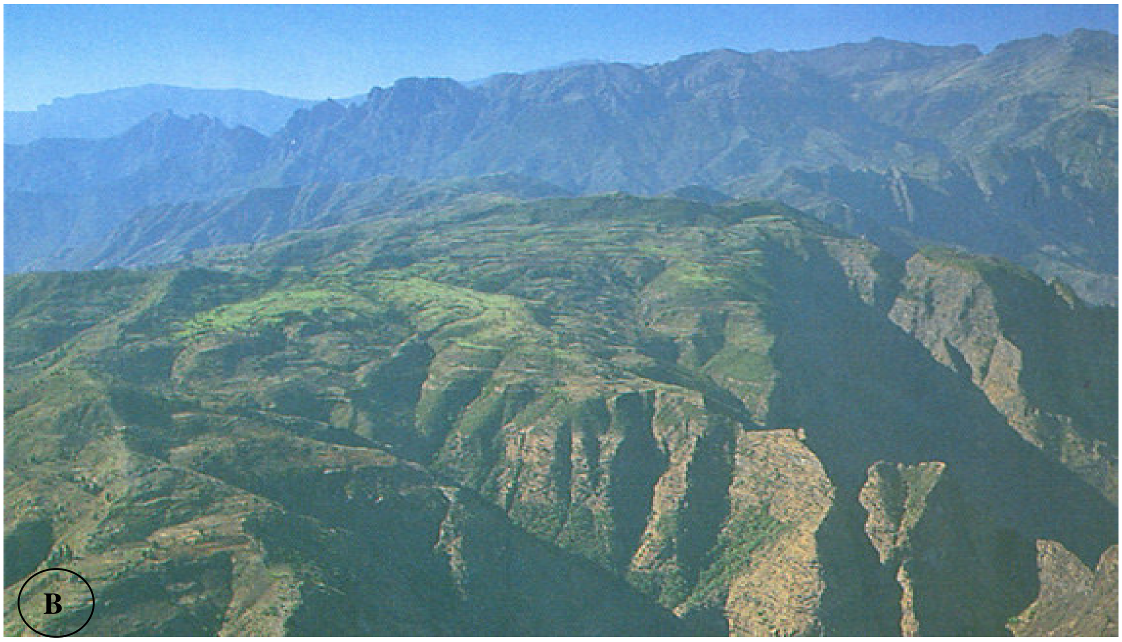

Figure 23. Partial views of scenery in BMNP

Table 7. Pair-wise comparison matrix for scenic attractiveness

	Elevation	Land use land cover	River	Slope
Elevation	1			
Land use land cover	1/3	1		
River	1/2	2	1	
Slope	4	3	2	1

The four factors were standardized and compute in IDRSI to get weights for each criterion. Analytical hierarchy process (pairwise comparison) method was involved to determine relative importance of the four criterions is depicted in Table 7. After pairwise comparison eigen vector of factor map weights is derived shown in Figure 24. The result shows that higher weight value is given to slope (0.45), elevation got the second weight (0.24), the third weight was for river (0.18) and the least weight (0.11) goes to land use land cover factor map. The consistency ratio of comparison was 0.05, which is acceptable. The resulting weights of factor maps were used in weight overlay evaluation on ArcMap to produce landscape scenic attraction potential map.

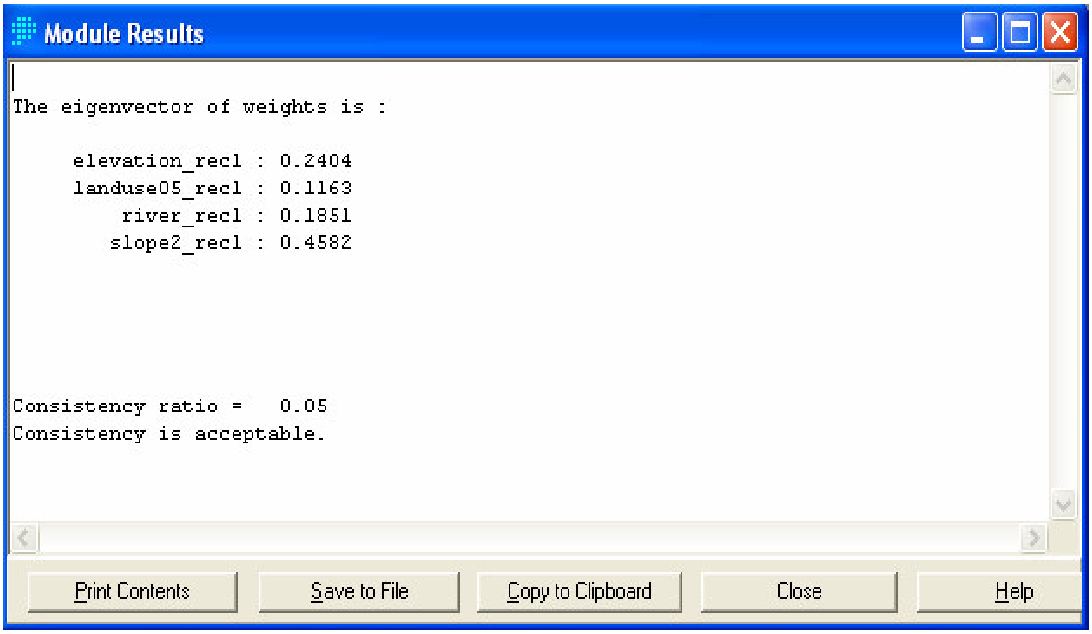

Figure 24. Eigen vector of factor map weights

4. Results and Discussion

4.1 Potential ecotourism sites

4.1.1 Identifying suitable sites for lodges

Different criterions are considered to evaluate site suitability. In order to compute overlay analysis to select suitable sites relative weights of each criterion is produced. Pair wise comparison of the 7 criterion was carried out to develop weights for each criterion; result of weight computed using pairwise comparisons for criterion is shown in Table 8. The derived factor weights are used for weighted overlay analysis. During weight overlay analysis the cell values of each input parameters were multiplied by the computed weight. The resulting cell values are added to produce the final out put raster. Then overall suitability was created; the result map is created 4 class of suitability. These suitability classes were assigned to their respective suitability classes on the basis of reclassified suitability classes during reclassification and multi criterion evaluation. When computing criterion reclassification and standardization; value 1 was given for higher suitability class and vice versa. Consequently higher raster value (4) indicates an area that is less suitable for lodge establishing, whereas lower raster value (1) indicates the area that is higher suitability for lodge establishing. Accordingly the 4 raster class created was assigned to their suitability class to produce suitability map; that are highly suitable, moderately suitable, suitable and not suitable (Figure 25). Most of the identified suitable areas for lodge fall in north and central part of the park.

Table 8. Factor weights derived by calculating the principal eigenvector of the pairwise comparison matrix

Factors	Weight
Slope	0.32
Geology	0.19
Wilderness campsite	0.18
River	0.12
Settlement	0.08
Elevation	0.06
Land use land cover	0.05

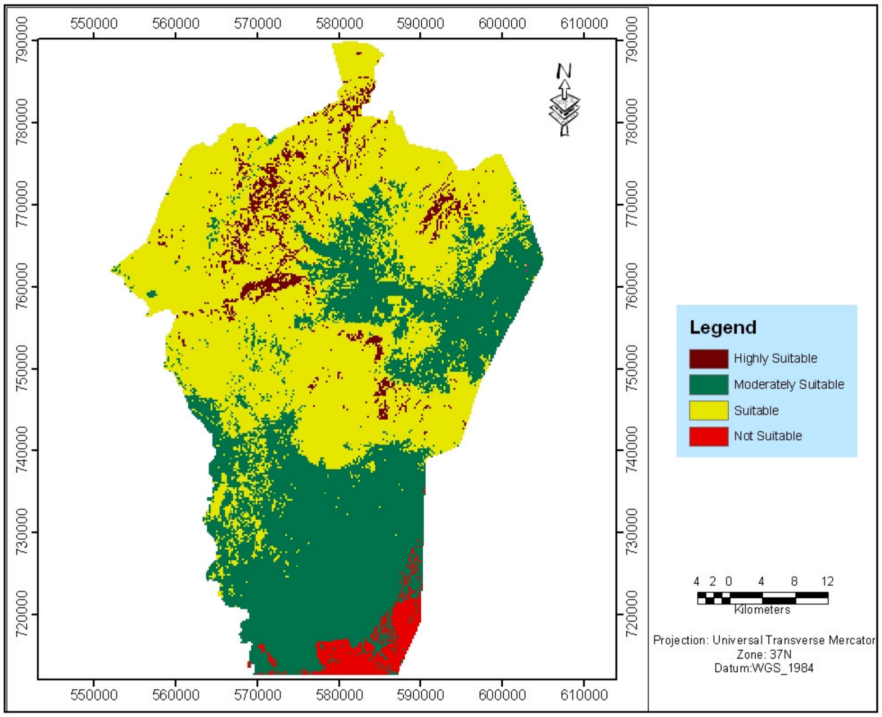

Figure 25. Lodge suitability map

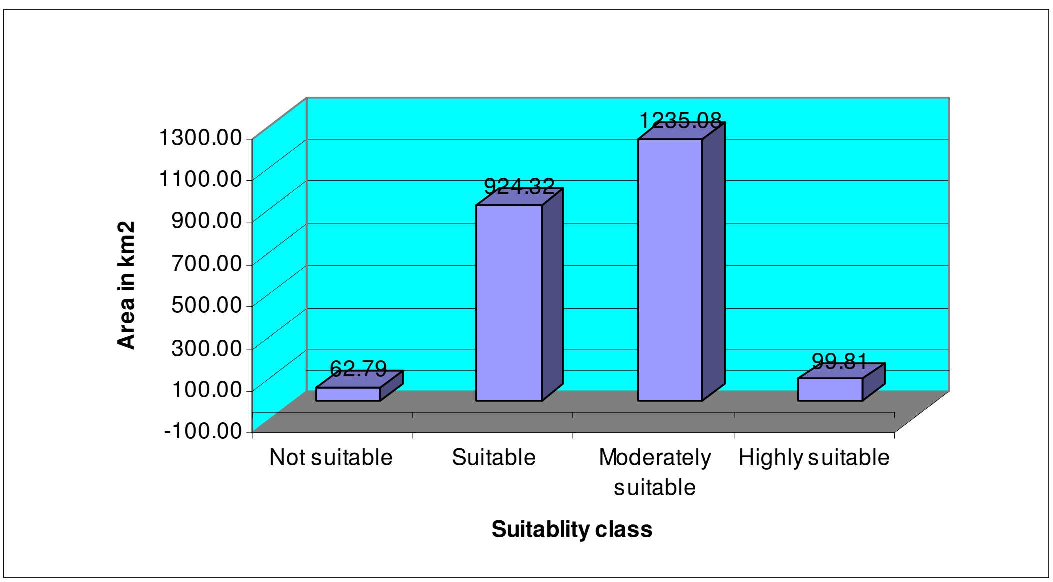

Figure 26. Loge suitability area coverage in km^2

Figure 26 indicates that result of area coverage hold in km^2 for each suitability class. Largest area is dominated by moderately suitable class (1235.08 km^2) where as least area coverage (62.79 km^2) is found in none suitable class.

From lodge suitability map (Figure 25) highly suitability class is extracted using conditional spatial analyst tool. The conditional tool allow for control of the output values based on conditions placed on the input values. The condition that was applied her was an attribute query to select the optimal lodge suitable sites. The result is shown in Figure 27 (A). As revealed in Figure 29 (A) there are many single cells representing optimal locations. These dispersed small cells are too small for the lodge site. Using the Majority Filter tool of ArcGIS these scattered small areas were cleaned up and removed. Then, filtered optimum suitable areas were converted from raster to vector data set inside a geodatabase (Figure 29.B).

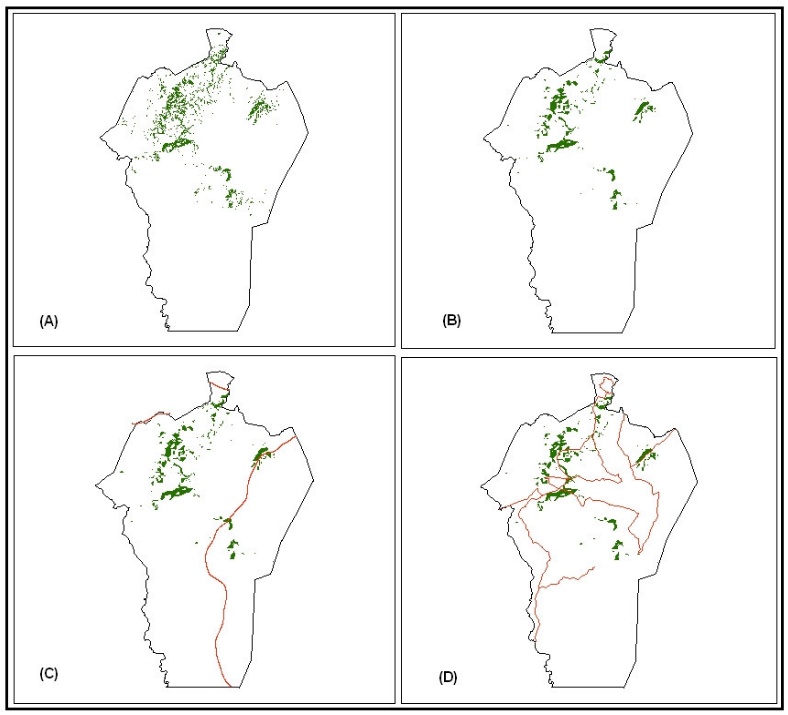

Figure 27. Potential high lodge suitable sites

All the locations in the optimum areas layer are suitable (Figure 29 A and B). Tourists are using either road or trekking route alternatives for their movement during visit in the park. Thus the lodge sites must have accessed either by road or trekking routes to be selected as optimum suitable sites. The road layer that passes through park boundary (Figure 29.C) and trekking routes of the park (Figure 29.D) was displayed on ArcMap with the created vector feature in the geodtabase that shown in (Figure 29.C). There are suitable areas for lodge sites that are not close to neither road nor trekking route; those areas area excluded. Using selection tool the optimum lodge suitable sites which are intersected by road and trekking routes were selected. Suitable site for lodge establishing that near to or crossed by road and trekking route are identified. Then locate the best suitable lodge sites, Figure 30 shows the final selected suitable sites.

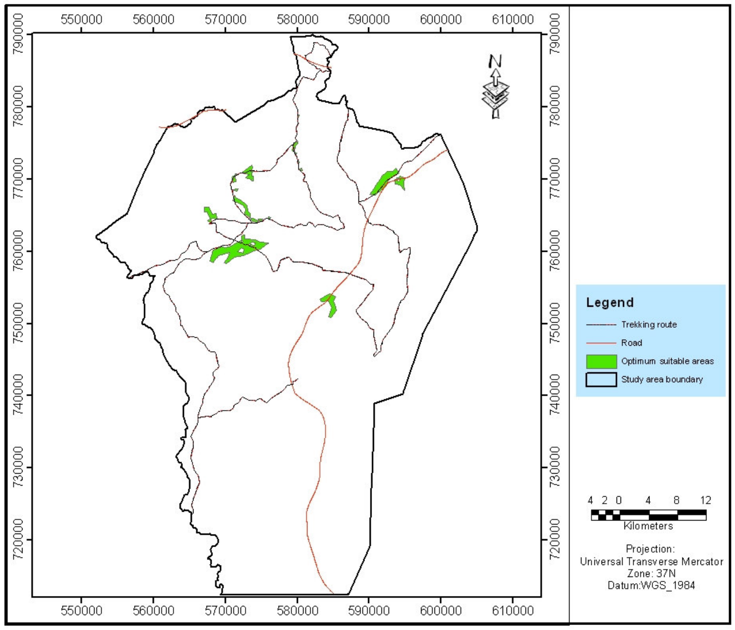

Figure 28. Selected lodge suitable sites map

The identified suitable sites accessed by trekking route are situated on woodland, bareland and grassland land use land cover type. Besides suitable sites accessed by road line is situated on grassland and erica land use land cover type. Bareland is ideal for establish tourist lodge facilities in the park.

4.1.2 Scenery mapping

For the function of mapping the scenery scenic potential areas in the park, this study focused on elevation, slope, distance from rivers and lad use land cover type as the criterions of scenery scenic in the study area. The overlay analysis was done after each factor was given the appropriate weight. The criterions were ranked by their weight, according to the degree of importance that they have for scenic potential. Pairwise comparison of the 4 criterion was carried out to develop the pair wise comparison matrix. Accordingly, the weight of factors in Table 9 was computed. After the overlay analysis of the 4 factors, the following scenery scenic map shown in Figure 29 is produced.

Table 9. Factor weights derived by calculating the principal eigenvector of the pairwise comparison matrix

No	Factors/Criterions	Weight
1	Elevation	0.24
2	Landuse lancover	0.11
3	River	0.17
4	Slope	0.48

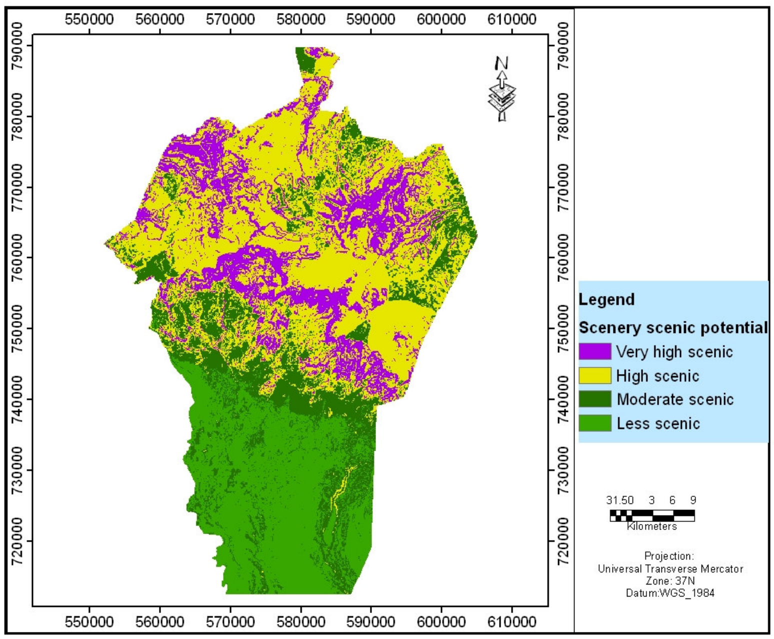

Figure 29. Landscape scenic potential

As it is shown in figure 29, very high scenic potentials are lies in the northeast, northwest and central part of the Bale Mountain National Park. The central parts that very have high scenic attractive areas are dominated by undulating and landscape which is dominated by erica type of vegetation. Some part the Northwest scenic areas are found along the main road from Addis to Bale. It has feature of steep slope and near to cliff land features are available with mountain peaks like Darkena 3899 m a.s.l. The northeast identified potential areas fall in to some part of the most known landscape of Bale Mountain National Park i.e. Sanete Plateau. Many mountain peaks like Batu Tiko (4000 m a.s.l), Wassema (4220 m a.s.l) and Archa'aan (4200 m a.s.l) are contained in this scenic potential area. The Worgona valley is also found in this area. In fact the less scenic class is dominated by Harena forest areas; this independently creates high forest scenic. However, land use land cover is used as one of the parameters for landscape scenic in this study as a result harenna forest area is not evaluated separately.

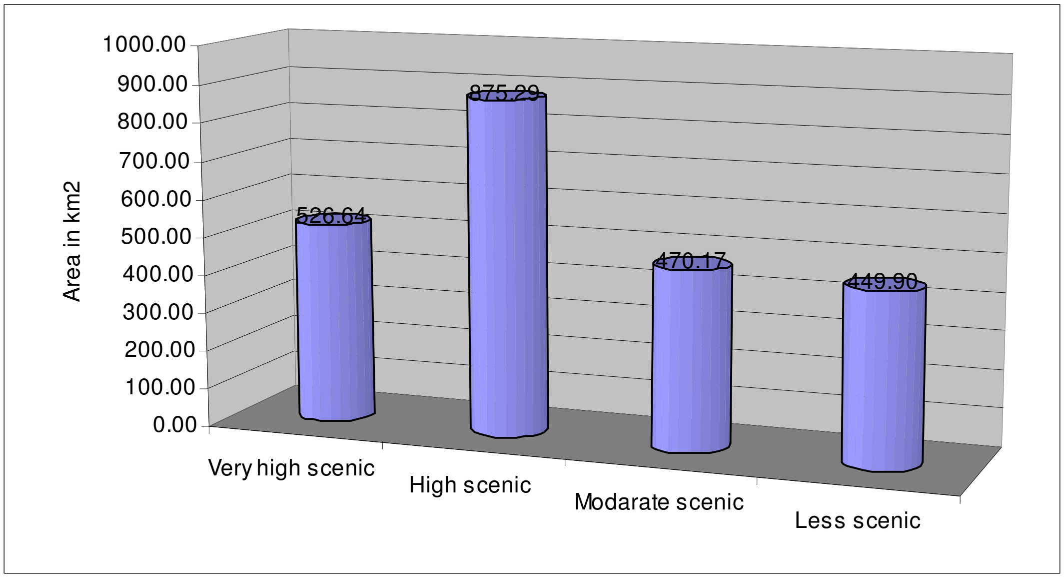

Figure 30. Landscape scenic potential area coverage in km^2

Figure 30 reveals that area proportion of landscape scenic result of a map. Very high scenic is occupying the largest share of area coverage (526.64 km^2) next to high scenic. Moderate and less scenic classes have 470.17 and 4490.9 km^2 of area coverage respectively.

5. Conclusion and Recommendations

5.1 Conclusion

The intention of this study was to assess the potential of scenery scenic (beauty) which is one of ecotourism attraction potential and analysis of suitable sites for establishing lodge to facilitate different services provision for tourists during their stay in BMNP.

MCE is done based on seven criterion (factor) maps to produce lodge suitability site analysis. These are land use land cover map, river map, settlement map, elevation map, slope map, geology and wilderness campsite maps. Land use land cover map is one of the factor map which was derived from Land sat ETM+ satellite imagery produced 6 land use land cover. Produced suitability map for lodge site have four classes of suitability: highly suitable, moderately suitable, suitable and unsuitable. Highly suitable sites were filtered and changed to vector data. While those areas accessed by road and trekking route are selected as final suitable sites. Also the landscape scenic map was produced four class of scenery scenic potential: very high scenic, high scenic, moderate scenic and less scenic.

The study has demonstrated the use of geographical information system and multi-criteria decision making framework in solving a spatial multi-objective problem of selecting suitable sites for lodge establishment and mapping the scenery scenic of Bale Mountains National Park; based on the stated objectives and criteria for the development of ecotourism industry. The suitability model allowed formal analysis factor weight and their spatial sensitivity for tourism facilities development. While the problem addressed in this study appears to have been essential, it demonstrates the applicability of MCE to similar but more complicated problems. The advantage of this methodology is that suitability analysis can easily be performed on the results by employing graphical user interface, which allows the decision-maker to decide.

The development of ecotourism is further enhanced by geospatial approaches; which have proved beneficial for supporting decision-making and planning tourism facilities and ecotourism resource for sustainable development; as ecotourism is an activity which strongly implies the geographical dimension and GIS is a technology specifically developed for the management and study of spatial phenomena. Moreover, tourism is a complex phenomenon involving besides its spatial dimension, social and environmental implications. Results from this study appear practically useful for tourism facilities development and ecotourism resource utilization.

5.2 Recommendations

- Additional research is needed to refine the suitability; the ecological sensitivity and risky areas should be identified considered as one factor in site suitability which is not included in this study due to absent of data

- Detail study of ecological value of the selected lodge suitable sites should be taken

- On the identified lodge suitable sites; the lodge be develop and managed in a basis that is sensitive to the principles of ecotourism and it is better implementation of environmentally sensitive architectural styles
- Map of the identified scenic potentials is needed to cheek with the reality on the ground before making any decisions

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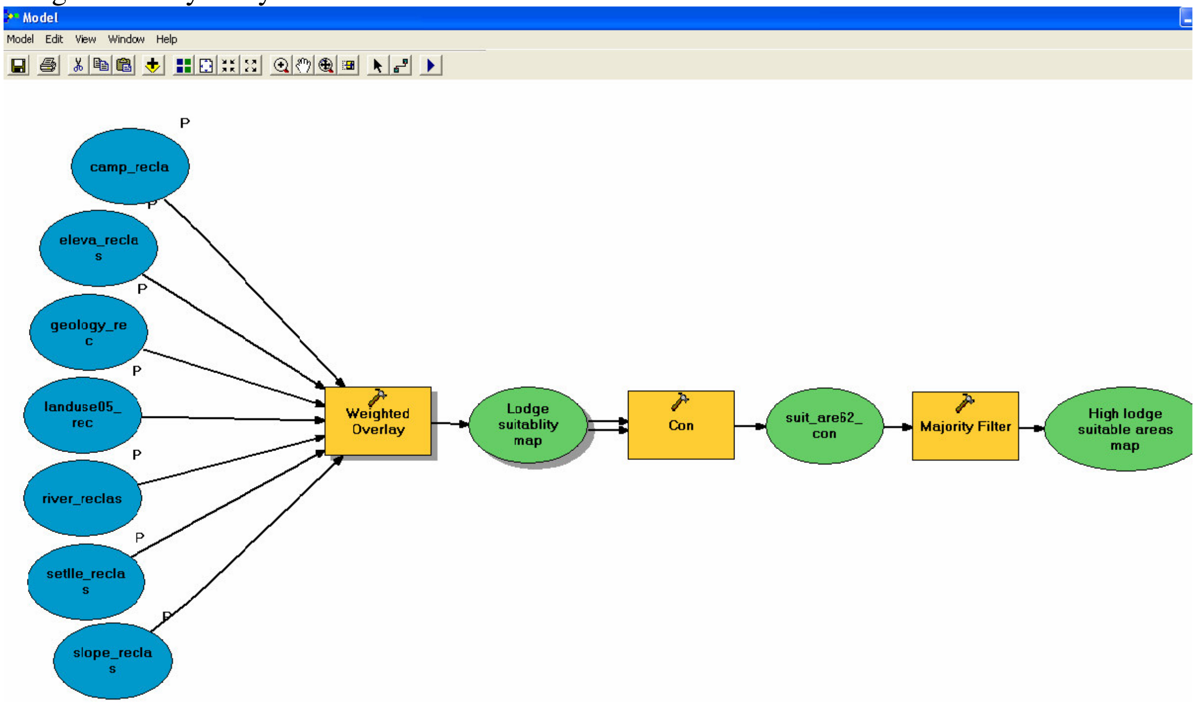
Appendix

Number of tourist arrival and revenue earned from BMNP

Year	Domestic Tourist	International Tourist	Total	Revenu erned in Birr
1994	610	790	1400	5500
1995	230	1289	1519	108764
1996	163	951	1114	55475
1997	179	1038	1217	84209
1998	894	1501	2395	144415
1999	259	1225	1484	103882
2000	1086	1068	2154	200959

Photographs from BMNP

Lodge suitablity analysis model



D E C L A R A T I O N

I here by declare that the dissertation entitled "***GEOSPATIAL APPROACH FOR ECOTOURISM DEVELOPMENT: ACASE OF BALE MOUNTAINS NATIONAL PARK, ETHIOPIA***" has been carried out by me under the supervision of Dr. K. V. Suryabhagavan, Department of Earth Sciences, Addis Ababa University, Addis Ababa during the year 2009-2010 as a part of Master of Science programme in Remote Sensing and GIS. I further declare that this work has not been submitted to any other University or Institution for the award of any degree or diploma.

Place: Addis Ababa
Date: June, 2010
Tewodros Kebede

C E R T I F I C A T E

This is certified that the dissertation entitled *"**GEOSPATIAL APPROACH FOR ECOTOURISM DEVELOPMENT: A CASE OF BALE MOUNTAINS NATIONAL PARK, ETHIOPIA**"* is a bonafied work carried out by Tewodros Kebede under my guidance and supervision. This is the actual work done by Tewodros Kebede for the partial fulfillment of the award of the Degree of Master of Science in Remote Sensing and GIS from Addis Ababa University. Addis Ababa.

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