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DEPARTMENT OF GEOGRAPHY AND ENVRONMENTAL STUDIES

GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING BASED SUITABILITY ANALYSIS OF URBAN DEVELOPMENT: A CASE OF JIMMA CITY, SOUTH WESTERN ETHIOPIA

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A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSITY, DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES IN PARTIAL FULFILLMENT OF THE REQUIRIMENT FOR THE DEGREE OF MASTER OF SCIENCE IN GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING

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This is to certify that the thesis prepared by **Kafalew Ensarmu** entitled as" Geographic Information System and Remote Sensing Based Suitability Analysis of Urban Development: The Case Of Jimma City, South Western Ethiopia." and submitted to Graduate studies of Jimma University, in partial fulfillment of the requirements for the degree of Master of Science in GIS and Remote sensing complies with the regulations of the University and meets the accepted standards with respect to the originality and quality.

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DECLARATION

This is to certify that this thesis entitled "GIS and Remote Sensing Based Suitability Analysis of Urban Development The Case of Jimma City, Western Ethiopia**"**, submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Geography and Environmental Studies with specialization in **GIS and RS** at Jimma University, department of Geography and Environmental Studies done by **Kefyalew Ensarmu** is an reliable work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for an award of any degree or diploma to the best of our knowledge and belief.

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ACRONYMS/ABBREVIATIONS

Amsl	Above mean sea Level
CSA	Central Statistical Authority
DEM	Digital Elevation model
GCP	Ground Control Point
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System
Ha	Hectare
Km^2	Square Kilometer
LULC	Land Use land Cover
RS	Remote Sensing
TIN	Triangulated Irregular Network
UN	United Nations

ABSTRACT

Site suitability analysis for specific project is the preliminary tasks in the context of modern urban land use planning and development. However, site analysis by its nature is the complex process. It involves consideration of multi-criteria decision making limited not only to physical condition of urban land-uses, but more attention should be given to integrate socio-economic and environmental factors. GIS based Multi-Criteria Evaluation (MCE) and Analytical Hierarchy Process (AHP) provides a wide range of powerful tools capable to transform, combine geospatial data with value judgments among conflicting criteria along with sets of alternatives. Nine factors such as landsatland-use/land-covers, river, slope, elevation, geomorphology, soil, road, aspect, and proximity to urban center were evaluated and prioritized as per judgment of urban planning experts. The influencing weight among factors has been computed using Analytic Hierarchy Process (AHP) in IDRISI 32 software. The overall Consistency Ratio (CR) of the module was 0.02% and fulfilled the tolerable threshold (CR ≤ 0.10). Finally, the Weighted Linear Combination (WLC) function of ArcGIS model builder has been applied to generate suitability map. Finding of the study clearly reveals that the city has dramatically grown in all directions in the last two decades Built-up area increased a lot in the last 20 years by consuming considerable amount of other land-use/land cover types. Result from suitability analysis shows that from the total area of Jimma City, about 1070.5ha (10.2%) of the land is grouped under suitable site; whereas majority of the city 6712.2ha (63.8%) falls under moderately suitable for urban development became categorized under suitable site for urban development. The critical importance of land for specified uses should be known either physical or economic suitability.

Keywords: *Land use/Land Cover, GIS, Urban Development, MCE*

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Urban expansion is one of the important areas of man's interaction with his environment with a great impact on the natural land cover. Urban areas describe a town, and a town is a place where people live and work, containing many houses, shops, places of work, places of entertainment, etc. Urban land as a part of the earth's surface has reasonably stable or predictable repeated activity and its suitability for agriculture; settlement and industry depend on its elements. Urban development suitability analysis is fundamental to land management decisions, planning, and utilization, providing a link between resources assessment and the decision-making process (Jahangeer et al., 2018). Land suitability for specific purposes is assessed by land-use suitability analysis. This decision-making process considers not only the natural attributes of the land but also its socio-economic and environmental features. In other words, land use decisions are based on complex, interrelated factors such as the characteristics of the land itself; economic conditions; social, environmental, and political constraints; and the objectives and needs of the land users (Mesfi, 2019). In the advancement of remote sensing and GIS, the identification of potential zone became very easy and economical (Scariah, 2016).

Site suitability is the method of understanding existing site qualities and factors that determined the location for a particular activity. It involves the detailed investigation of the natural resources and processes that characterize a site and include mapping techniques including GIS tools that help in processing the geographical database that displays the areas of the site, suitable for various planning objectives and alternatives (Misra, 2015). It is the usual practice of individuals, institutions, and organizations to undertake the task of searching for the optimal site for their intended projects such as a new school, a new bus terminus, or a new airport. GIS techniques offer an alternative approach that facilitates quick and easy remodeling for slight changes in sitting criteria and produces results as maps suitable for analysis and presentation (Misra, 2015).

Suitability analysis is used for planning, landscape designing, decision making, and analyzing different factors. It integrates different factors of an area such as location, physiographic, environmental processes, and development activities. Therefore, suitability analysis enables urban land administrators and municipal officers to make decisions and establish policies in terms of the specific land uses (Abebe, 2016). Using the principle of sustainable development, the environmental, social, and economic impacts can be managed to maximize positive impacts while minimizing negative effects. Urban planners use GIS in sustainable development research and decision-making (Rani et al., 2018). Guan et al., (2011); concluded that rapid urbanization, population boom, the level of economic status, and unplanned development activities are some of the major factors for the occurrence of urban development. However, the temporal-spatial pattern of urban development has not been carefully studied with the help of GIS and remote sensing in the study area. Therefore, the aim of this study is to find a suitable area for urban development of fast-growing Jimma city using GIS and remote sensing techniques.

1.2. Statement of the problem

Jimma city is one of the large regional economic communities in Oromia National Regional state. There is a sharp conflict between urban growth and limited land resources. Many studies concerning urban development management were conducted in this area, and most of them focused on monitoring urban sprawl, resources carrying capacity calculations or regional resource conservation problems. However, there is still lack of integrated urban land use planning for this area, leading to many socio-economic and eco-environmental consequences, such as disorganized urban development, unreasonable allocation of land-use types, and incomplete civil and environmental infrastructure (Praveen and Kumra, 2011).

Hence, there exists a definite spatial planning intervention for comprehensive urban development site identification in the city. However, there was still the debate exists on how to uphold effective urban land use planning in one hand, and maintaining proper natural resource conservation measures. The rapid progress made in modern geospatial science like GIS augmented with Multi Criteria Evaluation (MCE) techniques nowadays have been put forward with series of applications and capability to solve the complexity in any spatial decision making process (Merga, 2012).

Though several studies have been conducted in addressing urban development suitability using MCE integrated into Geographical information systems and remote sensing techniques in some towns of the country. For instances, (Mesfin, 2019, Seid, 2007 and Ayele, 2016) little research has been conducted in the study area. This study intended to fill the existing research gap by employing integrating GIS and remote sensing techniques with Multi Criteria Evaluation (MCE) through applying land use transfer matrix (LUTM) methods in Jimma city, south west Ethiopia.

1.3. Objectives of the study

1.3.1. General objective

The main objective of this study is to examine suitability for further urban development using GIS and Remote Sensing integrated with a multi-criteria evaluation technique in Jimma city.

1.3.2. Specific objectives:

- ⇨ To evaluate Land use/land cover change for the last two decades (2000-2020);
- ⇨ To identify the main determinant factors for urban development of Jimma City;
- ⇨ To evaluate urban development suitability by employing multi criteria evaluation techniques ;

1.4. Research questions

1. What is the extent of land cover changes from2000-2020 in the study area?
2. What are the main determinant factors for urban development Jimma city?
3. What are the criteria expected to be employed in the analysis of the suitability of urban development?

1.5. Scope of the study

Geographically, this study was conducted in Jimma city, south west Ethiopia. Potential factors influencing urban development doesn't include in the study which may be addressed in the future studies. Methodologically, this study was analyzes the suitable site for urban development, by applying geospatial techniques within the time horizon of October 2019 to September of 2021 academic year.

1.6. Limitations of the study

This Research work was limited to Jimma city Administrative. Not all this, but also there was many limitation in which researcher face challenge during the researching period. Those were problem of dysfunction of internet, absence of aerial photographs of intended years and high quality of the satellite image of the intended years and months. Time shortage due to there were others class for two courses in 1st semester, financial weakness for ground control data collection and so on were others limitation.

1.7. Significance of the study

The research may contribute to generate the suitable site for urban development in Jimma city. The outcomes of this study will benefit decision makers who are involved in incorporating urban planning into policies, government and nongovernment organizations, urban planners, policy and decision makers and researchers for further activities as well. It may also be source of information for further study in same or other studies. Identifying and analyzing the biophysical characteristics of vegetation which may help urban planning to improve quality of life in city.

1.8. Organization of the thesis

This study consists of five chapters. Chapter one presents background to the study, statement of the problem, objectives, research questions, significance, scope and limitations of the study. Chapter two reviews the theoretical and empirical literature. Chapter three gives description of the study area and details the methodology. Chapter four presents and discusses results of the study. The final chapter presents the conclusions and recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Concept of urban and urbanization

Urban is one in which large numbers of people are clustered together in very small areas called towns and cities. "Urbanization is a process of population concentration. It proceeds in two ways: the multiplication of points of concentration and the increase in size of points of concentration". The physical growth of urban areas can be explained demographically and functionally. While demographic definition of urbanization is restricted to factors such as population size and density, the economic functional definition refers to the territorial concentration of productive activities (industries) rather than population (Oluwasola 2007).

Urbanization is a form of metropolitan growth that is a response to often random sets of economic, social, and political forces and to the physical geography of an area, through which, the productive agricultural lands, forests, surface water bodies and groundwater prospects are being irretrievably lost. Rapid urbanization in the world is quite alarming especially in developing countries (UNFPA, 2007).

Information on accurate urban growth is of great interest in urban and suburban areas for diverse purposes, such as urban planning, water and land resource management, market analysis & service allocation. In the last decade, more attention has been paid to urban change as the impact of human behavior is affecting urban ecosystems. Research efforts concerned with detection and modeling of remotely sensed land cover/land use dynamics in developed countries tend to concentrate on changes driven by urban growth, particularly in large (Jat *et al.,* 2008).

Metropolitan areas growing cities are creating an alarming situation in respect of land use, lack of proper amenities, loss of agricultural land and infrastructure facilities in all countries of the world. Percentage of the world urban population is growing day by day due to wiliness of living in urban. If urban population will be grown in this way then next century will be the first urban century (Manonmani *et al.,* 2012).

2.2. Urban development in Ethiopia

The Western development trajectory has elucidated that urbanization occurred as a result of industrial development with subsequent demand for labor and growth in demand for more varied goods and services. However, in Ethiopia, agricultural productivity has not taken off and the country is still facing a major obstacle due to constraints of geography and transport, and natural resource limitation in terms of declining soil fertility and economic feasibility of exploiting water for crops. This means that the urban economy lacks an optimistic source of domestic demand from the hinterland although they have access to the wealth of basically unskilled labor with low purchasing power. National development strategies should, therefore, be built on factors that promote the virtuous circle of rural and urban development. Hence, the country's development policies and strategies are geared towards this end. PASDEP is the country's guiding strategic framework for the five-year period 2005–2009 (PASDEP, 2002).

PASDEP carries forward important strategic directions pursued under the Sustainable Development and Poverty Reduction Programmed (SDPRP) related to infrastructure, human development, rural development, food security, and capacity-building and also embodies some bold new directions. The foremost among them is the major focus on growth in the coming five-year period with a particular emphasis on greater commercialization of agriculture and enhancement of private sector development, industry, urban development and scaling-up of efforts to achieve the Millennium Development Goals (MDGs). Public investment in infrastructure to increase the productivity and purchasing power of urban centers can be more favorable to agriculture than are export oriented policies (Mary, 2003)

Investment in roads linking rural and urban areas plays a significant role in creating physical and economic linkages. For example, physical linkages like transport networks help in bringing agricultural products to market at cheaper cost. They also create mobility of people, capital, goods, and services between urban and rural areas. Economic linkages between urban areas and rural areas are urban centers offering markets for rural products and rural areas serving as markets for goods and services produced in urban areas. The urbanization of poverty has become a major global concern, when rapid urbanization is taking place at ever-accelerating rates in developing countries. In many countries of the world, a tremendously large majority of their population will soon be living in urban centers. Ethiopia is the least urbanized country in the world. However, today, Ethiopia's urban population growth is among the highest in the world.

This is accompanied by increasing poverty, a high unemployment rate, low governance capacities, weak infrastructure and poor municipal finance in cities. Nevertheless, Ethiopia's urbanization is not only a challenge, but is also an opportunity. It offers huge potential for the development of the country as a whole: well-managed cities contribute to reduce poverty through economic diversification and innovations, growing markets and the potential for urban rural linkages (Samson, 2004).

2.3. Nature of growth driven urbanization

Growth-driven urbanization is a result of the productivity of manufacturing firms and an increase in trad-able services. Manufacturing firms and tradable services are much less land intensive than agriculture and they have the potential of spatial concentration for various reasons including lower transportation costs, access to natural resource inputs and increasing returns (WDR, 2009). Both sectors can absorb the surplus labor in rural areas. Manufacturing productivity not only increases employment growth, but also stimulates the agricultural productivity through supply of inputs and relief of labor burden. Tradable services are distribution services that have lower transportation costs and relatively high consumers of the service and this sector can absorb growing rural labor force as the trade increases (Deng *et al*., 2008).

2.4. Context of urbanization and population growth in Ethiopia

In Ethiopia the demographic transition (with mortality rates falling first, and fertility rates falling subsequently after a period of very rapid population growth) and the urban transition (with populations becoming increasingly urban) have coincided in time. The demographic transition has started since the 1950s, while rapid urbanization began since the 1960s. When the rapid phase of the two transitions overlaps a high urban growth, rates are experienced as we shall see later. Ethiopia is now on the onset of a demographic transition. Since the beginning of the 20th century, Ethiopia is experiencing a high natural population growth rate compared to the previous long periods where there was virtually no long-term population growth due to very high and varied birth and death rates. Population had grown more than five times since 1900, three times since 1955 and had doubled since the early 1970s. By the year 2008, the total population of the country was 79 million, second most populous country in sub-Saharan Africa after Nigeria. Each year an estimated 2 million persons are added to the population. According to the projection made by CSA, the population increases at a rate (CSA, 2007).

The rapid urban growth in major cities poses enormous opportunities and challenges for the future sustainable development of a country. For instance, large cities are expected to be centers of innovation and wealth creation and need more resilient infrastructures and services resources as compared to smaller cities (Zhang *et al.*, 2016). This development, however, also draws energy and materials from distant and nearby ecosystems. Currently, more than 54 percent of the world's inhabitants are living in urban regions.

2.5. Land use/land cover Dynamics

Land is the major natural resource that economic, social, infrastructure and other human activities are undertaken on. Thus, changes in land-use have occurred at all times in the past, are presently ongoing, and are likely to continue in the future (Lambin *et al*., 2003; Moser, 1996). These changes have beneficial or detrimental impacts, the latter being the principal causes of global concern as they impact on human well-being and safety. For instance, deforestation and agricultural intensification are so pervasive when they aggregate globally and significantly affect key aspects of Earth Systems (Zhao *et al*., 2006).

Land cover is a biophysical characteristic which refers to the cover of the surface of the earth, whereas land use is the way in which humans exploit the land cover. LULC changes are caused by natural and human drivers, such as construction of human settlements, government policies, climate change or other biophysical drivers (Lambin *et al*., 2003; Kiros, 2008).

In response to the increasing demands for food production, agricultural lands are expanding at the expense of natural vegetation and grasslands (Lambin *et al*., 2000). These changes in land use/land cover systems have great impact, among others, on agro-biodiversity, soil degradation and sustainability of agricultural production (Lambin *et al*., 2003).

Throughout the world processes related to urbanization, development of transport infrastructures, industrial constructions, and other built-up areas, are severely influencing the environment, and are often modifying the landscape in an unsustainable way(McCormick *et al*., 2004).In many cases land-use activities go hand in hand with substantial modifications of the physical and biological cover of the Earth's surface, resulting in direct effects on energy and matter fluxes between terrestrial ecosystems and the atmosphere. For instance, the conversion of forest to cropland is changing climate relevant surface parameters as well as evapotranspiration processes and carbon flows. In turn, human land-use decisions are also influenced by environmental processes. Changing temperature and precipitation patterns for example are important determinants for location and intensity of agriculture. Due to these close linkages, processes of land-use and related land-cover change should be considered as important components in the construction of Earth System models (Schaldach *et al*., 2009).

The landscape concept used to map and assess LUCC allows us to explain relationships between Land-use practices and land-cover patterns, and considers land-cover change as driven largely by land-use types. For different-scale LUCC investigations, the landscape methodology is used on the base of remote sensing data of different spatial and temporal resolution, as well as conventional thematic maps and in-field data, to explain relationships between current land-use practices and land-cover patterns (Milanova *et al*., 2007).

2.6. Application of Remote Sensing and GIS on Land Cover Dynamics

Remote sensing is a science and art of obtaining information about an object or phenomenon without any physical contact with the object and thus in contrast to site observation. It is defined as the use of electromagnetic radiation sensor to record images of the environment which can be interpreted to yield useful information while GIS is a computer based system which used to capture, manage, analysis and interpret data in land cover dynamics study (Samuel *et al.,* 2009). Relating the quantitative remote sensing data with social science analysis and socializing the pixels is the main challenge in land use land cover change studies. But GIS enable us to understand the determinants of land use land cover change and to understand the cause-effect relationship between the change and the driving forces of the change (Mugagga, 2011).

GIS data bases are used to improve the extraction of relevant information from remote sensing imagery, where as remote sensing data provide periodic pictures of geometric and thematic characteristics of terrain objects, improving our ability to detect changes and update GIS data bases (Janssen, 1993 Satellite imagery provides a good source of data for performing structural studies of land space. Simple measurements of pattern such as the number, size and shape of patches can indicate more about the functionality of land cover type than the total area of cover alone (Janssen,1993).

2.7. The role of GIS and remote sensing in urban development

RS and Geographic Information system (GIS) is a novel technology widely used to survey the land use problem. The GIS adopts the numerical methods and spatial analysis tools to delineate the land use. The methods can yield the same results after repeatedly applying the same procedures. Moreover, they reduce the manpower and time consumption for the delineation of land use. In contrast with the manual methods, the GIS is the most economic and objective methods. They can be used separately or in combination for application in studies of urban sprawl. In the case of a combined application, an efficient, even though more complex approach is the integration of remote sensing data processing; The applications of Remote Sensing and GIS in urban studies at present is giving more weight on the acquisition of urban land use information and the comparison on the urban sprawl spanning most recent several decades, giving an image that remote sensing and GIS applications are located in the dynamic monitoring of urban growth only, therefore only in a few cases, we see GIS technology are applied in empirical analysis on the urban spatial structure (Barnes *et al.*, 2001).

2.8. Application of GIS and remote sensing in suitability analysis

GIS has been applied in many disciplines including geography, forestry, urban planning, and environmental studies. Particularly, in suitability analysis, GIS has a great role in multi criteria decision making process (Malczewski, 2006). Suitability analysis is built upon the concept of multi-criteria evaluation. Multi-criteria decision making (MCDM) or multi-attribute decision making (MADM) techniques involve the evaluation of several criteria or datasets to meet a specific objective (Eastman *et al.*, 2006). In MCDM process, criteria or datasets are examined for assigning relative ranks and individual feature weights based on the land use type for which suitability being examined. Weighted summation is sufficiently straightforward to use GIS data. It will be incorporated into the land-use suitability analysis.

The suitability analysis process requires the identification of the appropriate locations for a particular land use activity by considering physical resources (elevation, slope, aspect, climate), natural resources (soils, Geomorphology, hydrology, vegetation and wildlife habitat and environmentally sensitive areas), and existing land use and development of man-made facilities such as transportation systems, existing urban areas, and utility networks(Kuldeep, 2013).

2.9. Land suitability classification

According to FAO (2007) land suitability classification is divided into order, class, sub-class and unit. Land suitability orders indicate whether the land is assessed as suitable or not suitable for the use under consideration. There are two orders represented in maps, tables, etc. by the symbols S and N respectively. Order suitable land on which sustained use of the kind under consideration is expected to benefits, without unacceptable risk of damage to land resources. Order not suitable land which has qualities that appear to preclude sustained use of the kind under consideration; Land suitability classes reflect degrees of suitability. The classes are numbered consecutively, in sequence of decreasing degrees of suitability within the order. Within the order suitable the number of classes is not specified. There might, for example, be only two, S1 and S2. The number of classes recognized should be kept to the minimum necessary to meet interpretative aims. Class S1 highly suitable land having no significant limitations to sustain application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level; Class S2 moderately suitable land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land. Class S3 marginally suitable land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, this expenditure will be only marginally justified.

Within the order not suitable, there are normally two Classes. Class N1 currently not suitable land having limitations which may be manageable in time, but which cannot be corrected with existing knowledge of current acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner. Class N2 permanently not suitable land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in the given manner. The Subclasses are a more detailed division of classes based on land quality and characteristics (soil properties and other natural conditions). For example, Subclass S3rc is land that is marginally suitable due to rooting condition (rc) as the limiting factor. Land suitability units are subdivisions of a subclass. All the units within a subclass have the same degree of suitability at the class level and similar kinds of limitations at the subclass level. The units differ from each other in their production characteristics or in minor aspects of their management requirement often defined as differences in detail of their limitations. Their recognition permits detailed interpretation at the farm planning level. Suitability units are distinguished by Arabic numbers following a hyphen, e.g. S2e-1, S2e-2. There is no limit to the number of units recognized within a subclass.

CHAPTER THREE

3. METHODS AND MATERIALS

3.1. Description of the study area

3.1.1. Location

Jimma city Administration is one of the oldest and historic cities in Ethiopia. It is found in Oromia National Regional State, in Jimma zone (Fig. 1), located 352Kms to South- west of the Ethiopian capital, Addis Ababa. Geographically, the city is located at between 7º37′30″N latitude to 7º43′30″N and 36º48′0″E to 36º 52′30″E longitudes. Jimma City is the most important city in Southwestern Ethiopia and the study area has been chosen because of the fast rate of urbanization and informal settlement and little study were made on it (Abebe *et al.*, 2019).

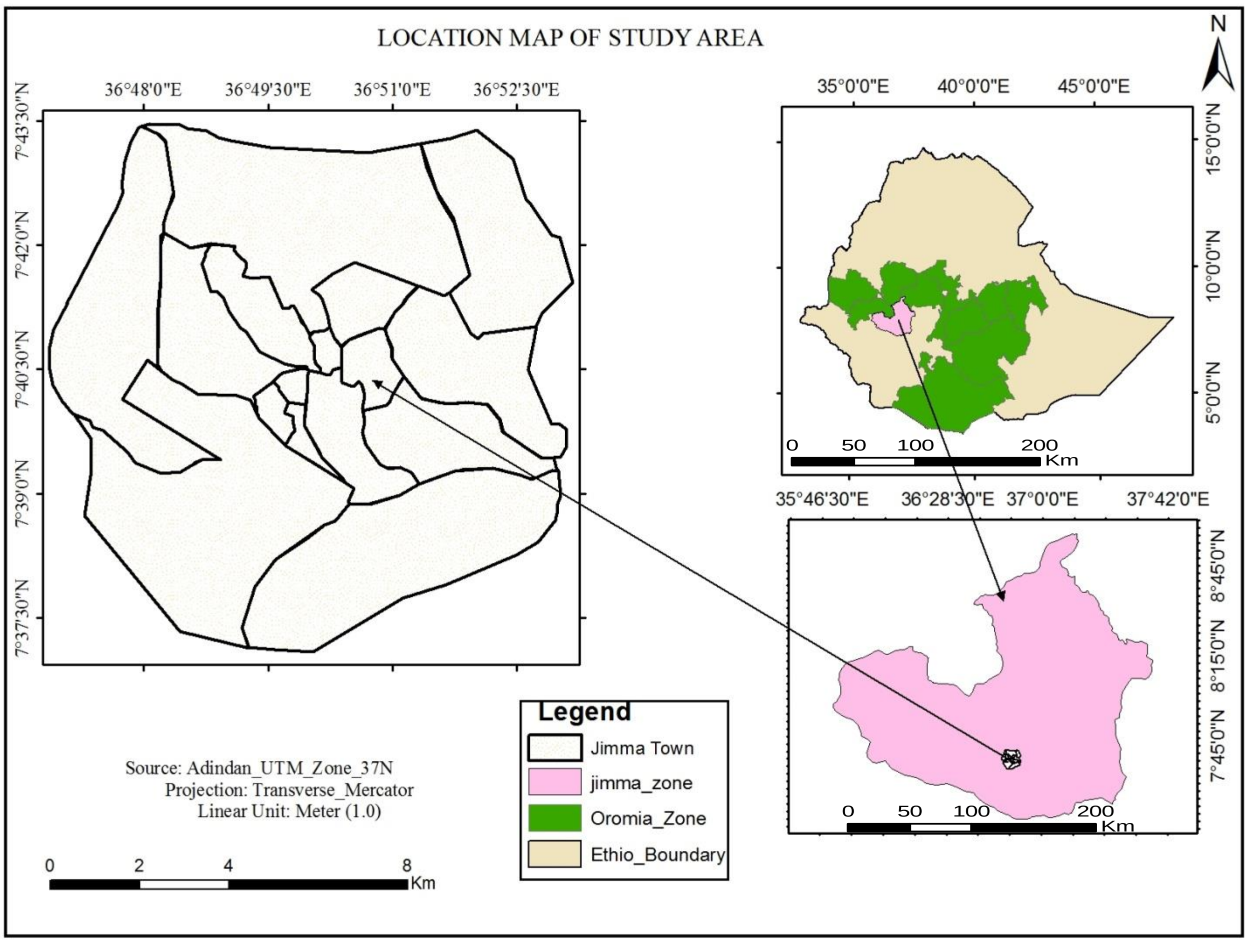

Figure 1: Location Map or the Study Area (source: Ethio GIS, 2021)

3.1.2. Topography

Jimma city is characterized by a hilly/ sloping landscape. Its major part, including the central, southern, and western parts, is characterized by flat to gently sloping topography. The elevation of the town boundary and its peripheries range from around 1700 masl in the south/along the Gilgel the Gibe River to over 2000 masl in the northern periphery of the town, i.e. in the Jiren area (Bedele, 2010).

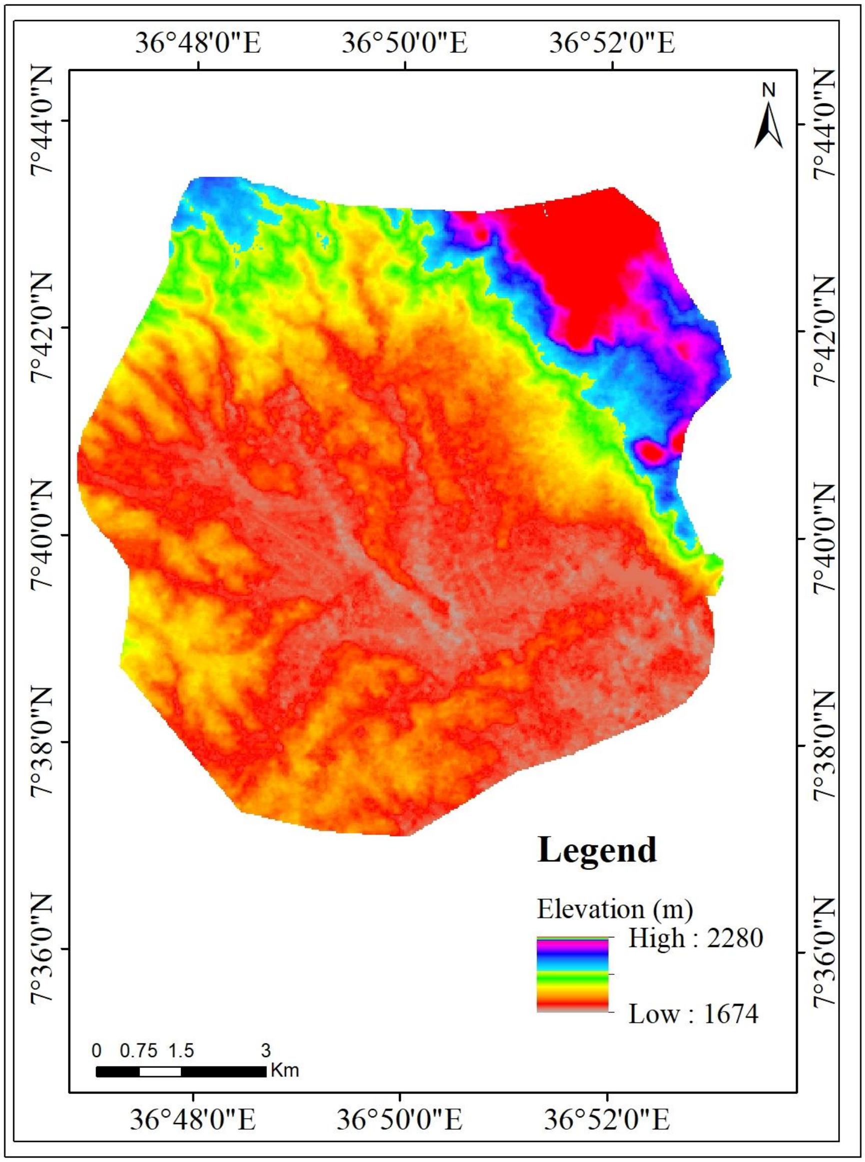

Figure 2: Topographic map of Jimma City (Extracted from ASTER DEM 30m)

3.1.3. Climate

Rainfall

Jimma city is characterized by temperate humid climate that has high precipitation, warm temperature and long wet period. The mean annual rainfall in the area is around 1500mm and annual potential evaporation is about 1465mm. The rainfall pattern shows major seasonal variation ranging from mean monthly rainfall of about 38mm in January to 229 mm in August. The main rainy season extends from June to September (Bedele, 2010).

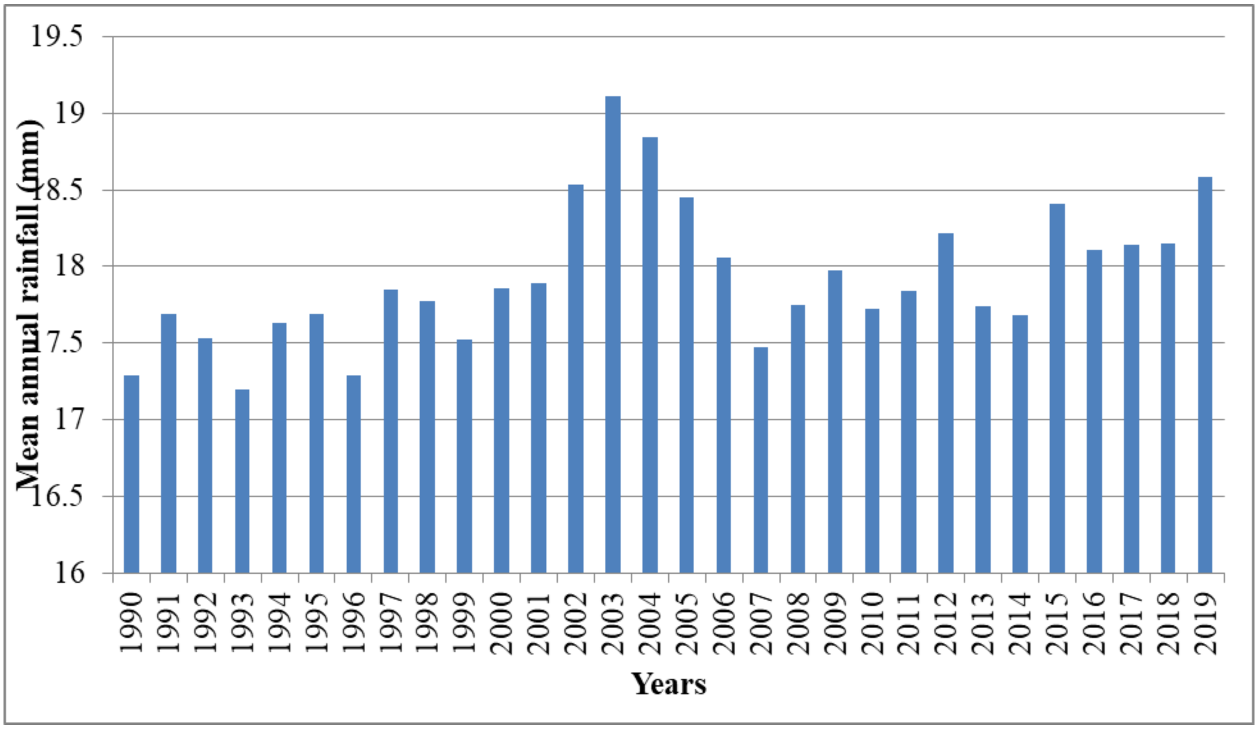

Figure 3: Annual rainfall of Jimma City

Source: (Computed from NMA, 2020)

Temperature

The mean temperature is between around 12^{o}c and 29^{o}c with the mean daily temperature of 19.5^{o}C. Temperature variation is observed among seasons with the warmest season extending from February to April and the coldest season from November to December 2^{0}c to 5^{0}c.

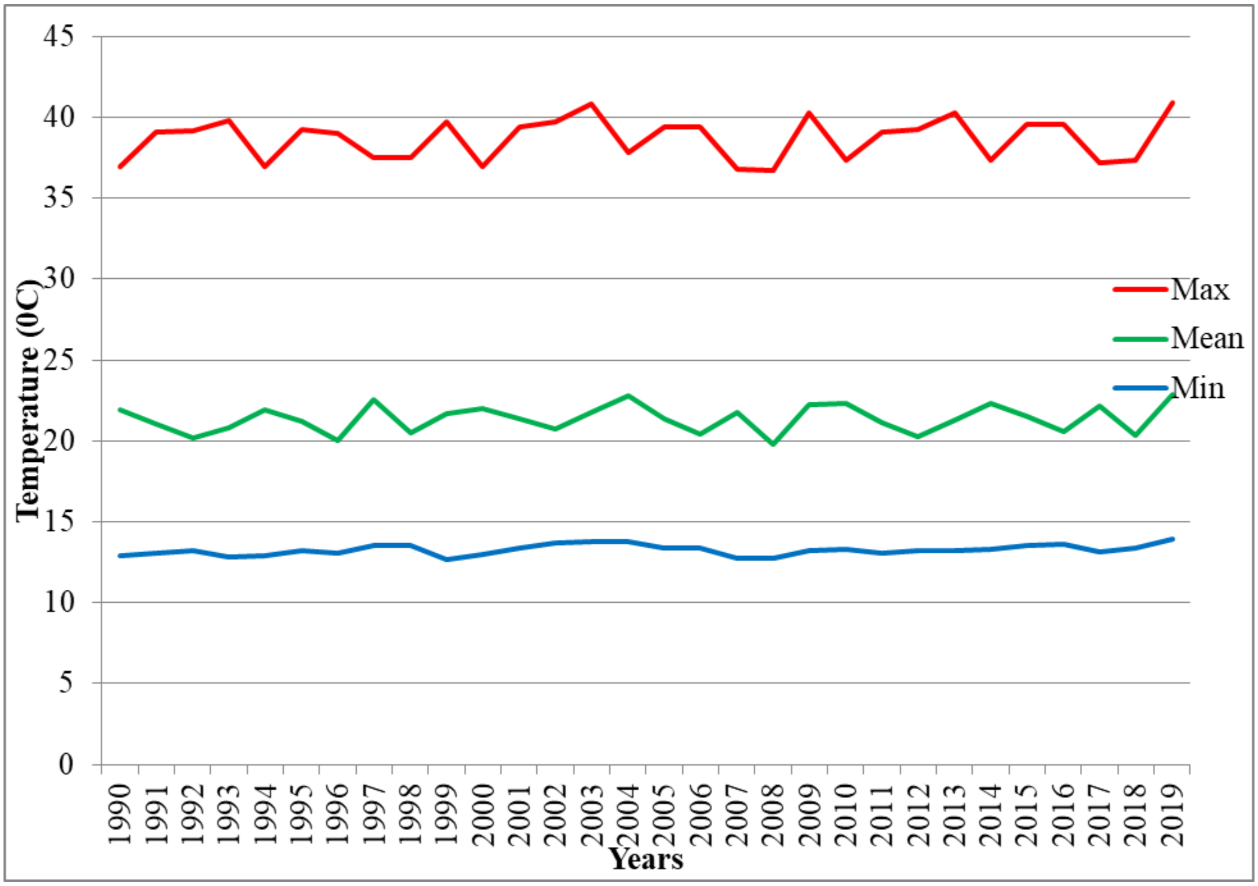

Figure 4: Minimum, Mean and Maximum Temperature of Jimma City

Source: (Computed from NMA, 2020)

3.1.4. Population

The city has a total population of 195,443, of whom 97,629 are men and 97,814 women with an area of 100.2 km^2. According to the 2013 projected estimate figure of Ethiopian central statistical Agency, the total population of Jimma city is 155,434 with 3.65% annual growth rate. As is true for other urban centers of the country, Jimma city consists of heterogeneous population in terms of ethnic groups. In view of this, Oromo, Amara, Dawro, Gurage and Kafficho are the five major ethnic groups living in Jimma city (Central Statistical Agency of Ethiopia, 2017).

3.2. Research design

To conduct this study, explanatory research design with Different methods MCE including GIS and remote sensing with the application of both qualitative and quantitative approaches was used. The reason for using this method was to compare the results from two different perspectives as relying on quantitative methods alone can hide important facts obtained from qualitative methods (Johnson and Onwuegbuzie, 2004).

3.3. Data Sources and types

Different data sources were refereed to analyze the land suitability analysis for urban development of the study area. The Landsat data was classified from satellite images of 2000 ETM+ and Landsat 8 OLI/TIRS of the year 2020. Normal ground verification work was carried out using Google Earth/GPS in order to identify the land use/land cover types and collect the point of the Urban Center of the study area.

Table 1: Data sets and sources

Data set	Sources
Soil	Ministry of Agriculture of Ethiopia
Elevation (DEM)	Downloaded from earth explorer website (USGS)
Geomorphology	Ministry of Agriculture of Ethiopia
Aspect	DEM data
Urban center	GPS from center of Jimma city
Slope	DEM data
Landsat	Landsat images of 2000 and 2020 was downloaded from USGS
River proximity	was generated from ASTER DEM 30m
Road proximity	Developed by digitizing open street map

3.4. Data collection

For two years, a high-quality cloud-free image was selected full scenes. The season of the year was preferred to get cloud-free images for ease of classification and facilitate comparison in classification activities. Google Earth (time slide) has also been used for preliminary interpretation of the historical imageries of the City. Necessary data including Landsat images of NASA, soil, Geomorphology, other different data were extracted from secondary data sources including ASTER DEM.

3.5. Software's and their uses in processing

Table 2: Software and uses

S/no	Types of Software used	Uses
1	ArcGIS software	For factor map development and LU/LC change
2	ERDAS IMAGE 2015 software	For satellite image processing
3	IDRISI selva 32	For weight module determination

3.6. Data Analysis

In order to detect land use/land cover in Jimma City during the years, 2000 and 2020 Landsat images were converted to a thematic map. Also, to investigate their relationships with the spatial patterns of land surface temperature, visible and near-infrared bands of ETM+ and OLI/TIRS images were used for classification of the land use/land cover types using a maximum likelihood algorithm. The supervised classification method using maximum likelihood classifier (MLC) became one of the most commonly used classification methods for Landsat imagery (Pire and Morgenroth, 2017).

The data from different sources were analyzed using software such as ERDAS Imagine 2015 and ArcGIS 10.3. A post-classification comparison was employed to perform LULC change detection (Yang et al., 2012). The land-use change matrix was produced, which showed quantitative data of the overall land use/land cover changes between 2000 and 2020 in the study area.

Classification is not complete until a satisfactory level of accuracy is achieved (Lillesand et al., 2008); thus, an error matrix was performed to assess classification accuracy. Accuracy assessment was carried out with the following procedure. Firstly, for each year image, 12 samples for each land-use class were selected from Google-earth images using a random stratified method to represent different land use/cover classes of the study area. Therefore, in this study a total of 60 reference data points from each year were collected which was used for classification and accuracy assessments, respectively. Then after classification, accuracy measurements (user and producer accuracies) were derived from the error matrix in percentage (Eq.1 and 2).

Kappa coefficient (Khat) is a measure of the agreement between two maps taking into account all elements of error matrix (Anand, 2018). It was used to evaluate the actual and a chance agreement between reference data and land use/cover class. Overall accuracies was computed by summing the number of pixels was classified correctly (diagonal numbers) then dividing them to the total number of pixels. User's and producers accuracies were computed by dividing the numbers of pixels that was classified correctly in each category (diagonal entries) divided by the total number of pixels that was classified in that category of row total and in same category of column total respectively. To test LULC classification accuracy multi-variety statistical measure was determined and selected for each time periods by applying the formula given below (Eq. 1).

$$OAC = \frac{\Sigma Xij}{N} * 100 \quad \text{...(1)}$$

$$Khat = \frac{(Obs - exp)}{(1 - Exp)} \quad \text{...(2)}$$

Where: OAC= over all accuracy,

PAC= producer accuracy,

UAC= user accuracy,

X_{i+}= the column total, and

K_{hat}= Kappa statistics,

X_{ij}= the diagonal values,

N= total number of samples,

X_{+i}= row total and obs=is (OAC),

r= the number of categories,

Exp = correct classification.

The present study attempts to introduce decision support system used for site suitability analysis. Geographic Information System (GIS) and multi criteria evaluation methodology was applied to select suitable sites for urban development. For this purpose, various thematic (information) layers such as slope, elevation, soil, road and river proximity, LU/LC, urban center, aspect and geomorphology (Table 1), maps was generated in ArcGIS 10.3.1. Each vector layers was rasterized by taking weight as a feature class. All the factors and constrains were internally classified in to five classes (high, suitable, moderate, less and Unsuitable) with values ranging from1 to 5, where value of 1 denotes the most suitable and value 5 denotes the least suitable for all factors and constraints was considered. Weights for each class of criteria were derived in IDRISI software using AHP methods. The method uses the expert preferences for comparing the classes and prepare matrix table. Higher weights were given to vacant/open lands and cultivated land with slopes less than 15 percent and riparian buffer factors for roads are considered. Using these thematic layers as factors, criteria map was generated by applying spatial Analytic Hierarchy Process (AHP). Accordingly, weight was derived for each class giving total sum of 1(Table 9).

In this study different scenarios were produced by giving different preference values to decision factors. The optimization of simulated scenarios developed in this study was applied to choose the best suited alternative based on six conflicting criteria. According to evaluation, scenario was defined from least to the most suitable urban development site. Spatial Analytic Hierarchy Process (AHP) is a type of decision support system that combines GIS and AHP to identify and rank areas that are suitable for urban development, through utilization of knowledge-based user preferences. The method is illustrated through a case study for site suitability of a Jimma city for its urban development using GIS and remote sensing based multi-criteria evaluation technique.

All factors were considered for urban development site were analyzed based on the Table 3 and their description are as follows:

3.6.1. Factors Development

Slope

Slope is one of the most important parameter for finding new suitable sites for urban expansion. In hilly areas people do not prefer construction on steep slopes because it increases the building costs as erosion process occurs during the construction activity in these areas and probability of natural disasters may occur (Suraj *et al.*, 2014).

Slope is an important criterion for hill terrain for finding suitable sites for built-up. Steep slopes are disadvantageous for construction purpose because the slope increases the construction cost (Figure 5). Slope map is an important criterion for site suitability analysis. Slopes greater than 40^0 are considered as steep slope, which are vulnerable to erosion and are not suitable for construction purpose. Slope less than 10^0 is generally suitable for urban development (Nayama and Vinaya, 2016).

Table 3: Area and suitability of slope of the study area

S/No	Slope interval (degree)	Area(ha)	Area (%)	Suitability classes
1	<10	3371.6	32.1	Highly suitable
2	10_20	3467.2	33.0	Suitable
3	20_30	2306.3	21.9	Moderately suitable
4	30_40	1116.0	10.6	Less suitable
5	>40	252.8	2.4	Un suitable
	Total	10514.0	100.0	

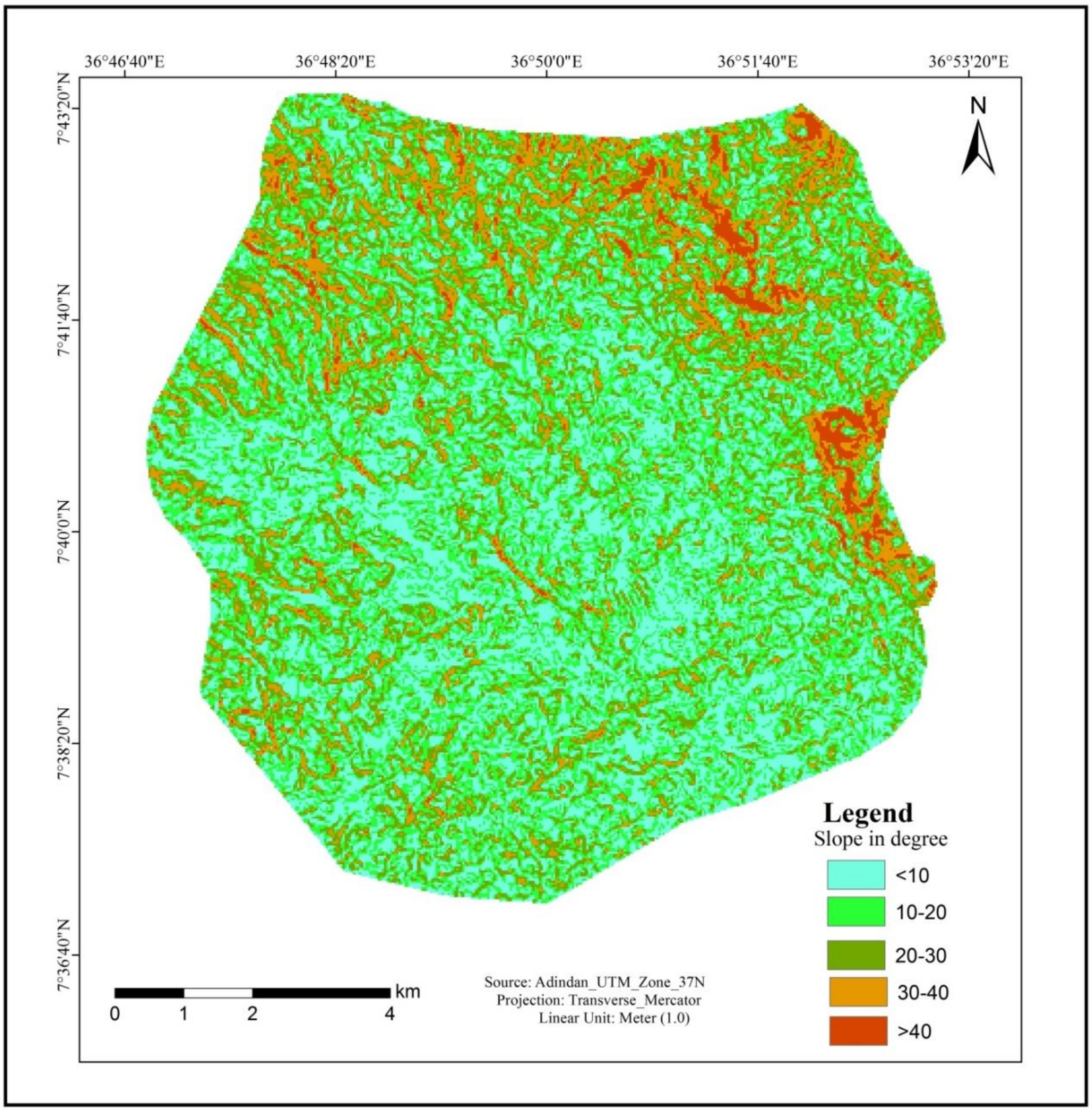

Figure 5: Map of slope factor of the study area

Land use and Land cover

Land use is the main basis for urban land suitability analysis; the distribution of various land-use types gives considerable constraints to urban land development (Mesfin, 2019). The type of land is defined by land used and layers of land cover to protect the primary agricultural land from urban expansion, bare/grassland and vegetation land being chosen for urban expansion. The land-use map of the study area was prepared from Landsat 8 image acquired in 2020. Five different classes of land use/land cover were categorized as vegetation; farm/cultivated land, water body, built-up area, and grassland. Land use/land cover map of Jimma city has been categorized as built up area, farm land, grassland, water body and vegetation because once a building is constructed; it remains there. Thus grassland, vegetation or farm/cultivated land is considered to be the highest suitable for urban development purpose (Santosh and Ritesh, 2014; Mesfin, 2019) (Figure 6).

Table 4: LU/LC map of the year 2020

	Year	**2020**	
S/No	LU/LC Types	Area(ha)	Area (%)
1	Built up area	4059.6	38.6
2	Farm land	3817.4	36.3
3	Grass land	2157.3	20.5
4	Vegetation	465.9	4.4
5	Water body	13.8	0.1
	Total	**10514**	**100**

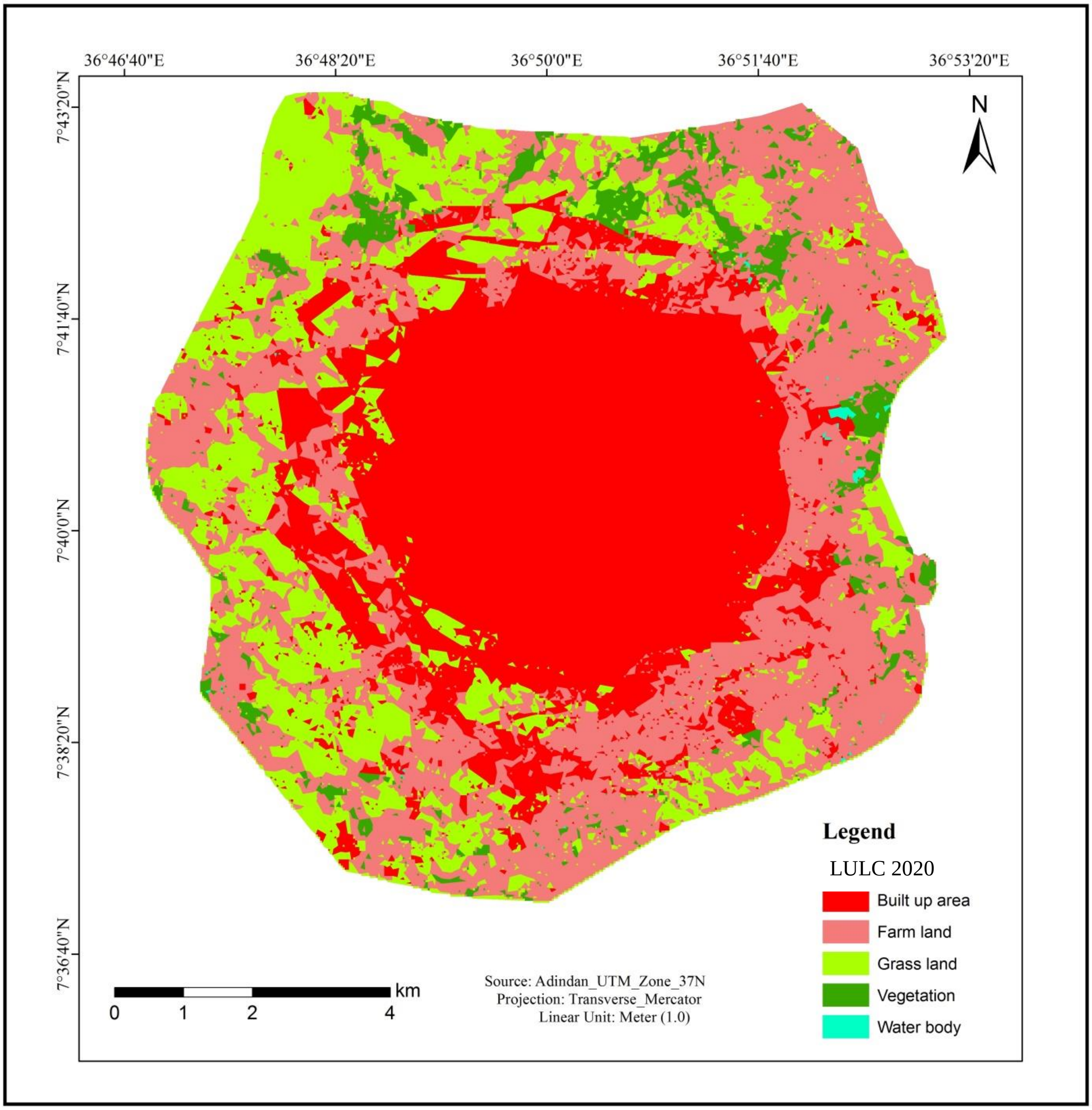

Figure 6: Land use land cover map of the study area

Elevation

Elevation is important factor for further urban development. Based on literature the elevation of study area classified to five categories i.e <1674, 1742-1818, 1818-1923, 1923-2054 and 2054-2280. From the above classes,<1695 were categorized as less suitable and 2065-2284 were classified as highly suitable for further urban development in the study area (Figure 7).

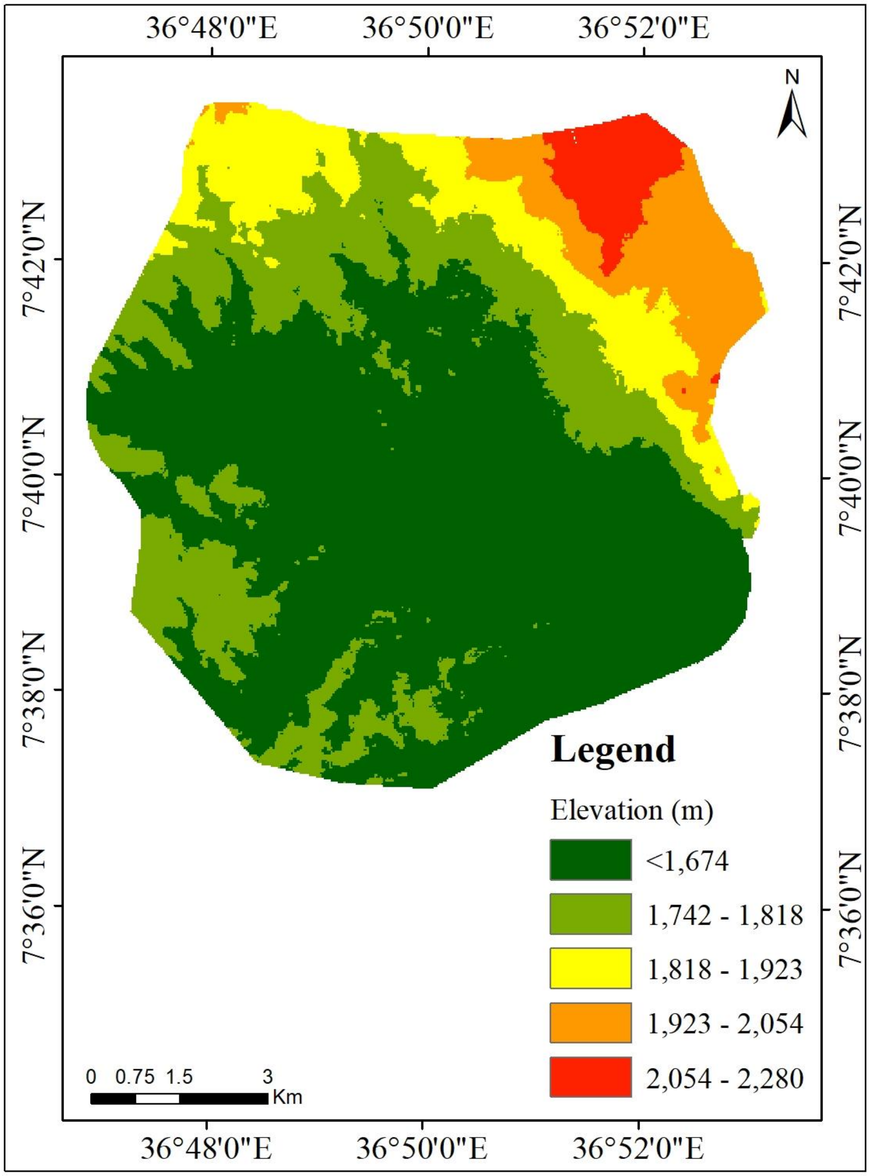

Figure 7: Elevation factor map

Road proximity

Easy access to road helps in movement and transportation at any place. However, the construction of new road is expensive especially in hilly regions. So effort is made to locate the site nearer to any existing road if possible. Moreover in order to find out better accessibility to the existing road, buffer zones have been created by taking 1000 meter distance from the road (Santosh and Ritesh, 2014; Mesfin, 2019).

The road network plays a very important role in the urban development. The road network was digitized from the OSM website. Buffer zones of 0-1000, 1000-2000, 2000-3000, 3000-4000 and >4000 (High, suitable, Moderate, Less and unsuitable respectively) was generated for urban development suitability analysis (Suraj *et al*., 2014).

As more settlement develops near the road networks because of the transportation facilities and very easy access to the nearby places and city center. Easy access to road helps in movement and transportation at any place. However, the construction of new road is expensive especially in hilly regions. So effort is made to locate the site nearer to any existing road if possible (Figure 8). The transport network is one of the main factors in determining urban development because the market, school, hospital, etc. connectivity to the road is required (Mesfin, 2019).

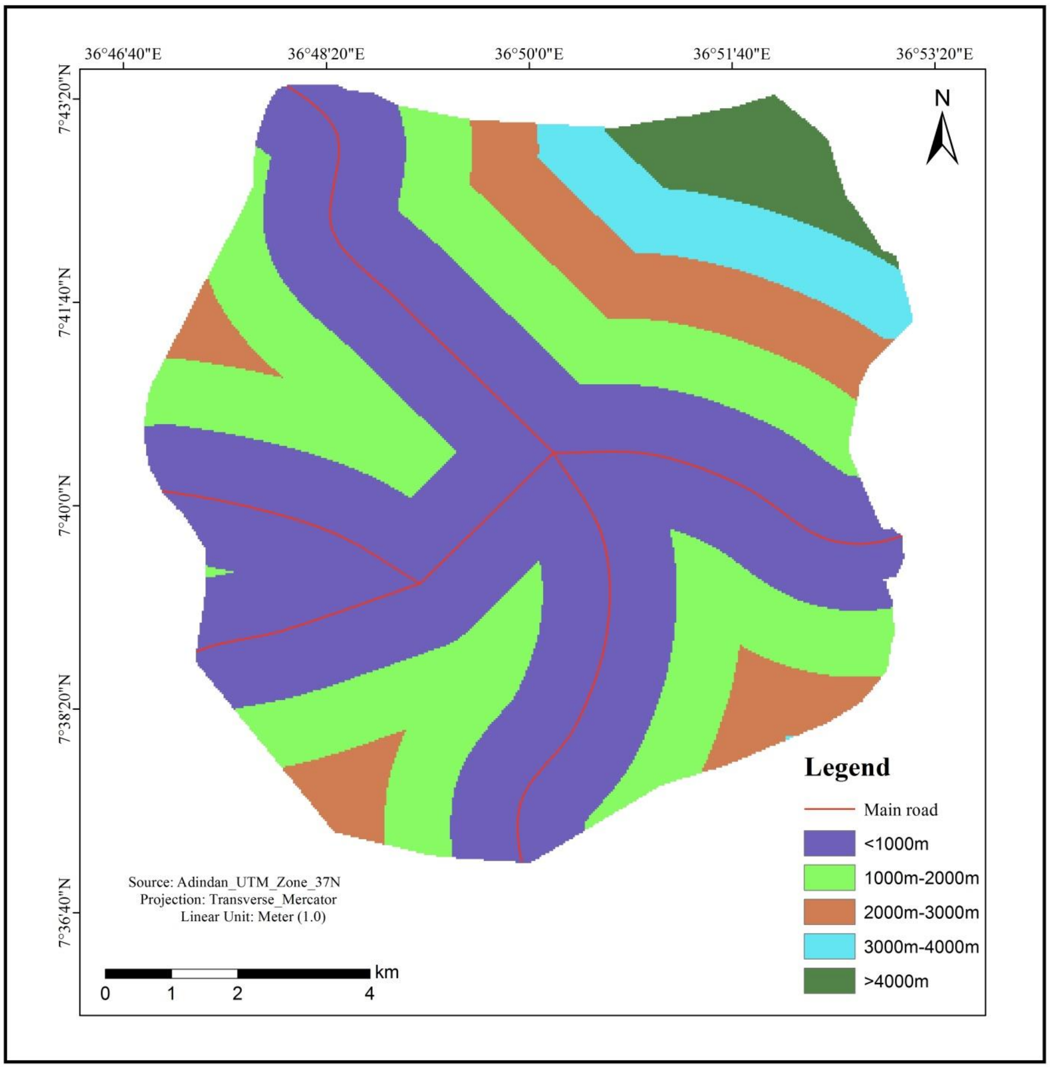

Figure 8: Map of Road factor of the study area

Soil factor

The characteristic of soil is a result of topography, climate and type of parent material, age and environment(Yhdego, 2007). Two major soil types are observed in Jimma area. These are reddish brown residual soils and alluvial soils of brownish gray and grayish white clay soils. The reddish brown soils are well drained soils which are found in the hilly and rolling/sloping areas. Whereas the alluvial soils are found in the low-lying flatter or gently sloping plains and these soils are poorly drained. Soil is the most important criterion for determining an area's suitability for urban construction. Joshua *et al.*, (2013) identified which soil types have high fertility, nutrient deficiency and high water holding capacity and will be used for urban areas (Mesfin *et al.*, 2019).

Soil type essentially gives a comprehensive idea on the basic soil properties of a location. By knowing a soil type, broad implications could be drawn on its suitability for its construction. Dystric nitosls is classified as highly suitable for urban development (Figure 9).

Table 5: Area and Suitability of soil types of the study area

S/No	Soil Types	Area(ha)	Area (%)	Suitability classes
1	Chromic vertisols	378.3	3.6	Less suitable
2	Dystric fluvisols	147.5	1.4	Suitable
3	Dystric nitisols	4449.5	42.3	Highly suitable
4	Eutric fluvisols	5538.7	52.7	Moderately suitable
	Total	10514.0	100.0	

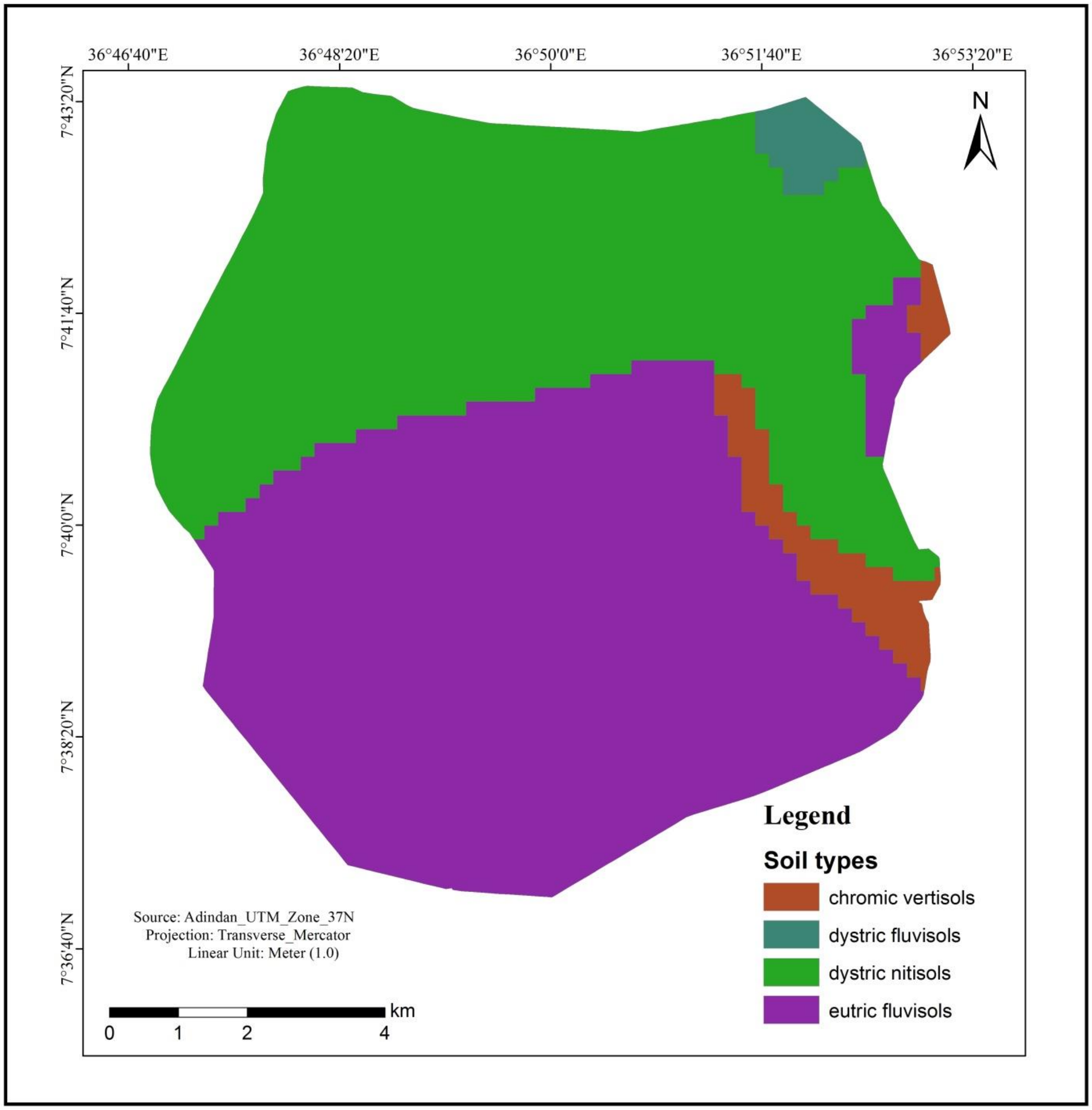

Figure 9: Map of soil factor of the study area

Rivers proximity

In this study, the drainage networks will be generated from ASTER DEM 30m. The area near the water bodies develops more rapidly than the area which is away from the surface water bodies (Santosh and Ritesh, 2014; Tesfaye and Degefie, 2019; Mesfin, 2019).

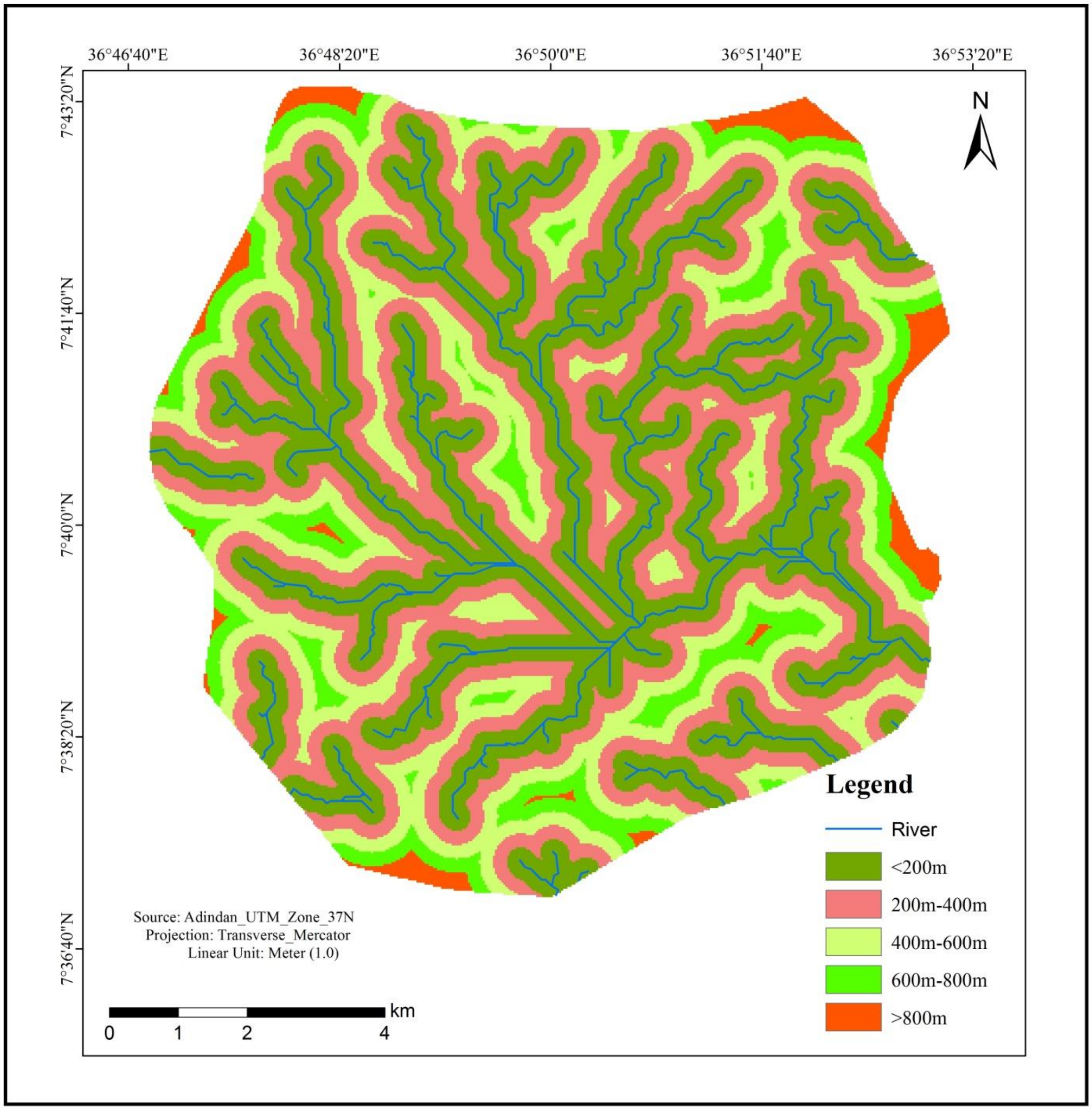

Figure 10: Map of River factor of study area

Geomorphology

Geomorphology can be defined as a science that studies the genesis and the causes of the evolution of land surfaces and their rate of change about nature and humans. Geomorphologic studies aim at describing the present nature of the topography and interpreting the causes of its formation. The residual landforms are identified based on the stage of denudation, which is when all the structure gets obliterated. These denudation landforms can also be classified based on dissection. Low dissected structural hills are given higher priority as compared to high dissected structural hills for construction (Santosh and Ritesh, 2014; Mesfin, 2019) (Figure 11).

Table 6: Area and suitability of Geomorphology

S/No	Land scape	Area(ha)	Area (%)	Suitability classes
1	Residual Landforms	8513.2	81	High suitable
2	Volcanic Landforms	2000.8	19	Suitable
	Total	10514.0	100	

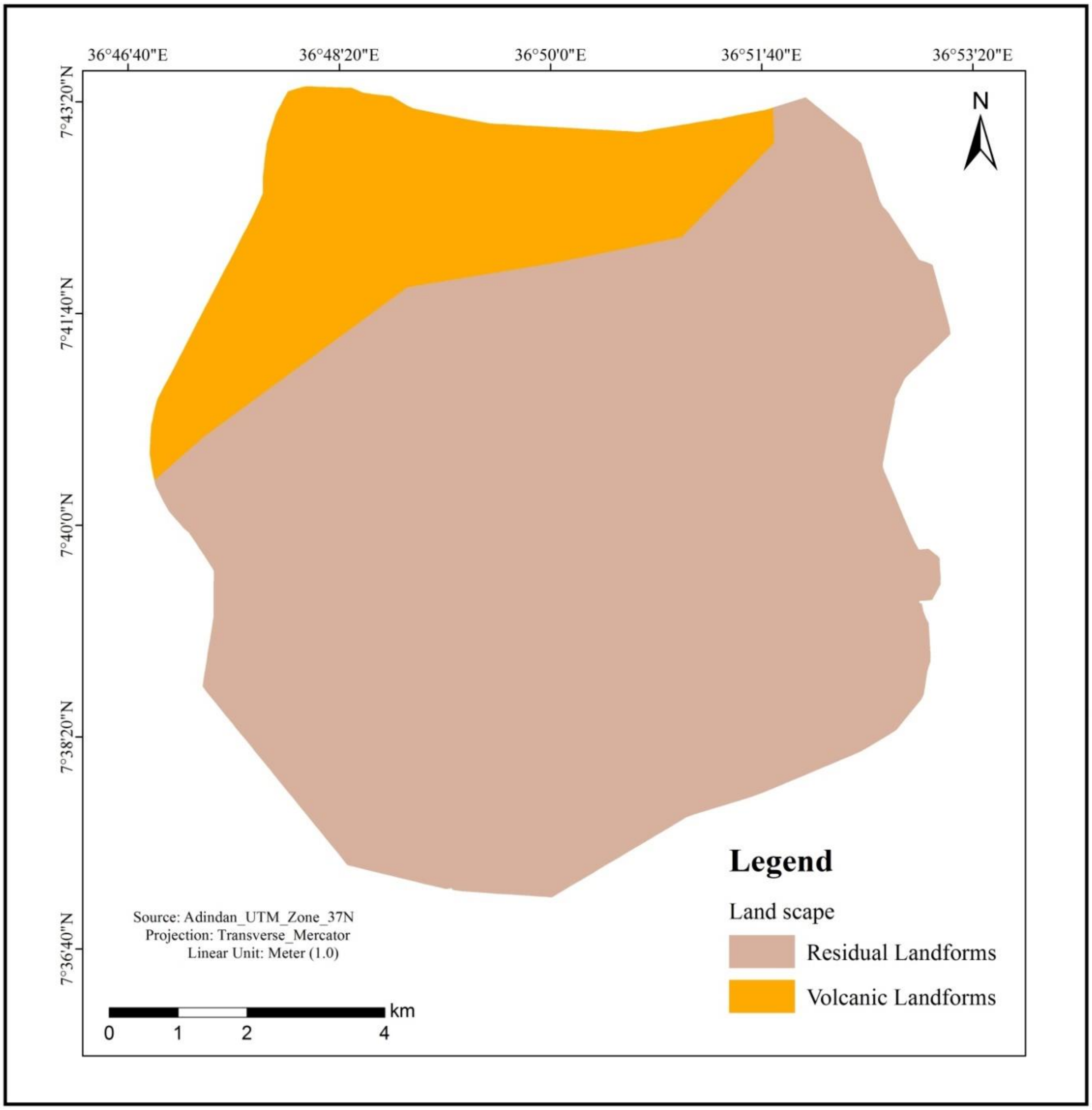

Figure 11: Map of Geomorphology factor of study area

Urban center

Jimma city has very powerful but limited central zone and it has still empty spaces for development. Additionally, it has small zones that can be re-generated. Therefore, it is significant to first use a central zone for development than proximate areas should be developed. Since center of the city is already well constructed and developed, priority is expected to be given to the peripheries of the city for further development (Suraj *et al.*, 2014). Master plan/GPS helps to digitize urban centers.

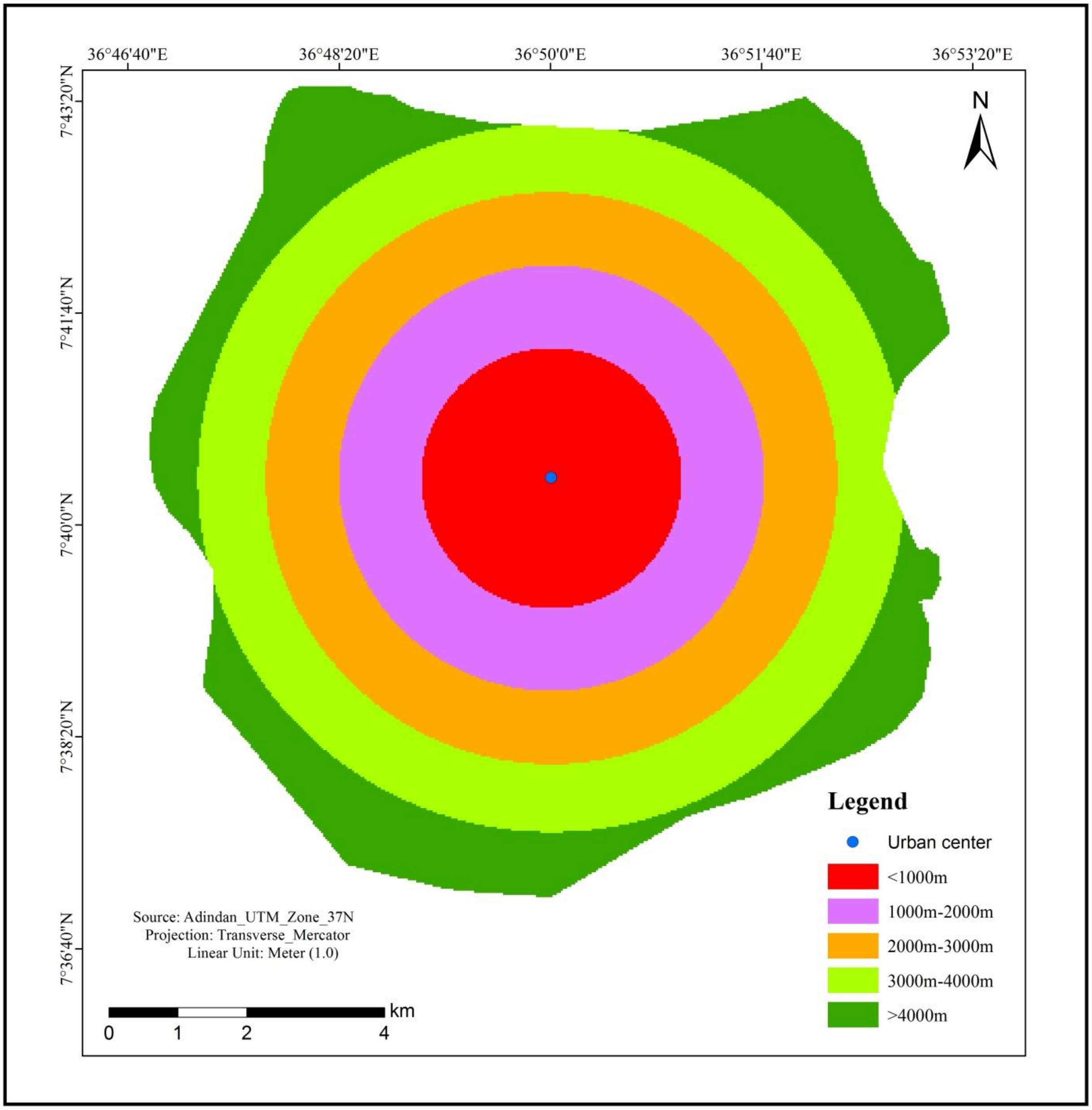

Figure 12: Map of Urban center factor of study area

Aspect factor

Aspect map generally refers to the horizontal direction to which a mountain slope faces. The south portion is highly suitable and north is less suitable for residential buildings based on the amount of sunlight available in these parts (Nayama and Vinaya, 2016).

The aspect has a strong influence on temperature and affects the angle of the sun's rays when they come in contact with the ground. Aspect generally refers to the horizontal direction in which a mountain slope faces. In the mid-winter north-facing slopes receive very little heat from the sun, especially in the northern hemisphere. On the other hand, south-facing slopes get much more heat rather than north-facing slopes (www.fsavalanche.org/encyclopedia/aspect).

In the present study areas with south-facing slopes come under high suitability because in hilly terrain people prefer the construction of houses in sun-facing areas because, in hilly terrain, it's cold during most part of the year. Only a few people prefer the construction of houses on east-facing slopes because east-facing slopes receive sun heat only during the morning time. Therefore, in the present study higher intensity of importance has been given to southern facing slopes rather than other slopes. East-facing slopes are colder than west-facing slopes as east-facing slopes face the sun only in the morning when temperatures are colder, whereas at the same time west-facing slopes take the sun in the warm afternoon mostly in a hilly area (Figure 13).

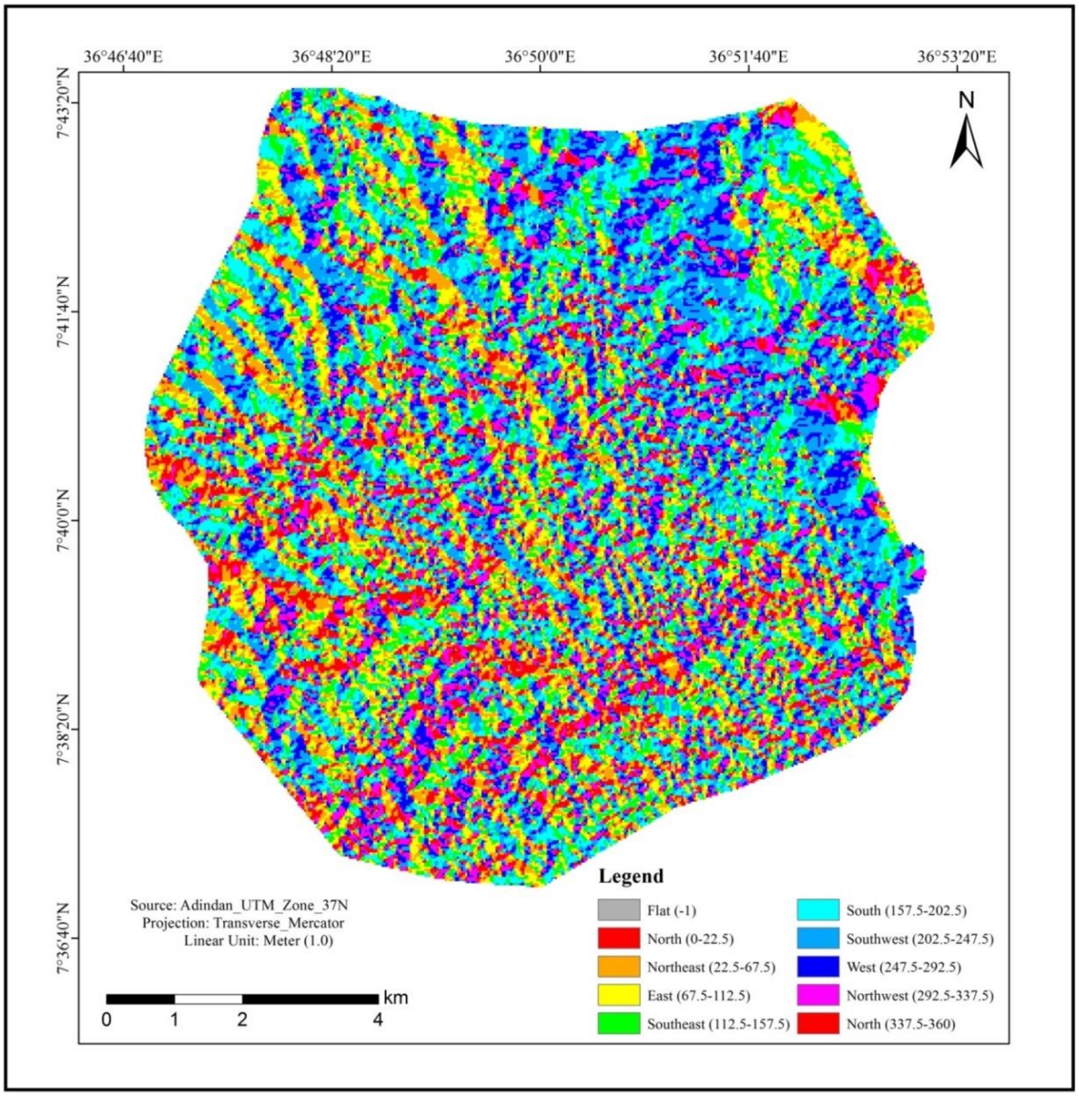

Figure 13: Map of Aspect factor of study area

3.6.2. Determining Relative Weight for each Criterion

After calculating the number of comparisons the pair-wise comparison is conducted, the selection criteria are rendered using a square matrix in one level relative to their importance to the study target. The diagonal elements of all square matrix compare to one matrix or unit matrix. The primary Eigenvalue and the respective own vector (normalized Principal Eigenvector) are also called priority vector (Saaty, 1987). As a consequence, if the value of the Consistency Ratio is greater than 0.1, the inconsistency is appropriate then validity is tested again.

3.6.3. Analytical Hierarchy Process

For this study researcher used AHP for generating weight for each evaluation criterion according to the decision maker's pairwise comparisons of the criteria. All the criteria considered in this study have no equal degree of importance therefore the importance of each criterion in relative to the other criteria will be determined by AHP. The comparison is about whether the row criterion is equal, greater or lower importance that of column criterion and the higher the weight, the more important the corresponding criterion.

3.6.4. Weighted Overlay Analysis

The Weighted Overlay method uses one of the most commonly used methods for overlay analysis to solve multi-criteria problems such as site selection and models of suitability. The reclassified map will assign weight by AHP based on their suitability factors. Finally, they overlaid together than the most suitable urban development site of the study areas was selected.

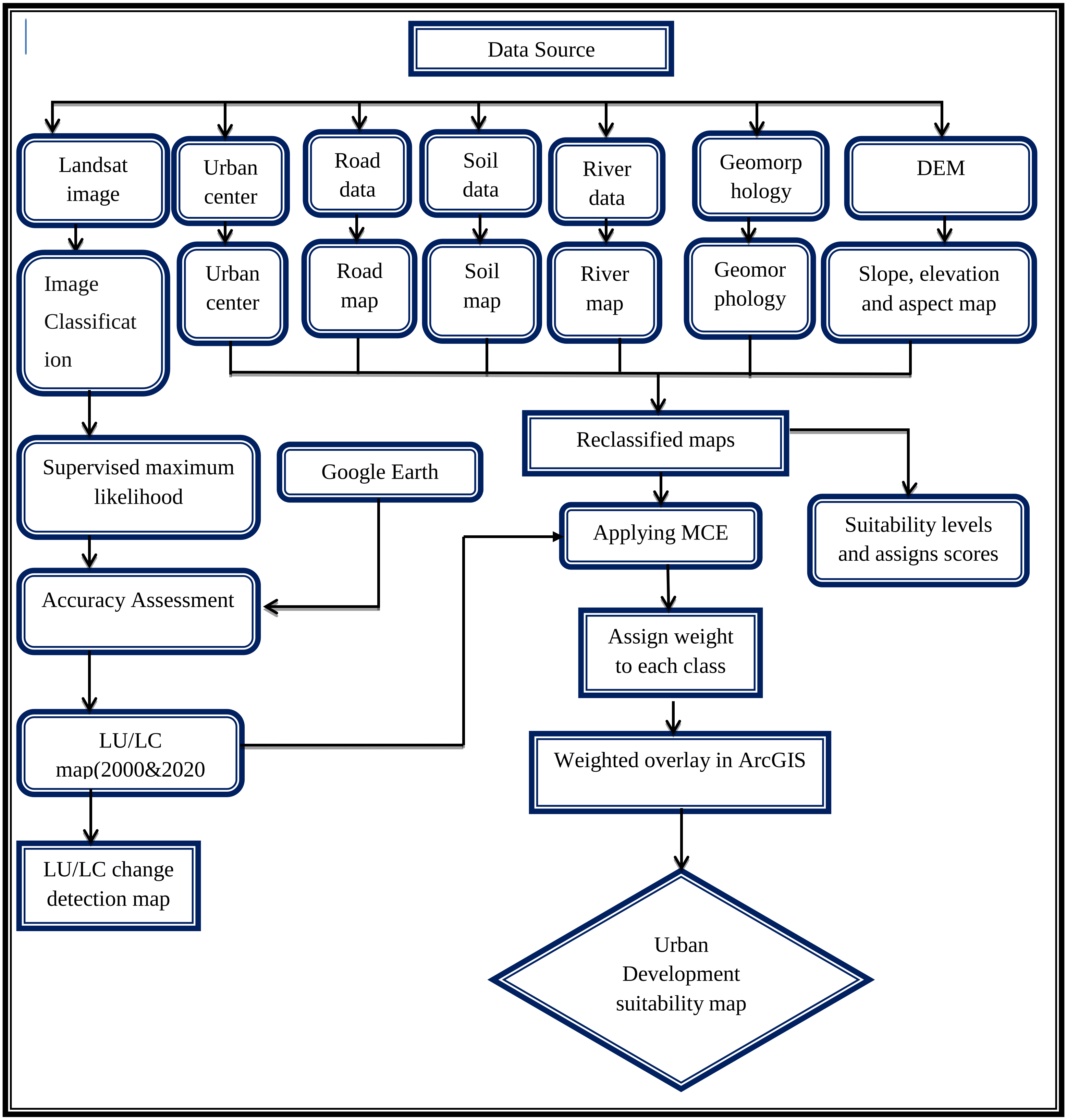

Figure 14: Methodological flow diagram

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1. Evaluation of Land use land cover changes

4.1.1. Land Use/Land Cover map of Jimma city 2000 and 2020

Based on the Landsat image data LULC of Jimma city was classified into five main classes. The detail information about land use/land cover of the year 2000 and 2020 was presented in table below.

Table 8: Land use land cover of the year 2000 and 2020

S/No	**LU/LC Types**	**2000**		**2020**		**Change (2000-2020)**	
		Area(ha)	Area (%)	Area(ha)	Area (%)	Area(ha)	Area (%)
1	Built up area	1332.3	12.7	4059.6	38.6	2727.3	25.9
2	Farm land	5114.3	48.6	3817.4	36.3	-1296.9	-12.3
3	Grassland	3271.0	31.1	2157.3	20.5	-1113.7	-10.6
4	Vegetation	762.4	7.3	465.9	4.4	-296.5	-2.8
5	Water body	34.0	0.3	13.8	0.1	-20.2	-0.2
	Total	**10514.0**	**100.0**	**10514.0**	**100.0**		

Land use and land cover (LU/LC) of the year 2000 and 2020 of Jimma City are shown in Figure 15 and 16 below.

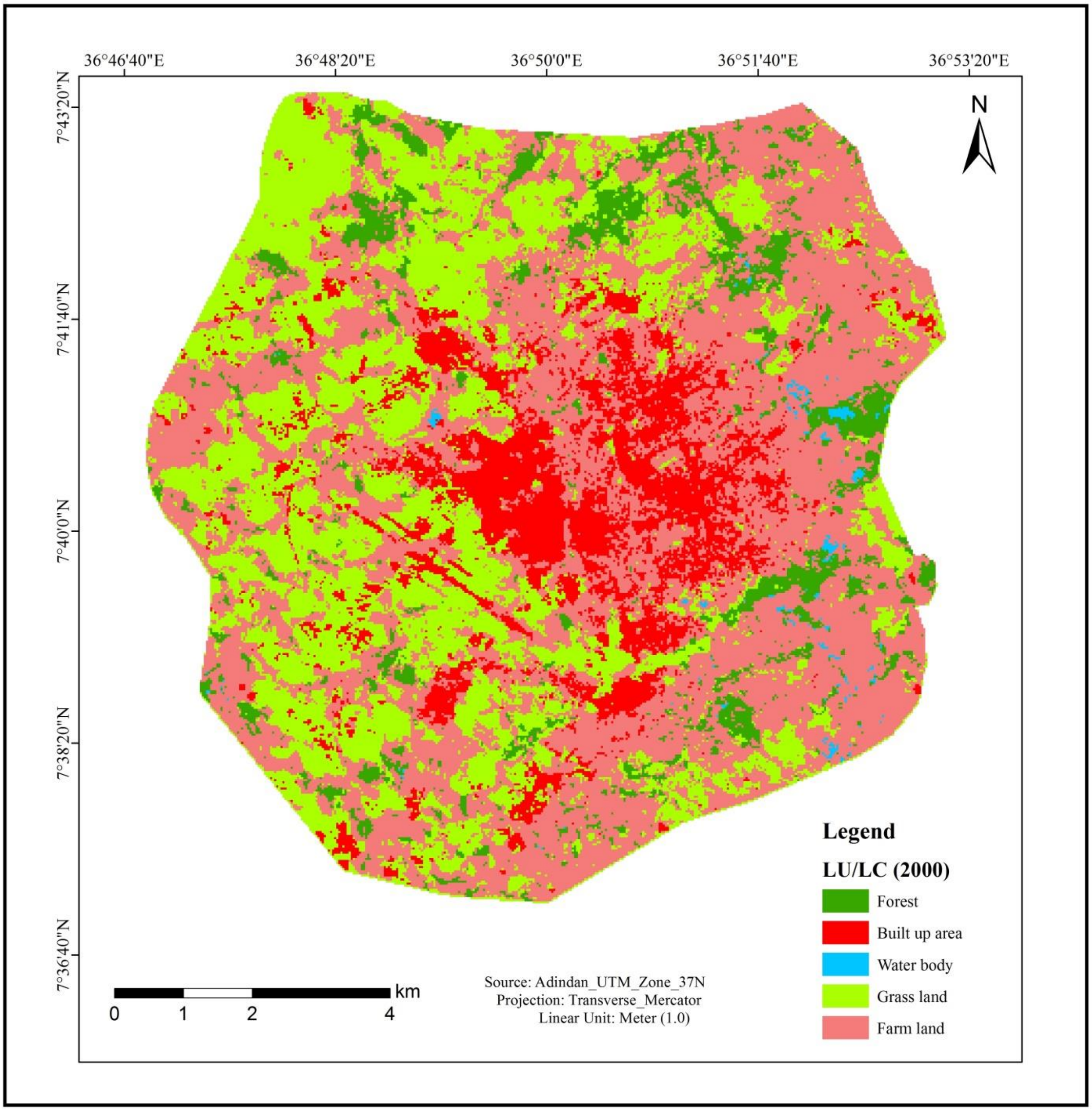

Figure 15: Land use/ Land cover map of the study area in 2000

Land use and land cover of the study area were classified into five classes based on (Bisrat et al., 2018), these are built-up area, forest, farmland, water body, and grassland. Among this land use/land covers cultivated/farmland was the main land-use class with an area of (48.6%) of the total area of Jimma city in 2000. This result is in line with (Sewunet, 2017).

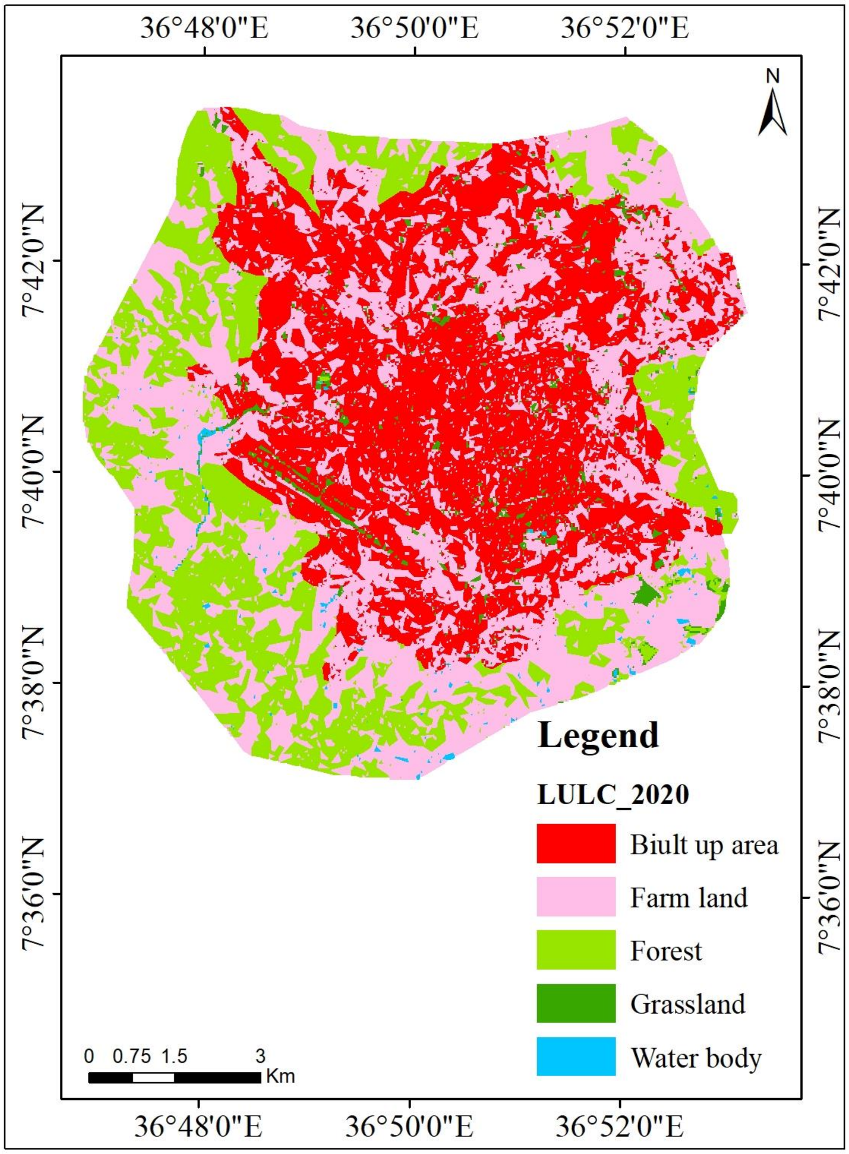

Figure 16: Land use/Land cover map of the study area in 2020

During 2020 built-up areas and water body share the largest and least percentage of LU/LC classes, respectively. The land use/land cover classification of the area for the 2020 built-up area is rapidly increased. Other land use/land covers become gradually decreased as illustrated in (Figure 15). This result was a line with the result forwarded by (Feyisa *et al.,* 2016).

4.1.2. Accuracy Assessment

Land use and land cover accuracy assessment for 2000 and 2020 was produced. Accuracy assessment was employed to find out those errors so as ensure reliability of the produced LULC maps. The classified maps were assessed and compared with a referenced data and ground truth using an error matrix. The overall accuracies for the two reference years 2000 and 2020 are 95.4%, and 94.6% with the Kappa statistics of 0.93 and 0.91, respectively. The Kappa statistics value greater than 0.80 (i.e., 80%) represents a strong agreement and a value between 0.60 and 0.80 represents a substantial agreement (Landis and Koch, 1977). Hence, the maps met the accuracy requirements for change detection analysis (Anderson et al., 1976), and there is a positive correlation between the remotely sensed classified samples and the reference data. Details of each year's land use/land cover class accuracy assessment for both years under investigation period as indicated in Table 9.

Table 9: Error matrix of land use and land cover for 2000 and 2020

	2000		**2020**	
LU/LC class	Producers Accuracy (%)	Users Accuracy (%)	Producers Accuracy (%)	Users Accuracy (%)
Built-up area	89.4	90	98.9	98.9
Vegetation	99.3	99.8	98.6	99.8
Farm land	98.9	97.4	97.3	98.22
Water body	100	99.4	100	98.4
Grassland	90	97.2	88	98
Overall Accuracy	95.4%		94.6%	
Kappa coefficient	0.93		0.91	

4.1.3. Land-use/land-cover change matrix

Conversion matrixes were analyzed for each period clearly show the source and destination of the major Land use/Land cover Changes. The land-use/land-cover change matrixes of Jimma city were computed (Table 10). In the change matrixes the row of the table stands for the initial year and the column of the table symbolize the final year of the change. Moreover, all change matrixes show gross gain and loss of each land cover category during the study periods. The diagonal numbers, which written in bold show the unchanged pixels. During the study period between 2000 and 2020 the matrix result have shown that 1314.5ha farm land, 1106.9ha grass land, 290.7ha vegetation land, and 19.6ha water body were changed in to built-up area. Based on these result the largest area of farm land was changed to other LU/LC classes and the least one is water body and 7747.5ha (73.68%) of the study area landscape remained unchanged (Figure 17). This implies around 26.31% of the total landscape of the study area was converted from one land-use/land-cover type to the other. This result can be supported by the result of (Habtamu, 2018; Nigatu, 2014; Sisay, 2014).

Table 10: Land-use/land-cover change matrix between 2000 and 2020

LU/LC types		**2020**					
		Built up area	Farm land	Grass land	Vegetation	Water body	Total
2000	Built up area	1327.9	2.1	2.3	0.0	0.0	1332.3
	Farm land	1314.5	3792.5	6.3	0.8	0.2	5114.2
	Grass land	1106.9	16.0	2148.0	0.2	0.0	3271.0
	Vegetation	290.7	6.0	0.7	464.8	0.1	762.4
	Water body	19.6	0.8	0.0	0.2	13.5	34.1
	Total	4059.6	3817.4	2157.3	465.9	13.8	10514.0

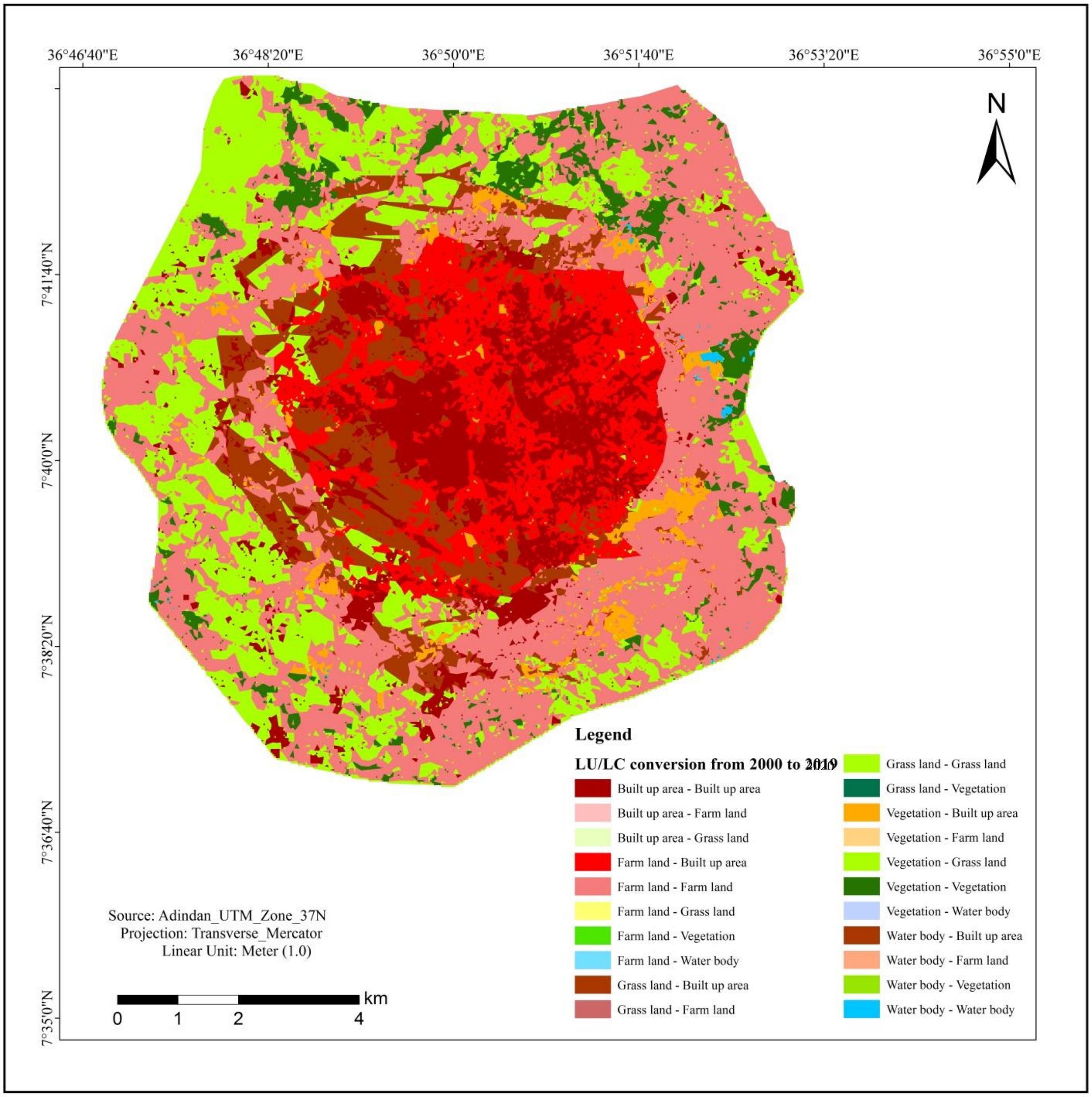

Figure 17: LU/LC conversion (post classification) from 2000 to 2020 of Jimma City

4.2. Factor development and giving weight using Analytic Hierarchy Process (AHP)

Soil type, slope, elevation, road buffer, LU/LC, soil type, river buffer, aspect and geomorphology factors were created to develop further urban suitability in study area. AHP is one of the most popular Multi-Criteria Decision Making Model (MCDM) techniques developed by Saaty (1980). It is used to identify the best one from a set of alternatives with respect to several criteria. The basic principle of AHP is to solve a problem by forming hierarchies. To ensure the credibility of the relative significance used, AHP also provides measures to determine inconsistency of judgments mathematically. Based on the properties of reciprocal matrices, the consistency ratio (CR) can be calculated. CR < 0.10 indicates that level of consistency in the pair wise comparison is acceptable.

Saaty (1980) suggests that if CR is smaller than 0.10, then the degree of consistency is fairly acceptable. But if it is larger than 0.10, then there are inconsistencies in the evaluation process, and AHP method may not yield meaningful results. The standardized raster layers were weighted using Eigen vector that is important to show the importance of each factor as compared to other in the contribution of urban land suitability analysis. Accordingly, the Eigen vector of the weight of the factors was computed in IDRISI 32 software in analysis menu decision support/weight module. In this study, a pair of criteria were valued at the same time using the scale of nine points (degrees) ranging from1/9 to 9.

4.3. Calculating Factor Weights and Overlaying the Identified Suitable Sites

Afterward preparation of maps of all features like road buffer, LU/LC, soil type, river buffer, aspect and Geomorphology were converted to raster files and separate datasets were created using weightage and rank. Different layers having different scores were laid and the scores of each composite class were added. The larger the weight, the more important is the criterion in the overall function. The weights were developed providing a series of pair wise comparisons of the relative importance of factors to the suitability of pixels for the activity being evaluated. The system by which the weights were produced follows the logic developed by Saaty (1980) under the Analytical Hierarchy Process (AHP). Weight rates were given based on pair wise comparison 9 point continuous scale (Table 10). These pair wise comparison were then analyzed to produce of weights that sum to 1. The factors and their resulting weights were used as input for the multi criteria evaluation part for weighted linear combination of overlay analysis. Finally, the suitability map was prepared (Figure 18).

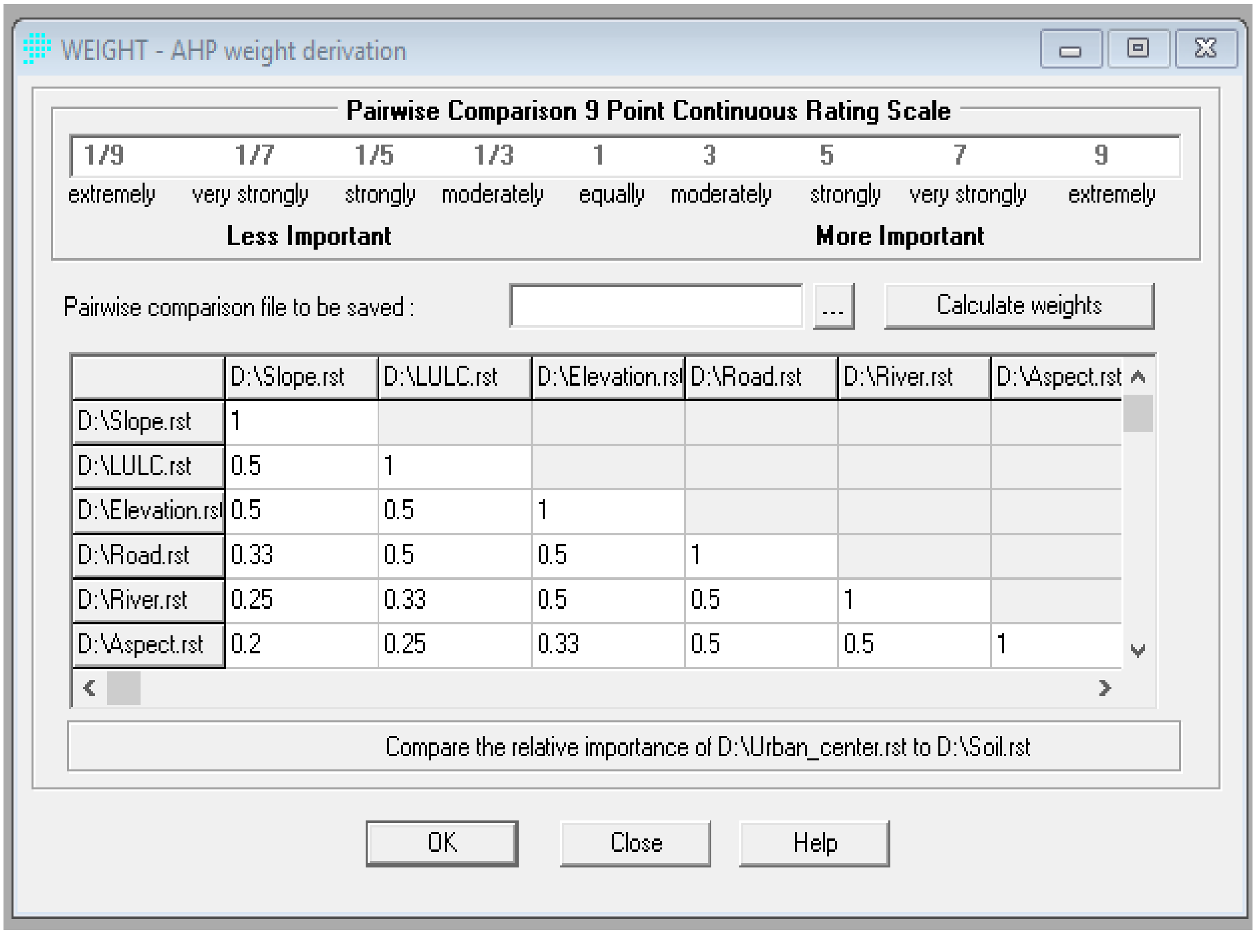

Figure 18: Pairwise comparison of different factor

Source: (Saaty, 1980)

Table 11: Weightages and parameters in determination of site suitability analysis

No	Spatial data (Layer Name)	Sub-Criteria class	Ranking	Level of suitability	Influence (%)
1	Distance from river	<200m	1	High suitable	8%
		200-400m	2	Suitable	
		400-600m	3	Moderately suitable	
		600-800m	4	Less suitable	
		>800m	5	Un suitable	

2	Geomorpho logy	Residual landform	1	High suitable	3%
		Volcanic landform	2	Suitable	
3	LU/LC	Grassland	1	High suitable	21%
		Cultivated	2	Suitable	
		Vegetation	3	Moderately suitable	
		Water body	4	Less suitable	
		Built-up	5	Unsuitable	
4	Types of Soil	dystric nitisols	1	Highly suitable	4%
		dystric fluvisols	2	Suitable	
		eutric fluvisols	3	Moderately Suitable	
		chromic vertisols	4	Less suitable	
5	Aspect	South	1	Highly suitable	6%
		South- West	2		
		South- East	3		
		West	4	Suitable	
		East	5		
		North- West	6	Moderately suitable	
		North- East	7	Less suitable	
		North	8	Unsuitable	
6	Elevation	<1674	1	unsuitable	16%
		1742-1818	2	Less suitable	
		1818-1923	3	Moderately suitable	
		1923-2054	4	Suitable	
		2054-2280	5	Highly suitable	

7	Slope (in degree)	<10	1	Highly suitable	28%
		10-20	2	Suitable	
		20-30	3	Moderately	
		30-40	4	Less suitable	
		>41	5	Unsuitable	
8	Distance from Road (m)	0-1000m	1	Highly Suitable	11%
		1000-2000m	2	Suitable	
		2000-3000m	3	Moderately Suitable	
		3000-4000m	4	Less Suitable	
		>4000m	5	Unsuitable	
9	Distance from Urban Center	<1000m	5	Unsuitable	3%
		1000-2000m	4	Less suitable	
		2000-3000m	3	Moderately	
		3000m-4000	2	Suitable	
		4000-5000m	1	Highly suitable	

In the current study, the C.R. matrix of the eight important parameters in site suitability assessment for urban development is 0.02 (Figure 19). Therefore the pair-wise matrix appears to have sufficient internal consistency to be considered acceptable.

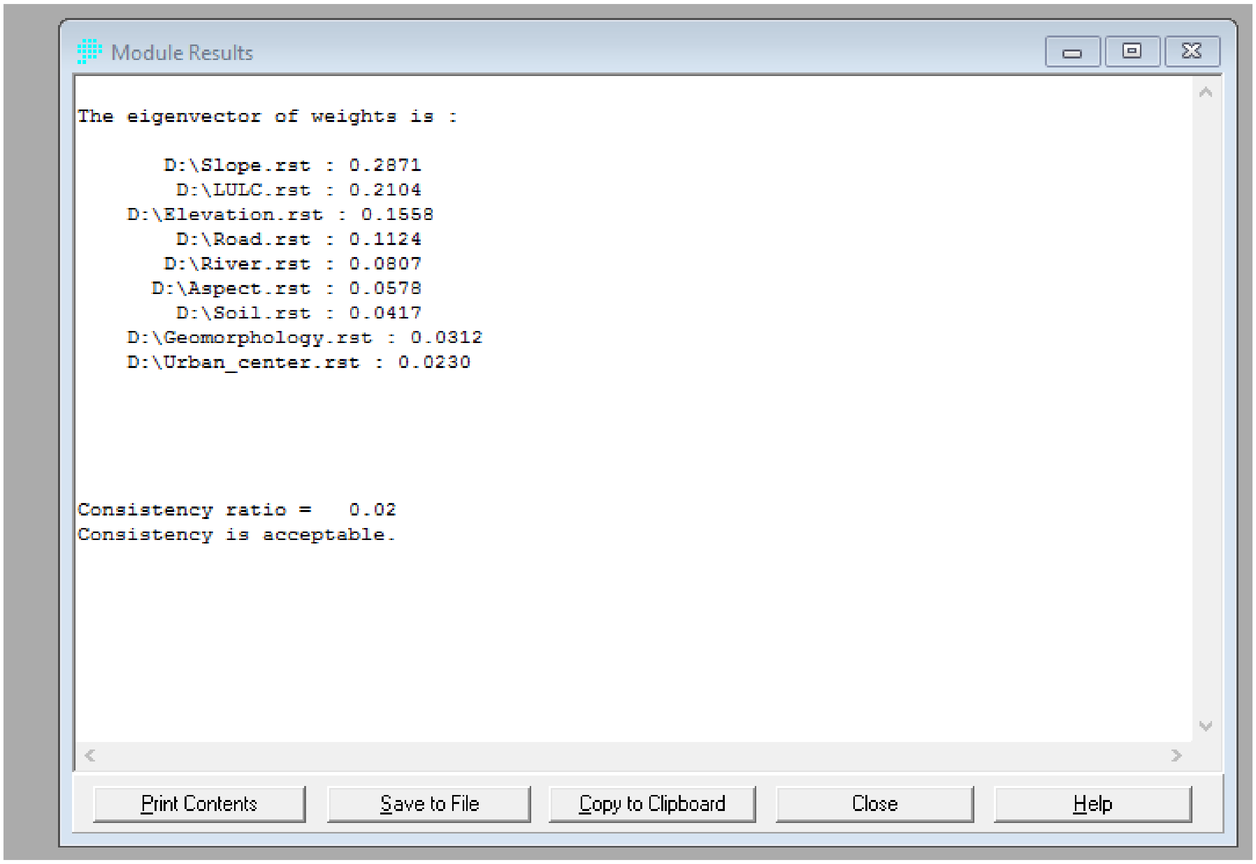

Figure 19: The eigenvector of weights

4.4. Suitable Sites for Urban Development

Land use/land cover map of Jimma city has been categorized as vegetation, farm land, water body, built-up area, and grassland because once a building is constructed; it remains there for a number of years. Thus grassland, vegetation and agricultural/farm land is considered to be the highest suitable for further urban development purpose (Chang, 2006). The final site suitability map describes that the study area was divided into four suitability classes (Figure 20).

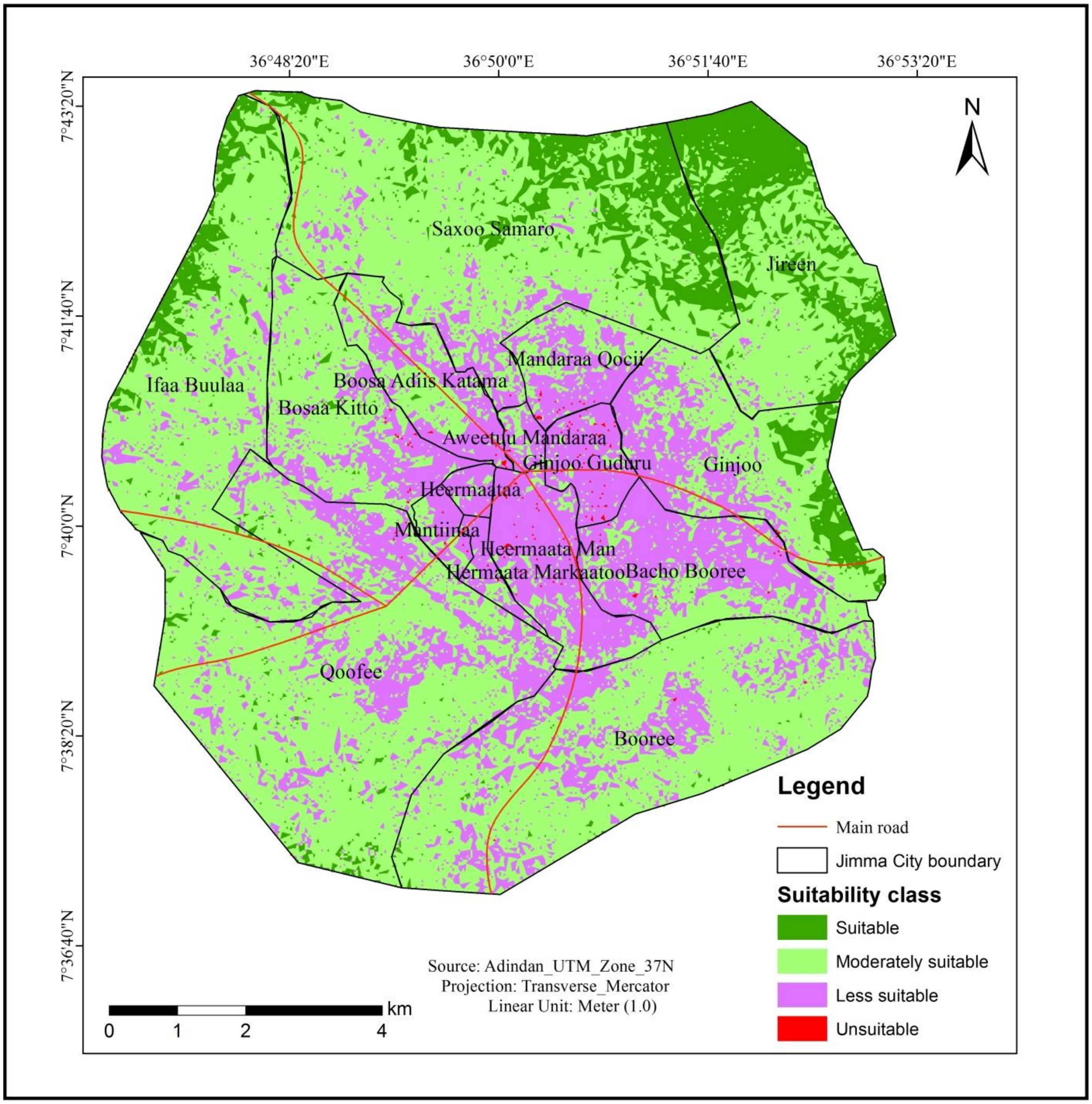

Figure 20: Urban development Suitability map of Jimma City

From the total area of Jimma City, about 1070.5ha (10.2%) of the land is grouped under suitable site; whereas majority of the city 6712.2ha (63.8%) falls under moderately suitable for further urban development (Table 11). This result was a line with the result forwarded by (Chuvieco and Huete, 2010).

Table 12: Suitability Classes

S/NO	Suitability classes	Area (Ha)	Area (%)
1	Suitable	1070.5	10.2
2	Moderately suitable	6712.2	63.8
3	Less suitable	2714.3	25.8
4	Unsuitable	17.0	0.2
	Total	10514.0	100.0

The areas of the proposed sites were calculated in GIS environment as it is shown in the Table 12. The suitable site has an area value which accounts 1070.5ha and followed by moderately suitable site which accounts 6712.2ha while less suitable area accounts 2714.3ha. The suitable site constitutes 10% of the total area of study area and moderately suitable site constitutes the highest area coverage i.e. 63.8% of its total area. On the other hand unsuitable/not suitable lands of study area constitute 17.0ha which is 0.2%. Fig.19. deep green color indicates suitability map for further urban development in Jimma city. This result was a line with the result forwarded by Negasa Jeba (2017).

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

This study assessed urban land use/land cover change for the year 2000 and 2020; and analyzed suitable site for further urban development of Jimma City by integrating GIS and Remote Sensing techniques with Multi-criteria Evaluation.

Mapping of urban land suitability have been done in the view of developing urban land with four different classes such as suitable, moderately suitable, less suitable and unsuitable for urban development. Identification of suitable sites for urban development is also important for planners, policymakers, and rulers to do sustainable development. The study clearly reveals that the city has dramatically grown in all directions between the years 2000 and 2020. Built-up area increased a lot in the last two decades by consuming a considerable amount of other land-use/land cover types.

Using image of 2000 and 2020 there are rapid urban expansion of the study area. In general as the change detection analysis results revealed, this observed consistent expansion was attributed to the conversion of vegetation/forest and farm land into built-up area at different stages. On the other, grassland indicates decrement in different time of study. For example in between 2000 and 2020 grassland decreased. This was due to conversion of land form from grassland and farm land to built-up area in the study area. The two major land use/land cover converted in to built-up areas in both specified time interval i.e. 2000 and 2020 is grassland and farm lands.

Of the total area of Jimma city more than half percent i.e. 63.8% falls under moderately suitable whereas about 10.2% is grouped as suitable site for further urban development. The remains 25.8% and 0.2% become grouped as less and unsuitable area for further urban development in the study area.

5.2. Recommendations

Based on the findings obtained in this study, the following recommendations are forwarded:

- ✓ The city is expanding from year to year because of various reasons. Hence the expanding areas are suffering from in adequate urban infrastructure and the burden of the provision of this urban infrastructure falls on the municipality. It is recommended that the municipality should form partnership ben land suitability site selection.
- ✓ The combination of GIS with AHP is powerful tool for land suitability analysis for urban development. Therefore, GIS-based AHP for land suitability has proven to facilitate efficiency from the economic point of view as compared to the traditional methods for further urban Land-use strategy must take account of urban land suitability in relation to the expected future needs and the possibility of meeting demands.
- ✓ The critical importance of land for specified uses should be known either physical or economic suitability. This means not only whether it is important that this specific area of land should be used in particular way but also whether a particular area is physically suitable.
- ✓ The outcomes of the study were help the local people as well as planners to formulate and implement suitable master plan for development of urban region. Further field investigation needed before the final decision is made.

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