JIMMA UNIVERSITY
COLLEGE OF SOCIAL SCIENCES AND HUMANITIES
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

MULTI-CRITERIA EVALUATION TECHNIQUES FOR SELCTION OF POTENTIAL SITES FOR RESIDENTIAL HOUSING DEVELOPMENT IN JIMMA TOWN, SOUTH WEST ETHIOPIA

A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (MSC) IN GEOGRAPHIC INFORMATION SYSTEMS AND REMOTE SENSING

BY: ABDO ABDULKADIR

OCTEBER, 2019

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October, 2019

Jimma

DECLARATION

I, Abdo Abdulkadir, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

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List of Acronyms

AHP----------------AnalyticHierarchy Process

CSA-----------------Central Statistical Authority

C^0 -------------------Degree clishel

DEM----------------Digital Elevation Model

FAO-----------------Food and Agricultural Organization

Km^2 -----------------Square Kilometer

MCE----------------Multi Criteria Evaluations

mm-----------------milimeter

GIS----------------- Geographic Information System

GPS---------------- -Global Position System

UTM----------------Universal Transverse Mercator

Abstract

Land suitability analysis has growing importance in identifying suitable land resource for some specific uses. Due to the dynamic urban growth trends, city administrators and planners are faced with difficulties in supplying suitable urban residential housing. Therefore identification of potential sites for residential development in urban areas is one of the critical issues of planning. As a result the study dealing to determine potential Suitable Sites for future residential housing Development in Jimma town by using GIS and Multi-Criteria Evaluation technique. Thus the main objective of the study was assessing the current site selection practice and identifying the main criteria for residential housing development, generating suitability map and evaluating proposed residential housing development. To accomplish the task the study uses both primary and secondary data sources like expert interview, literature and Geospatial data (landsat 8OLI-TIRS of 2019, DEM, Structural plan and cadastral survey data). ERDAS imagine, ArcGIS and QGIS software was used to accomplish the analysis. The internal factors that cast a shadow image on the quality of the current residential housing development plan preparation were the experience and skill gap of the plan preparation team that caused for the proposal of existing wetland site for residential land, existing industrial area for settlement and proposing residential area on slope greater than 25^0 *rise. The finding of the study illustrated that about 4097.59 ha (38.78%), 1208.2 ha (11.43%), 1021.28 ha (9.67%), 1420.66 ha (13.44%), 1571 ha (14.87%), 1247.96 (11.81%) of the total urban landscape of the study area is Restricted, unsuitable, less suitable, moderately suitable, suitable and highly suitable respectively for future urban residential housing development respectively. Five potential sites were identified for future residential housing development having suitability class of highly suitable, suitable and moderately suitable in Southern, South eastern, western, North western and North Eastern part. The analysis obtained from the evaluation of proposed residential site by municipality with the final suitability map of this study reveals that; 19.03%, 9.32%, 11.96%, 17.85% 19.11% and 22.74% of the proposed residential housing development proposed on Restricted, unsuitable, less suitable, Moderately suitable, suitable and highly suitable respectively. Hence, the municipality should revise the proposed residential housing development and in order to better spatial urban land use planning and supplying safe and comfortable land for urban residential housing development for urban resident the way of planning should be shifted from the previous rudimentary subdivision layouts to GIS-MCE and AHP technology.*

Key words: Suitability, GIS, MCE and Residential housing

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study.

Due to the increasing population and economic growth, human activities have continuous impacts on land use. Such impacts might lead to series of complexities toward environment and land resources development (Huang and Xia, 2001). Issues related to population and land use competition has emphasized the need for more effective land use planning and policies. Today, about 7.4 billion people call earth their home. By 2050, population is projected to reach 9.7 billion. Among this today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050 (UN, 2018). However, the world's ever-increasing population in cities and rapid urbanization have raised serious issues of the quality of urban residences, such as air pollution, traffic congestion, and fragmentation of natural spaces (e.g., open space, green space and wetlands) (Huang et al, 2019).

Facing restriction at the social-economic level and from pressures of the environment optimizing urban residential land is a challenging task for urban planning agencies. Thus, reliable, quantified, rapid and fine-grained urban residential land suitability analysis has become essential for urban planners to improve urban residential environments and to better understand the urbanization process (Chen, 2014)

According to FAO (1996) guidelines, a crucial stage in land-use planning is the suitability analysis, which is a central part of land-use evaluation. From the 1990s, the analysis of land characteristics in identification of land suitable for development can play an essential part in the planning process (Bruijn, 1991). Among the many concerns of urban planners, in guiding the spatial arrangement of activities is the optimum utilization of land for the benefit society (Lwasa, 2005).

Land suitability analysis is the process of determining the fitness of a given tract of land for a defined use. In other words, it is the process of determining whether the land resource is suitable for some specific uses and to determine the suitability level (Sherry, 2000). Suitability analysis enables elected officials and land managers to make decisions and establish policies in terms of the specific land uses (Al-Shalabi, 2006)

A residential area is a land use in which housing predominates, as opposed to industrial and commercial areas. The residential developments required to focus on the affordability of the residents to live and work with accessibility, infrastructural facilities, environmental quality, financial ability etc. (Masel and Mansourian, 2016). But most of the residential home developers mostly concern on the availability of the land and did not give consideration the social infrastructure, physical factors and environmental factors. As result in the long term residents face many difficulties in day to day living in those particular locations. Therefore, evaluation of locational suitability of the residential development is most important to a country to provide a better living for the people. In the long term, a country with a good living environment can earn good benefits from the society, and it maximizes the highest and best use of the land.

With the support of geographical information system (GIS) technology, land-use suitability analysis has implemented (Huang et al, 2019). GIS can combine different types of information to help with better decision making and is also a high-quality visualization tool. A multi-criteria evaluation (MCE) can compare each factor according to their importance and generate weights of each factor. Therefore, incorporating MCE methods into GIS is the most common method for generating a final suitability map.

Jimma town is among the fast growing urban centers in the country, primarily because the population of the town is increasing from time to time according to CSA report of 2007 the population of the town increasing with 3.65% annual growth rate and the growth of population in the town has created a higher urban land demand than previous decades, leading to significant change of landscape. Hence the expansion of the city is becoming irregular, uncontrolled and often resulting in creation of slums. In this context it is very important to find suitable site for residential housing development to overcome the problems and undesirable urban growth in Jimma town.

1.2. Statement of the problems

The residential developments are basically located, the affordability of the residence who are decided to live and work and also accessibility, infrastructural facilities, environmental quality, financial ability. But most of the residents not considered the natural and physical hazard, waste disposal system, drainage system etc. Large percentages of people select their residential locations without any scientific feasibility analysis and therefore considerable amount of residents are face many difficulties.

Like other developing countries, the nature and character of spatial developments in Most cities of Ethiopia does not only pose a daunting and challenging task of improving the lives of the urban dwellers but also searching for optimum solutions to the haphazard spatial developments and inadequate infrastructure within settlements. The kind of living environment created by haphazard development has led to a deplorable living environment for most of urban populations in Ethiopia (UN-HABITAT, 2014)

In Ethiopia most of urban planners and developers were increasingly ignoring the natural environment and causing damage to it. In most cities of Ethiopia while planning for residential home; Planning was dominated by an emphasis on physical building and re-development activities by ignoring social issues and environmental concerns. As a result most of urban residential development has been putting negative impact on surrounding environment and not comfortable for living in terms of social infrastructure for urban dwellers (Weldemariam and Iguala, 2016). According to Ministry of Urban Development, Housing & Construction in Ethiopia only for few urban residential settlements are properly planned and serviced while for the big proportion of urban residential settlements are not properly planned. Besides the existence and extension of this planning gap, the current planning procedures involve methods which are time and resource demanding activities and often far behind the speed of development of settlements.

Similarly in Jimma town, spurred by rapid population growth and its strategic location in south west Ethiopia, it is evident that unprecedented urbanization process is undergoing over the past few decades. As per the national population and housing census of 1994, the town was the home of about 88,867 populations and about 120,600 populations during the census period of 2007 As a result, in much recent years, the city has experienced the intense demand for residential land following footstep of population growth. Moreover, the rising demand for residential housing land coupled with traditional planning techniques in the town tends to push urban dwellers to expand and built houses into different corridors of the city without adequate social infrastructural facilities like road accessibility, clean water, electricity, schools, health post and solid waste disposal facilities.

Due to the planning gap for residential housing development in the town, currently there has been high level of residential housing development on unsuitable area; most of developers never consider their constructions matched with the locational suitability and building house on protected areas of wetlands, on steeper slopes by clearing natural forests, flood prone areas, on productive agricultural land and adjacent to waste disposal site. This unplanned residential home development in the town contributed to a lot of environmental, social and economic impact to the area and the resident itself.

According to Jimma zone Land administration and Use office One of unavoidable impact of unplanned urban residential housing development in the town is the loss of prime agricultural land especially in the last 10 years; most of the productive farm land of the surrounding wereda of the town has been converted to urban residential use which contributes to the shortage of agricultural product supply in the town. There is also extensive development of residential housing development on high risky area of steep slope and at the bank of river by clearing natural forest results an increased incidents of periodic flooding, landslide and pollution of streams and rivers, the polluted streams in turn pose danger to both aquatic life and human beings who draw water from the same streams for domestic purposes in the downstream.

Recently different studies have been conducted on suitable site selection for urban residential housing development and planning using GIS and MCE; (Al-Shalabi ,2006; Mu, 2006; Madurika, 2017; Kevin, 2010; Blachowski. *2016;* Murseli et al, 2012*and* Weldemariam and Iguala, 2016). Thus most of those study concentrated in Identification of Potential Sites for future Housing Development, there is a gap in evaluating the proposed site for residential housing development and there is lacking of research done on similar topics in our study area and take this opportunity to do the research and analyze for using GIS technology to cover the gap of planning in residential housing development in Jimma town.

Since urbanization process and population growth is inevitable, an alternative approach of GIS based model for urban land use planning by highlighting a procedure to identify factors for assessment, classify land based on the criteria, generate a suitability model and evaluate existing, potential and proposed areas for housing using the suitability model could play an important role to effectively satisfy the demand of urban dwellers (Lwasa, 2005). Hence this study was attempted to determine potential Suitable Sites for future Housing Development in Jimma town by using GIS and Multi-Criteria Evaluation technique.

1.3. Objectives of the Study

1.3.1. General objective

The General objective of the study was to determine potential Suitable Sites for future Housing Development in Jimma town by using GIS and Multi-Criteria Evaluation technique.

1.3.2. Specific Objectives

To achieve the above mentioned general objective, the following specific objectives were set:

- Assessing the current site selection practice for residential housing development in Jimma town and identify criteria for locational suitability for residential development.
- To identify suitable site for future residential housing development and generate residential housing development suitability map of the study area.
- To evaluate the suitability of the proposed site of residential housing development in the study area

1.4. Research Questions

Based on the above mentioned specific objectives the following research questions was developed to guide the study

1. What are the suitability criteria that need to be considered in residential housing development site selection?
2. Which sites are the most suitable for urban residential developments in Jimma town?
3. Is the proposed residential housing site by municipality is consistent with the finding of the new suitability site of the study?

1.5. Significance of the study

Of all urban land uses, residential use demands for more land than any other and thus it is the most significant land use in the context of space needs.

In Ethiopia a number of researches have been conducted on GIS based site suitability assessments in urban area, but; most of them focus on suitable site selection for waste disposal/land fill. Only few researches were conducted on suitable site selection for residential development in Ethiopia and no one has done on similar topics in the study area. Therefore, this particular study was focus on a criteria analysis of land-suitability assessment for residential housing development in Jimma town of South west Ethiopia by application of GIS and MCE technology has the following significance s;

- The findings of the study may assist urban land use planners and developers, Police makers, discussion makers and environmental managers especially for plan the future residential land use planning of the study area properly and maximize benefits from the use of land resources. .
- The findings of the research are beneficial to various groups. Many stakeholders are trying to understand the nature of residential property market that follows the property development. This is useful for the people who are looking for the suitable & profitable places to purchase the residential properties and to identify the development level of the area
- The findings of the study could be an initial input for future research direction for interested groups in the area.

1.6. The scope and limitation of the study

The Research deals with GIS Based MCE Approaches to locational suitability for future urban residential housing development in Jimma town of Oromia regional state. Currently the town covers 106.34 km^2 total area of land. The study was focus on assessing the current site selection practice for residential housing development and identifying the criteria for locational suitability for residential housing development, Mapping suitable site for residential housing development and finally evaluating the suitability of proposed site of residential areas in Jimma town by combining GIS and MCE. Different spatial data sources that were relevant for residential housing development (Environmental and Socio-Economical criteria) were used. The criteria were selected based on expert opinion and extensive literature survey and the weight of each criterion also provided based on expert opinion in AHP methods.

There are some limitations in the study, such as:

- Lack of data and time limitation. The limited database is still a challenge for future studies. In this sense, implementing the spatial data information system is a major task to be worked upon during research period. As well as no proper data record system on required information in other governmental authorities too.

1.7. Organization of the Thesis

The thesis was organized in five chapters; Chapter one presents the background of the study, statement of the problem, and research objectives. It also addresses the significance of the research ,scope and definitions of key operational terms. Chapter Two presents the literature review, where a general review of current knowledge relevant to the research topic is provided. Chapter Three describes the description of the study area and the methodology used in the study and data collection techniques and in depth analysis are explained as well. Subsequently, Chapter Four presents the results and discussions; finally, the paper present Chapter Five that was gives an overall summary of the research findings and recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Land use planning

With the increasing demand for land, land use planning and land evaluation have become more important as people strive to make better use of the limited land resources. Land evaluation is the process of assessing land performance for specified purposes (Rossiter, 1996). Land suitability assessment, a typical analysis approach for land evaluation, is the process of determining the fitness of a given tract of land for a defined use (Steiner, 1991). It is an indispensable part of land evaluation in the process of land use decision making. Accordingly it can argued that land use planning is a technical process which deals with physical, economical, environmental as well as social factors of users of that area**.**

Land suitability assessment was introduced to China in the end of 1970s. In the past decades, land suitability assessment has been adopted as an important part of land use planning in rural areas, urban areas and the fringe of urban and rural areas of China. In China, land suitability evaluation for a given crop is the most widely used aspect of land suitability assessment (Fang and Liu, 2004)

Land-use suitability analysis aims to identify the most appropriate spatial pattern for future land uses according to specified requirements, preferences or predictors of some activity (Collins etal., 2001). In order to determine the most desirable direction for future development, the suitability for various land uses should be carefully studied with the aim of directing growth to the most appropriate sites.

Traditionally, land-use suitability analysis was performed by employing specialists of various disciplines to evaluate the decision problem and recommend the most appropriate location based on their expertise (Streinitz et al, 1976).However, the need to integrate the different ideas of all these various specialists into a single decision model resulted in the use of spatial data, to aid in the decision making process (Pawanda, 2013).

The approach to land suitability assessments is made up of three steps. The first step is selecting the influencing factors and grading the weights and relative values for the factors. The second step is incorporating the maps and database in GIS. The last step involves calculating the suitability score of each land parcel for the given use and making the land suitability map. (Mu, 2006)

Land suitability assessment can help planners to select appropriate areas for government activities, residential land use, and industrial land use and so on. By taking the results of land suitability assessment into development consideration, the planners and decision makers can plan the future land use planning properly and maximize benefits from the use of land resources.

2.2. Suitability Process

Feasibility evaluation requires consideration of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for a defined land use. The process of evaluation of locational feasibility housing site selection begins with the recognition of an existing or projected need. This recognition triggers a series of actions that starts with the identification of geographic areas of interest. In the past, an evaluation criterion was based almost purely on economical and technical criteria. Today, a higher degree of sophistication is expected. Evaluation criteria must also satisfy a number of, Physical criterion and Social criterion

2.3. Factors Defining the Patterns of Urban Land Use

Cities, and the associated process of urbanization, are the product of industrialization and changes in technology. While the form of urban places has changed dramatically, particularly in the last 50 years, the basic structure of cities have been remarkably flexible (Cohen, 2003).

The importance of land use decisions in any urban area tends to locate activities in places best suited for them. The spatial differentiation of land use pattern becomes more marked and complex as the corresponding linkages and degree of specialization increases. Essentially, urban land use within any locality is conditioned by two factors. These include non profit use of land particularly for the construction of roads, parks, gardens, playgrounds, educational buildings and government offices. The other factor includes land which is developed with profit making motive. It includes the development of sites for offices, residence and industries. The profit use of land is highly dependent on the non-profit use of land. Alter the later and the former will be altered (Bracken, 1981, Rangwala, 2002).

2.4. Urban Land Use Problems and Implications in Africa

The location, structure and design of residential areas in relation to other basic and community services required by urban residents comprise some of the most absorbing problems facing planners in different parts of the world today. The present pattern of urban land ownership with the inadequacies of the existing land areas have contributed largely to the contemporary urban land-use problems in many cities of the Africa. The private and social needs of urban families are intimately affected by the physical arrangements of living within urban areas. Although various social and economic problems associated with urban development in tropical Africa have received considerable attention by social scientists for a very long time, less attention has been paid to the physical problems. Similarly, planning authorities in the countries of the region have shown little concern for the mounting physical problems associated with the existing pattern of urban land-use in their cities.

Consequently most urban centers in the region are characterized by overcrowding, congestion, slums, squatting and the inadequacy of basic services, community facilities and civic amenities. The solution to these land-use problems in the cities of tropical Africa will be largely impossible without the formulation of an effective urban land policy by public authorities in the countries of the region. (*CLKnet Forum 7 Report- www.clknet.or.tz,2012)*

2.5. Classification and Types of Urban Land Uses

2.5.1. Residential:

Amount of land depends on the way of which new households are formed and on immigration. Residential zone consist of pure residences and residences with mixed activities. In the mixed use small business and manufacturing activities that do not cause nuisance to residents are located within predominantly residential areas.

2.5.2. Commercial areas:

Category includes all types of wholesale, retail and service activities serving areas larger than neighborhoods. *Included in this category are the following:*

- Major Central Business Districts in urbanized areas
- Minor Central Business District in less urbanized areas
- Highway Service Centers or Commercial Strips such as highway gas stations, traveler's inn and restaurants.

2.5.3. Institutional Areas:

It covers the major public and semipublic uses like educational, cultural, religious, health, protective and government services. It includes Services such as educational services, health services, sport and recreational facilities, worship places and cemeteries which provide service to the residents of a town as well as the neighboring rural areas and urban centers.

2.5.4. Industrial uses:

It includes manufacturing, refining, fabricating, assembly, storage, parking and other incidental uses including food processing, cottage industry, sawmills, rice mills, steel mills, chemical processing plants, etc

- Also included are the proposed industrial estates/subdivision

2.5.5.Open and Green Spaces

The so called "non-functional open spaces" and includes lands reserved for greenbelts and buffer zones; and other vacant lands reserved for specific or functional purposes. Major Contents of the category includes: Open space for outdoor recreation, necessary for the preservation of natural resources; Open space for the managed production of resources; Open space reserved for public safety against risks from environmental elements; Open space for future expansion; Right-of-ways reserves for future upgrading of road size, etc. (http://www.aboutcivil.org/)

2.5. The specific of the residential use of land

Businessman locates their activities where they can maximize profits and households live where they can maximize utility that is achieving the greatest residential benefits. Here it is important to examine that prominent factor that determines profitability and utility. The answer is accessibility(Shattri et al, 2006)

For residential land use, the property is a multidimensional commodity, characterized by durability and structural inflexibility, as well as spatial fixity. Each residential unit has a unique bundle of attributes, its accessibility to work, transport and the amenities, and the structural characteristics, neighborhood and environment.

Chapin *(1995)* stated that the following function of residential area to support the needs of residents in a way that also furthers such community goals as environmental quality and efficiency.

- **Shelter:** this encompasses the traditional concern of housing, and basic services, such as water, sewer and electricity.
- **Security:** Providing safe, stable, and ordered setting free of danger from Traffic, violence, criminal actions, and other physical and psychological hazards.
- **Chilled rearing:** Facilitating transmission of values through family neighbors, peer groups, churches, community organizations, schools and play space
- **Symbolic identification:** Providing a sense of place, belonging, pride and satisfaction to the resident.
- **Social interaction:** Providing personal associations through social networks, organizations and physical facilities.
- **Leisure:** Providing recreation, entertainment, cultural and educational facilities and programs and open space.
- **Accessibility:** Providing access to employment, shopping and personal Services required maintaining a household, as well as to regional scaling entertainment and leisure opportunities.
- **Financial investment:** Protecting the large financial stake in the residence, this often services as an investment for future financial security for the homeowner
- **Public efficiency:** Minimizing public or societal costs associated with meeting the needs of households, including the costs of water and sewer, garbage and trash collection and the costs of maintaining public capital improvements such as streets and sidewalks.

2.6. Criteria for Location of Residential Use

Suitability Factors are the characteristics of the land which will be considered in determining the relative suitability of different locations for a particular land use. The suitability factors to be considered are specified by the user and can include the full range of natural features including slopes, soils, flood plains, and landslide prone areas. They can also include other suitability factors such as the distance to amenities such roads and parks or to disseminates such as hazardous waste sites (Huang et al, 2019).

Chapin and Kaiser (1978) stated that, the development of urban residential land use is influenced by numerous factors. These include physical, socio-economic and environmental quality and amenities. The first step that was taken in this analysis was to collect all of the data that would be needed to meet all of the criteria. Criteria were selected to evaluate potential housing sites and to support decisions concerning the location of additional housing areas.

The criteria must be identified and include factors and constraints. The criteria were selected on the light of literature and planning guidelines (master plan) in USA and in the other countries like Malaysia. These factors include,

I. **Topographical aspect**

Topography factors affect the land use planning and the important factors associated with topography include aspect, elevation and steep slopes. From the master plan policies, considered that the sites is not suitable for housing development also we have to a void the high elevation area because the planning in the areas costs a lot to the government, particularly supplying the mountains area by facilities like roads, water supply, electricity, and so on, are much more costly in comparisons with the flat areas. Among the physical factors that are commonly studied in residential site selection. Areas with exceeding 10 % are usually not suitable for residential development (Chapin and Kaiser 1978). The idlest areas for housing residential use are areas with 2-6 % slopes.

II. **From the goal of safely.**

The presence physical hazard reduces the suitability of a site. For Selecting safe housing sites and a void the risks is deriving from water. Chaping stated that the risks here can arise from flooding in the rainwater season

III. **From the goal of minimization of the cost of urban development reducing mobility.**

Road accessibility is one of the important parameters for urban development as it provides linkage between the settlements. The distance to existing urban areas is important because the significantly impact moving costs, so the roads are an important factor in housing development because their presence indicates human activity. The locations must be adjacent to built up areas (existing neighborhood), in the low-density

Belching (2000) cited in (Ekanayaka, 2016) investigated the factors which determine the acceptable residential location. He mentioned different factors which are highly significant in locational suitability for residential development such as accessibility, neighborhood quality, environmental Quality, negative environmental influences (pollution, traffic etc), environmental factors (wetland, wildlife, senic rivers etc), desired infrastructure, reasonable size and design, surrounding uses, excessive traffic congestion and additional factors (historical development, topographical features and size, dynamic changes and, government Policy). Those factors highly affect the residential uses and these factors should be considered when selecting a suitable location.

Site selection requires consideration of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for a defined land use. Better residential development is based on a complex array of critical factors drawing from physical, demographical, economic, policies, and environmental disciplines. (Al-shalabi, 2006)

Lwasa, 2005 in his study in residential housing development in Kampala city of Uganda. It specify the criteria from the following general broad view

- Physical criteria including physical factors such as slope, soils, drainage conditions
- Environmental criteria, which refers to the suitability of the site from the conservation and ecological point of view
- Socio-economic criteria, including land prices, distance from the site to employment area and proximity of the area to the existing infrastructure.

Identifying criteria for residential housing development is important for the purpose of ensuring the maximum society's benefits (Weldemariam and Iguala, 2016) he considers eleven economic and environmental factors support identification of potential sites for housing development in Dire dewa municipality in Ethiopia. The economic factors like; Slope, Accessibility to road and railway, Accessibility to road and railway, Distance from built-up (developed) Area, Proximity to urban center and Population Density. Environmental Factors like; Aspect (Topography), soil. Flood area, Distance from airport and Land-uses/land-cover

Miles (2000) suggests that factors that are important in locating sites for residential developments include:

- Physical suitability for development: slopes, soils, hydrology, land availability
- Legal restrictions, government regulations (zoning and other land use controls)
- Existing land use patterns and location of other residential development
- Access, including proximity to interstate highways
- Distance to employment sources
- Distance to shopping centers
- Availability of amenities (water, restaurants, parks)
- Neighborhood factors: age of surrounding housing stocks, schools, crime

However, multiple sites may be suitable when evaluated across the range of criteria, yet one is developed. Development may further be moving in a single direction or sector of a city although suitable sites are available in other areas. This suggests that certain factors may be important than others in determining the location of new projects.

Residential areas are highly demanded spaces in the urban form. In urban areas this consists of 30%- 50% of the developed land. Moreover, in addition to dwellings, residential areas contain other uses that support the day —to-day life of city dwellers. Therefore optimum utilization of land is important phenomena for that. For fulfill above task we need to identify suitability areas for that. Taking into consideration the residential suitability, suitability analysis can be used as a tool.

2.6. Structure of the Suitability Classification

In FAO's (1976) Framework for Land Evaluation, the structure of the suitability classification is described recognizing qualitative, quantitative and of current or potential suitability in four categories of decreasing generalization. Each category retains its basic meaning within the context of the different classifications and as applied it different kinds of land use.

1. **Land Suitability Orders** Land Suitability orders indicate whether land is assessed as suitable or not suitable for the use under consideration. There are two orders Suitable and not suitable represented in maps, tables, etc.

Order "Suitable"- Land on which sustained use of the kind under consideration is expected to yield benefits which justify the inputs, without unacceptable risk of damage to land resources.

Order "Not suitable"- Land which has qualities that appear to disqualify sustained use of the kind under consideration.

2. **Land Suitability Classes:** Land suitability classes reflect degrees of suitability. The classes are numbered one after the other, in sequence of decreasing degrees of suitability within the Order.

Class S1-"Highly suitable": Land having no significant limitations to sustained 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 Si land.

Class S3 -"Marginally Suitable"(Less): Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increases required inputs, that this expenditure will be only marginally justified.

Class NI- Not Suitable: Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost.

The process of suitability classification is often easier than it might appear. Although theoretically there are an almost unlimited number of land-use requirements and land qualities, in practice only a few have a major influence on suitability. These factors change from place to place and depend, of course, on the nature of the land used. Each land use has requirements and limitations that relate separately to its objectives, its management needs and to environmental issues **(**Ekanayake, 2010).

2.7. Site Selection Tools

Geographic Information System (GIS) and Multi Criteria Decision Analysis (MCDA) techniques have been used in solving site selection problems. GIS techniques and procedures play an important role in analyzing decision problems and MCDA techniques and procedures provide for structuring and design of decision problems, evaluation and prioritization of alternative decisions (Florent et al, 2011).

2.8. The Role of GIS for Land Suitability Analysis

Geographic Information System (GIS) is conventionally seen as a set of tools for the input applied to computerized information storage; processing and retrieval system that have hardware and software specifically meant to cope with geographically referenced spatial data and the corresponding attribute data (spring, 1997).

Culbertson et al. (1994) noted the great potential for GIS technology in planning for sustainable development, as an extension of its traditional use in environmental analysis by integrating common database operations such as query and statistical analysis with the unique visualization and the geographic analysis benefits offered by maps.

Land suitability assessment is one of the contributions of GIS application. GIS technology has been used to assess the criteria requested to define the suitability of land (Joerin, 2001). GIS combined with qualitative and quantitative methods for suitability analysis that can provide the necessary tools for the integration of both social and ecological data into a meaningful database. In the process of suitability assessment, GIS supported spatial assessment is based on weighting relevant factors (or map layers in a GIS database), such as slope, elevation, soil types, existing land use and social service (Mu, 2006).

From the perspective of land suitability analysis, it is important to note that the layered approach involving the idea of breaking the geography of a real world (landscape) into a series of attribute layers was used to develop the first map overlay technique. The layers are the bases for combining a set of maps displaying land suitability for different land uses (McHarg, 1969). In general, the raster data model has traditionally be recognized as the more appropriate approach for land-use suitability applications. Consequently, such functionality as Boolean operations, proximity analysis, buffer operations, and overlays can be more easily implemented in the raster model(Ekanayake, 2010)

2.9. Multi-Criteria Evaluation (MCE)

Multi-criteria Evaluation is primarily concerned with how to combine the information from several criteria to form a single index of evaluation. MCE techniques are numerical algorithms that define the suitability of a particular solution on the basis of the input criteria and a weight together with some mathematical or logical means of determining trade- offs when conflicts arise (Heywood et al., 2002). A spatial multi-criteria decision problem involves a set of geographically defined alternatives from which a choice of one or more alternatives is made with respect to a given set of evaluation criteria (Carver, 1991).

The data are processed using GIS and MCE techniques to obtain information for making the decision. The process of spatial multi-criteria evaluation combines and transformed geographical data (input) into a result decision (output). The MCE procedures define a relationship between the input maps and output maps which involves evaluation of geographical events based on the criterion values and the decision maker's preferences with respect to a set of evaluation criterion. (Lukoko et al, 2016).

Step 1. Defining Site Selection Criteria: In the first step, the analyst declares the type of facility and defines the regions of interest. Based on the facility type and the regions of interest, the analyst defines the sitting criteria.

Step 2. Preparing Criterion Maps: After defining the siting criteria, the analyst prepares the criterion maps based on the predefined siting criteria. A criterion map represents the spatial distribution of an attribute that measures the degree to which its associated objective is achieved. The procedure for generating criterion maps is based on different GIS functions.

Step 3. Data Standardization: Given a variety of scales on which each criterion can be measured, MCE requires that values contained in the various criterion map layers be transformed to comparable units (standardized to a common scale).

Step 4. Multi criteria Evaluation: A number of MCE techniques have been implemented in the GIS environment for tackling site selection problems. AHP, OWA, and the extension of AHP using OWA operators are three of the most commonly used techniques for solving the sating problems.

2.10. The Analytical Hierarchy Process

The Analytic Hierarchy Process (AHP) is a powerful and flexible decision making process which helps people to set priorities and make the best decision when both qualitative and quantitative aspects of decisions need to be considered. AHP was developed in 1970's by Thomas Saaty, as a decision-making theory. (Ekanayaka, 2016).
AHP currently one of the important techniques for analyzing land suitability. AHP is categorized under the multi-criteria decision analysis approach and is an effective technique that helps planners and decision makers to analyze all data before arriving at a final decision for future land-use changes (Nguyen, 2006). AHP has been integrated with GIS tools to identify the importance of the criteria used and to calculate weights by using a scale of importance and the opinion of experts (Mohammad, 2013).

The main framework of AHP is a hierarchical model. It comprises goal, criteria, perhaps sub-criteria and alternatives to each problem or decision. Pair wise comparison matrix is most important procedure of AHP. The criterion pairwise comparison matrix takes the pair wise comparisons as an input and produces the relative weights as output and the AHP provides a mathematical method of translating this matrix into a vector of relative weights for the criteria (Malczewski, 1996).

In the pairwise comparison matrix, two elements are compared at a time using a scale that ranges from "extreme important" to "equally important", and their inverses (down to 1:9). Based on the criterion weights derived from the pair-wise comparison matrix, scores for group attributes in the hierarchy are calculated as a weighted average of elements in the group. Following table 1 indicates AHP scales for pair-wise comparisons. (Milad et al, 2015).

The Pairwise Comparisons Method was developed by Saaty in the context of the Analytic Hierarchy Process (AHP). This method involves pair wise comparisons to create a ratio matrix. As input, it takes the pairwise comparisons of the parameters and produces their relative weights as outputs. The pairwise comparison matrix is the most important procedure of Analytic Hierarchy Process. AHP provides a mathematical method for translating this matrix into a vector of relative weights for the criteria (Malczewski, 1996; Eastman et al., 1995). It is a procedure by which criteria evaluations are compared and acted upon (Eastman et al, 1995). In the pairwise comparison matrix, two elements are compared at a time using a scale that ranges from extreme important to equally important and their inverses. Based on the criterion weights derived from the Pairwise Comparison Matrix, scores for group attributes in the hierarchy are calculated as a weighted average of elements in the group.

Table 1: The AHP Scales for Paired Comparisons

Intensity of pair wise comparison	Definition
1	Equal Importance
2	Equal to Moderately Importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extremely importance

Source: Saaty (1980)

CHAPTER THREE

3. DESCRIPTION OF THE STUDY AREA AND METHODOLOGY

3.1. Description of the study area

3.1.1. Physical setting

3.1.1.1. Location

Jimma town is located at about 355 km south west of Addis Ababa, the capital city of Ethiopia, the townn extends between geographic coordinates of at 7° 40′ 19″ E to 7° 41′ 56″ E latitude and 36° 36′ 52″N to 36°53′ 25″N longitude (Figure 1).

It is bordered with Kersa Wereda in the east; with Manna wereda in north, and Manna & Seka Chekorsa in west, Dedo in south direction. Currently, the town has been restructured in to 17 urban Kebeles (administration units) having the total area of 106.34 km^2.

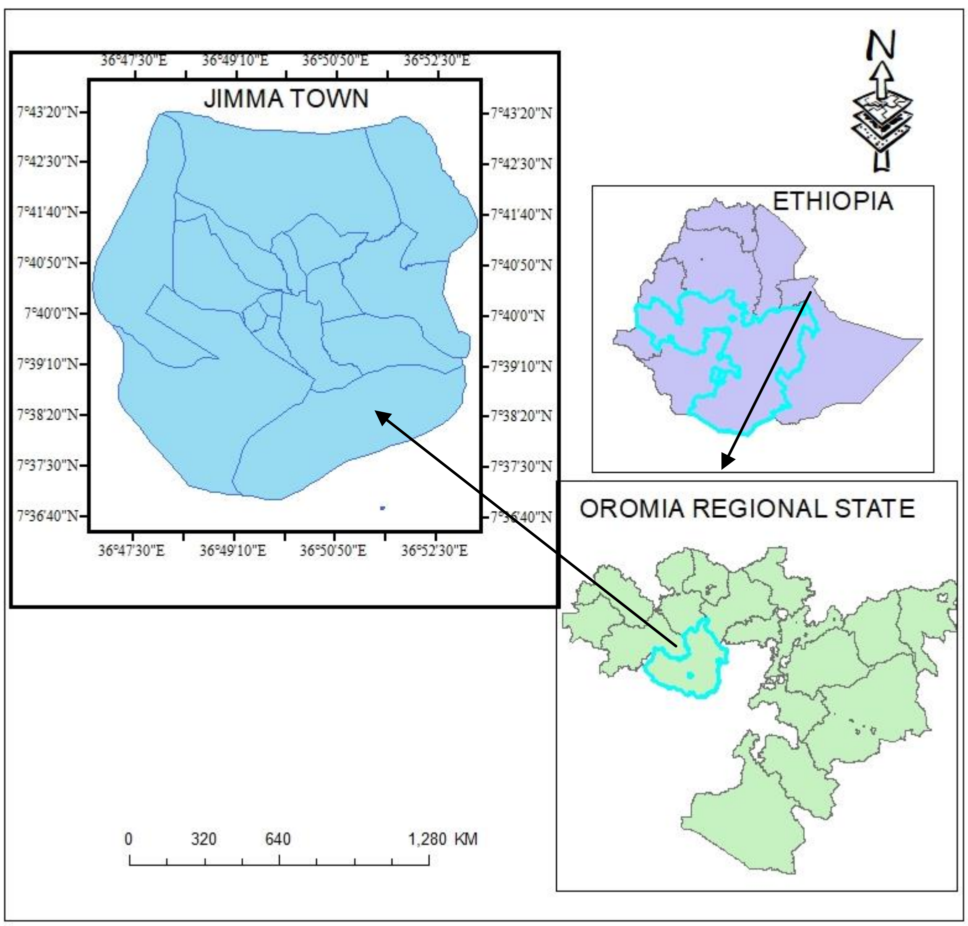

Figure 1: Map of The study area

3.1.1.2. Topography and Land form

Jimma town lie on an elevation varying from 1670m asl to 2281m. the lowest elevation of the town found in the south/along Gibe River. Whereas the highest elevation of the town located in the northern periphery of the town, i.e. in the Jiren. Topography of the town can generally be divided in two main zones: Escarpment and Alluvial plain zones. Escarpment zone: represents topographically elevated areas and surrounds the city in the northwest, north and east. Alluvial Plain zone: contains fairly broad valleys and represents lower grounds and elongated low-hills. It starts from the foot of the escarpment zone and trends to the south- south east. This zone covers most of the settlement area of the town and diminishes into flat further south of the town. The major part of Jimma town, including the central, southern and western parts, is characterized by flat to gently sloping/undulating topography, while the northern and eastern parts of the town and its peripheries are characterized by hilly/ sloping landscape (Figure 2).

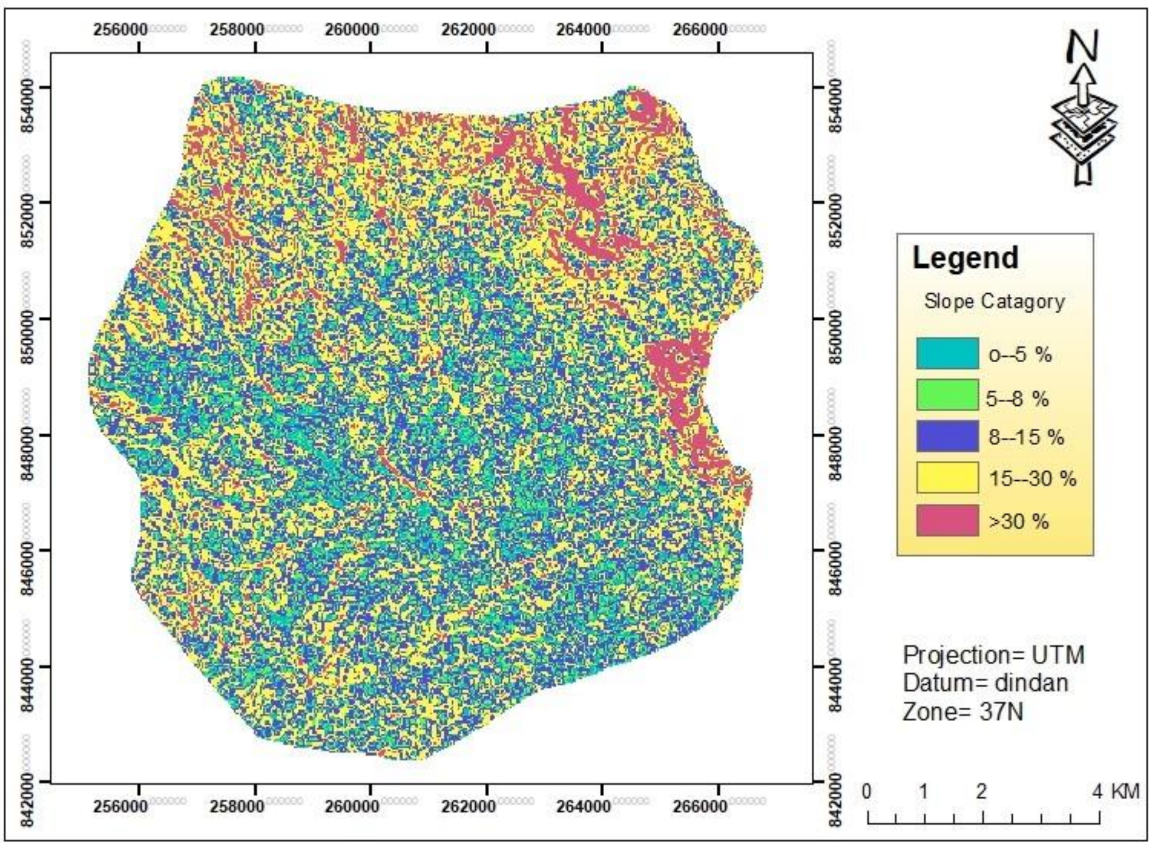

Figure 2: Slope Map of The study area

Table 2: Slope class of the study area

Slope Range (%)	Area Cover (ha)	Percentage (%)	Class name and description
0-5	4015.9	`1.19	Flat to almost flat terrain
5-8	74997.31	22.27	Gently undulating to undulating terrain
8-15	59764.96	17.74	Rolling terrain
15-30	138263.9	41.05	Hilly terrain
>30	59796.68	17.75	Steep dissected to mountainous terrain

3.1.1. Climate

The study area is characterized by temperate humid climate that has high precipitation, warm temperature and long wet period. According to 14 years rainfall data collected from the National Meteorological Agency of Jimma Sub-branch, the annual rainfall of Jimma Town from 1952-2015 varies from 1414.4mm to 2392.3mm with a mean annual value of 1769.7mm. Although Jimma area has almost all year round precipitation, According to 2018 rainfall data of Jimma meteorological center (Figure 3) Most of the rain occurs in May, June, July and August while December, January and February is the lowest rainy season of the study area.

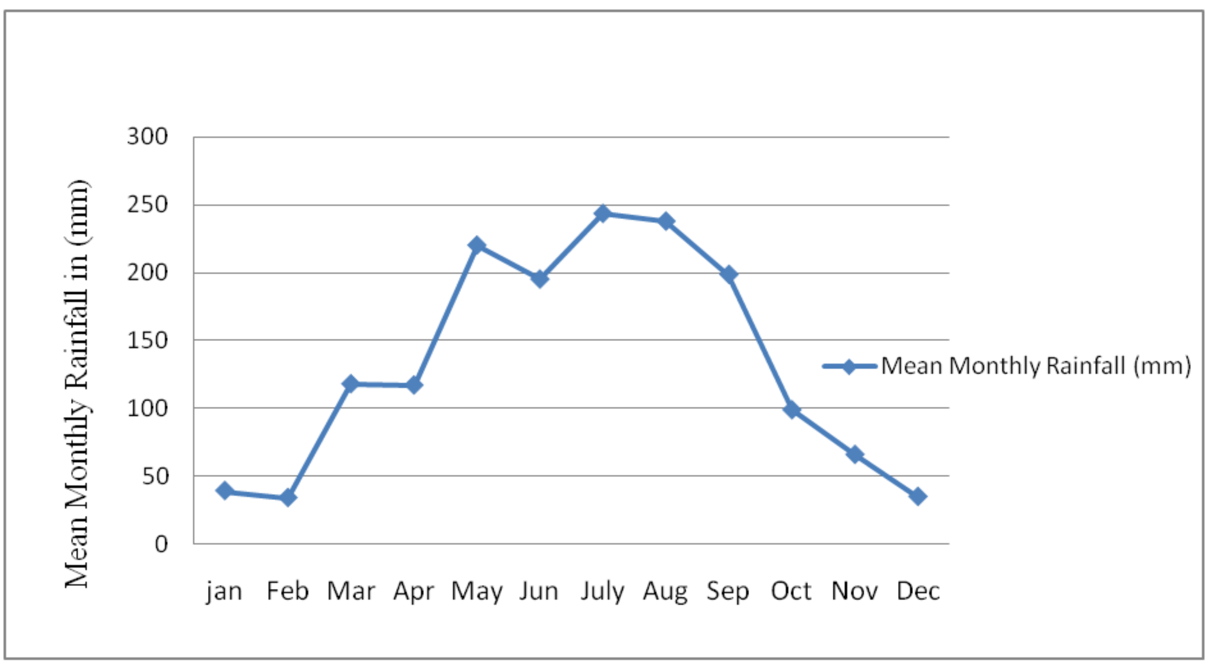

Figure 3: Mean monthly Rainfall of the study area

Source: Ethiopia Meteorological Agency (2018)

The mean annual temperature of Jimma town is between 12^{o}C and 29^{o}C with the mean daily temperature of 19.5^{o}C. Maximum temperature in Jimma town occurs in March and April and minimum temperatures are at their lowest in November to February. The mean monthly meteorological data for the 2018 year of the area is presented in figure 4 below.

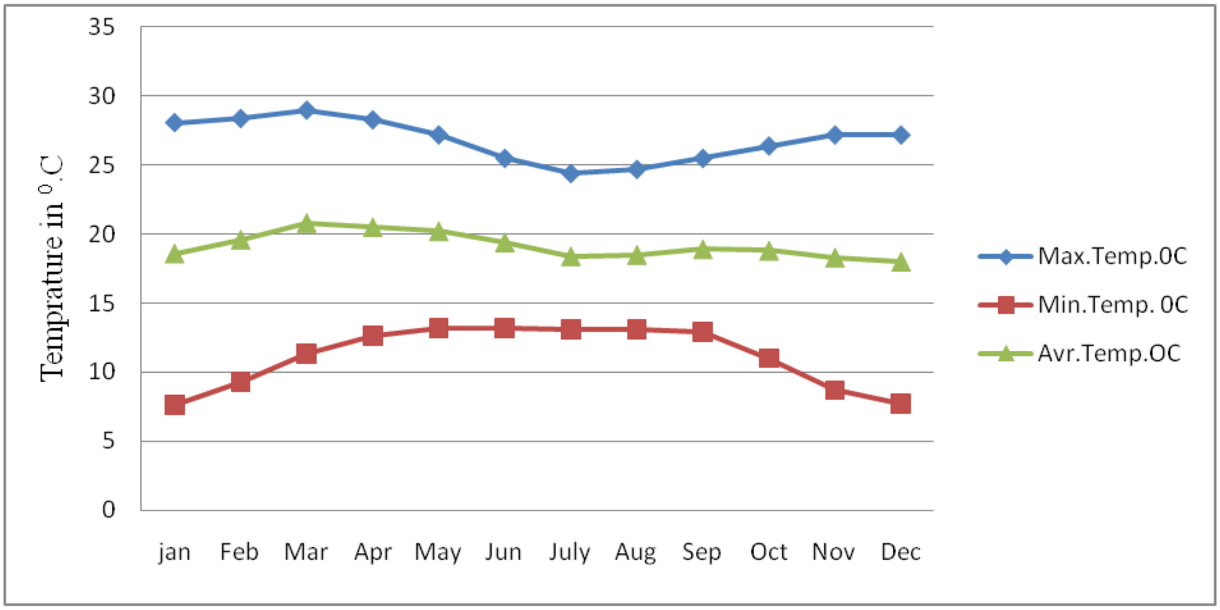

Figure 4: Mean monthly Max and Min Temperature of the study area in 2018

Source: Ethiopia Meteorological Agency

The average maximum temperature in the study area varies from 25.8°C in 1952 to 28.62°C in 2000 and the average minimum temperature varies from 10.12°C in 1955 to 12.91°C in 2010. In the period of 1952 to 2015, the mean annual maximum temperature showed a warming trend of 2.74 °C per decade (Table 4).

Table 3: Variations of annual maximum and minimum temperature in Jimma (1952-2015), Source: National Meteorological Agency.

Year	1952	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
Average annual temp.^{0}C(Min)	11.3	10.12	10.33	10.95	11.28	10.81	11.2	10.69	11.5	11.83	10.95	11.31	12.91	12.32
Average annual temp. ^{0}C (Max)	25.8	26.95	28.28	26.69	26.18	26.39	27.18	26.97	26.52	28.05	28.62	27.9	27.37	28.54
Mean annual temp. ^{0}C	18.5	18.54	19.3	18.82	18.73	19.6	19.19	18.83	19.01	19.94	19.79	19.6	20.4	20.43

3.1.2. Geology and Soils

On the basis of information provided in the Jimma City Profile of 2008/2009, the geological formation of the Jimma area consists of various Tertiary Volcanic and younger Quaternary Sediments. Due to mostly thick soil formation and good vegetation cover, outcrops of the volcanic rocks are not common in the area. The volcanic rocks vary from basalt to rhyolites in lithology and include basaltic flows, acidic flows, ignimbrites and tuffs of the so-called Maqdala and Ashange groups.

According to the extracted digital soil data, the town has four major soil classes based on FAO/UNESCO soil classification system. They are eutric fluvisols (55%), dystric nitisols (40.5%), chromic vertisols (3%), dystric fluvisols (1.5%) Except the permanent wet & swampy area where the soil is rich in organic clays both of the major soil types are suitable for urban developments as foundation materials

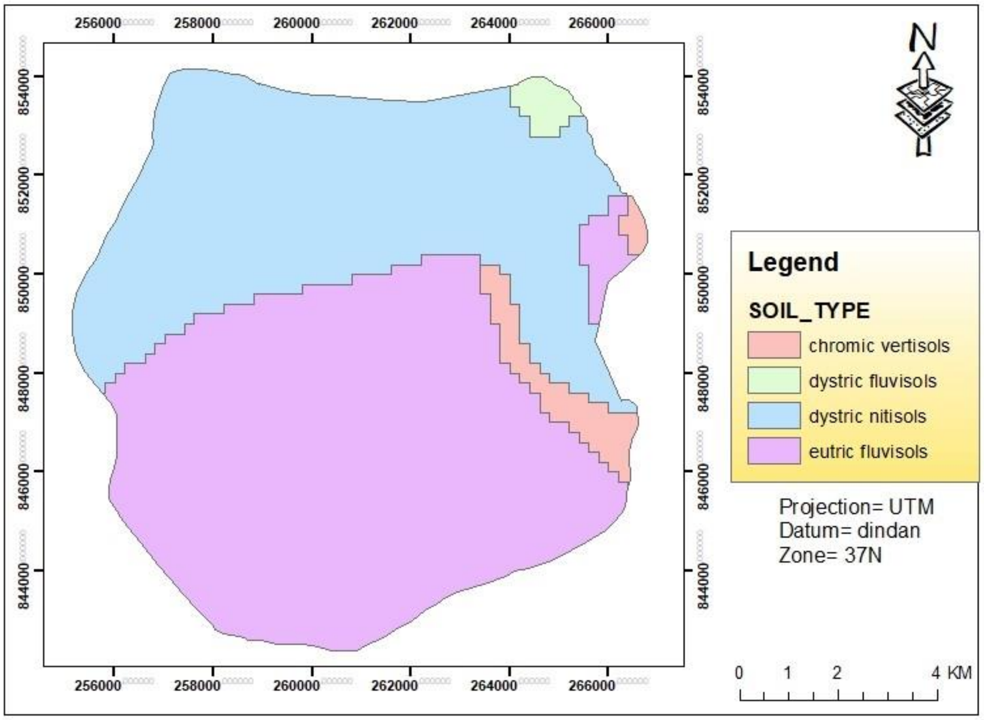

Figure 5: Soil Map of the study area

3.1.3. Hydrology &Hydro geology

3.1.3.1. Surface water

The catchment of the natural drainage of Jimma town is defined by the Jiren, Seto Semero, Kitto Kore, and Ela Dale at the north and flows down into the core of the city then to the south to Boye Wetland and Gilgel Gibe River. Areas beyond the hills at the north also drain to Aweytu River.

3.1.3.2. Hydro geology& Groundwater

Jimma area is located in the southwestern Ethiopia plateau in an area of moderate relief and is situated on a low hill to the north of the wide alluvial plain of the Gilgel Ghibe River. It is also underlain by tertiary volcanic rocks, while the valleys bedrock is overlain by alluvial sediments. These alluvial sediments occupy the broad valleys of the study area. The thickness of the alluvial sediment beneath the surface ranges from20m in the upper part to greater than 200m in the deeper part of the valley. The volcanics is mainly composed of massive rhyolites with alternating trachytes, tuffs, ignimberites, and subordinate basalts. Based on topography, variation in hydraulic properties of the volcanic rocks and alluvial sediment, and their location the main hydrological basin the Jimma area is classified into three sub-basins as the Kochi, Awetu and

Kitto sub-basins. The Kochi sub-basin is drained by the Kochi stream which joins Awetu stream at Boye. On the other hand, the Kitto sub-basin drains by the Kitto stream finally joins Awetu stream at Dedo Bridge.

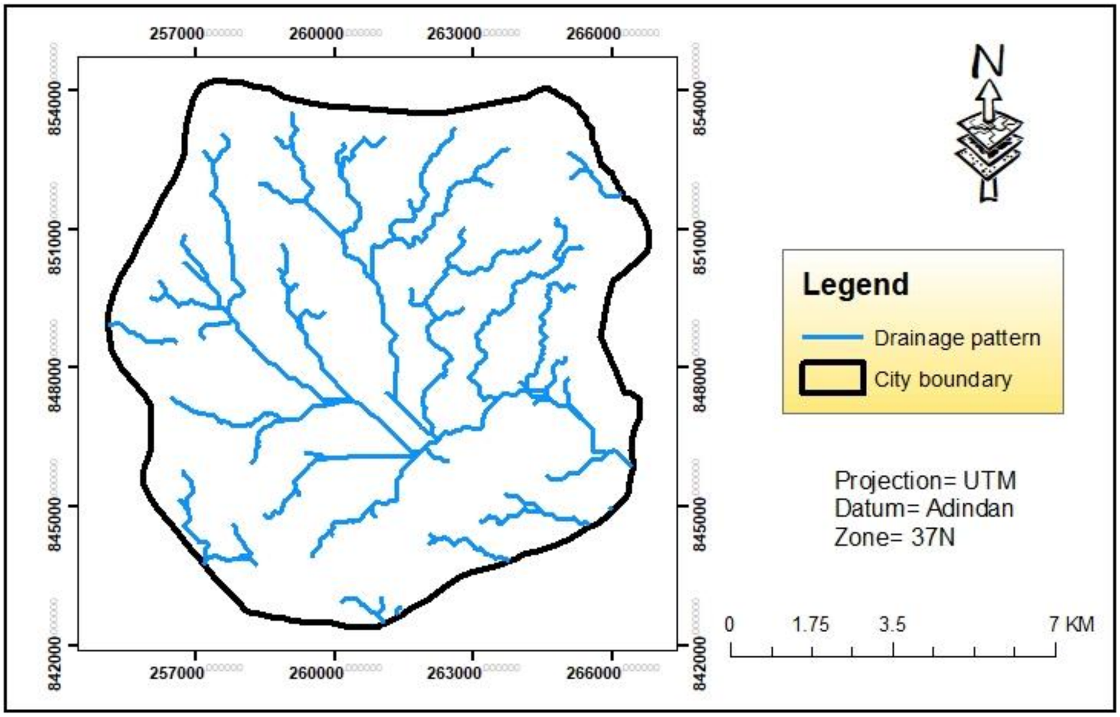

Figure 6: Drainage pattern Map of the study area

3.1.4. Demographic and Socio-Economic characteristics of the study area.

The 1994 Population and Housing Census of Ethiopia indicated that there are a total of 88,867 people living in Jimma town, out of whom 43,874 were males and 44,993 females which account 49.4% and 50.6% respectively. Based on the 1994 Census result, the projected total population size of Jimma town in Year 2007 was 167,359. However, according to the 2007 Population and Housing Census of Ethiopia, the total of population of Jimma town in year 2007 was only 120,600, out of which male and female were accounted 50.24% and 49.76% respectively. This indicates that the population of Jimma has been growing at the rate of 2.3% per annum during the period between the two censuses. According to the 2013 projected estimate figure of Ethiopian central statistical Agency, the total population of Jimma is 155,434 with 3.65% annual growth rate.

According to data obtained from Jimma town administration in the year 2018 the total population of the town reaches to 242,621population (table 5).

Table 4: Total population of the study area

No	kebele	Number of House hold	Male	Femel	Total
1	Jiren	835	2017	2026	4043
2	Ginjo	6115	14754	14768	29522
3	G/Guduru	3090	7470	7461	14931
4	M/Qocii	3899	9405	9427	18832
5	Saxoo	2854	6886	6901	13787
6	A/Mandara	3602	8690	8708	17398
7	B/Addis	2913	7031	7047	14078
8	B/Kitto	4218	10180	10193	20373
9	Hirmata	2427	5857	5880	11737
10	Ifa Bula	1085	2620	2629	5249
11	Qofe	1408	3423	3441	6864
12	Bore	1571	3795	3806	7601
13	H/Markato	2359	5697	5712	11409
14	H/Mantina	2937	7089	7098	14187
15	Mantina	2935	7084	7103	14187
16	B/Bore	7543	18204	18206	36410
17	H/Gibe	413	1006	1007	2013
	Total	50204	121208	121413	242,621

Source: Jimma town administration (2018)

According to the report of Finance and Economic Development Office of Jimma town (2010), the main economic activities in the town are commerce and small scale manufacturing enterprises. The local urban–rural exchange in the area has contributed significant business activities in Jimma. The industries in the town are small scale and cottage industries like grain mils, wood and metal workshops, coffee hullers, hollow block manufacturing, bakeries and pastries. The dominant manufacturing activities that account 70% of the total number of manufacturing enterprises in the town are grain mills and wood works. This indicated that there are no big industries in the town.

Archaeological and Cultural Heritage

The major cultural heritage sites in the town include the palace, mosques and tombs of the kings and their relatives at Jiren and a one storey building in the town. The palace, named as ‘Aba Jifar Palace’, is located at higher ground in Jiren Kebele and there are two mosques within the palace compound, which were constructed during the reign of Aba Jifar II. There are also household utensils and personal belongings of Aba Jifar II which are gathered in a building found in the centre of the town, which is being used as a museum. ‘Mesgida Afurtema’, is another mosque constructed during the reign of Aba Jifar II. It is located at about 500m south of the Aba Jifar Palace compound. There is also a family cemetery of Aba Jifar II near the Mosque 40. Furthermore, there is an old one storey building, known as ‘Melessie Foq’, in the town along the road that leads to the Jimma Airport. The building is important because of its architectural resemblance with the Aba Jifar II palace and its construction around the same time. Its age is around 100 years and it is probably the oldest house in the town boundary. The above indicated historical monuments and relics have both cultural and economic importance. They are the material evidences of the past history and culture of the people who lived in and around the town. They are important tourist attraction places in the Jimma area. In particular the Aba Jifar II palace and the Museum are visited by many tourists annually. The collections in the Museum include relics mainly of household utensils and personal belongings of Aba Jifar II, and ethnographic collections.

3.2. Methodology of the study

3.2.1. Research Design

The research design which is used for this study is mainly categorized in to two main parts, which is data collection and data analysis. Figure 7 is shown the conceptual frame work for the research design.

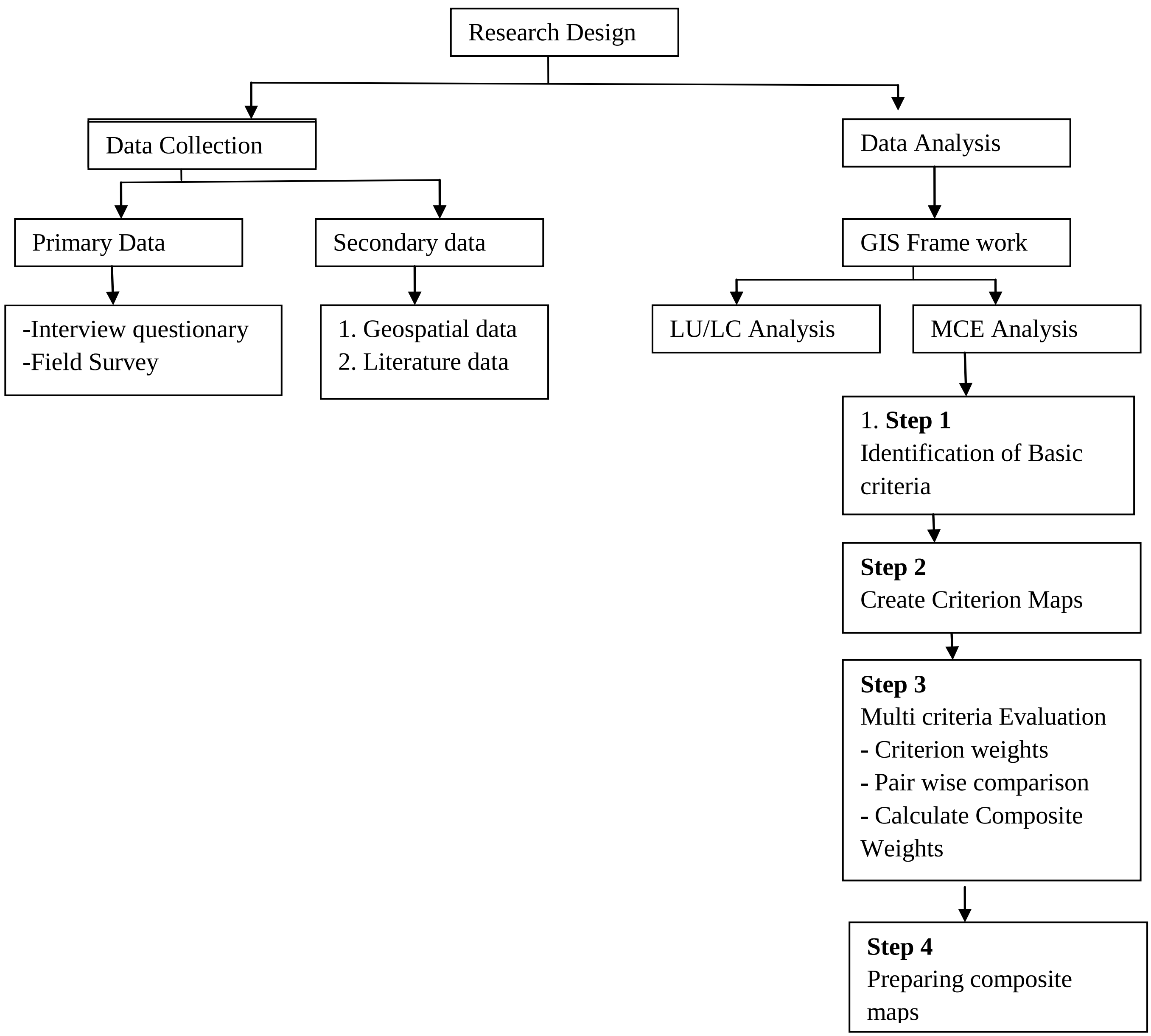

Figure 7: Research design

3.2.1.1. **Data Types and Sources**

Both primary data and secondary data were used under the research.

I. Primary data

Primary data collected from both experts' and residents' to identify the main criteria for residential housing development and assign weights for criterions. The following sub section are described the way of primary data collection for the research study.

A. Interview data

Structured interviews with 25 experts were conducted. The expert was purposely selected because it is important to select those who are deep knowledge about residential housing planning working at different institutions in different professions like town planners, architects, surveyors, environmentalist, land use planners and administrators were interviewed(table 6). The interview aimed at identifying the main criteria for urban residential housing development and the corresponding weight for each criterion.

Table 5: List of Selected Experts in related Institutions

Institution	Experts Designations	Number of Experts
Oromia Urban planning Institute	Town Planner	3
	Architect	3
	Engineer	3
	Quantity Surveyor	2
Oromia Land Administration and Use office	Town Planner	3
	Land use expert	2
Oromia Environment, Forest & Climate Change Authority	Environmentalist	3
Jimma Town Land Administration & Use office	Land Administration head	1
	Town Planner	2
	Land use expert	2
Jimma Town Administration	head of the office	1
Total		25

B. Field survey

Field survey also conducted using Global Positioning System (GPS Garmin 60) to generate primary information regarding to identifying the spatial location of environmentally sensitive area such as wetland, forest land and waste disposal site, collecting Coordinate point for training site for land use classification and accuracy assessments. The final suitability map was also verified at field level.

II. Secondary data.

The study used different secondary data sources in order to identify and analyzing suitable site for future residential housing development in Jimma town. Geospatial data, records, and reports data that were obtained from different sources was used for this study.

Digital Geo spatial datasets in raster and vector formats that was collected from various sources for preparation of factor maps was used this includes;

- Satellite imagery consisting of ASTERT Global elevation Model (DEM) with 30m x30m spatial resolution was used to generate the Slope map of the study area.
- Landsat 8 (OLI-TIRS) satellite image of 2019 was used to generate LU/LC of the study area. Landsat 8 sattalite pay loaded consists of two science instruments that is operational land imagery and thermal infrared sensors (TIRS). The sensors provide seasonal coverage of the global landmass at a spatial resolution of 30m (visible, NIR, SWIR); 100m (thermal); and 15m (panchromatic).

Table 6: Source and Types of Remotesensing data.

Satellite Sensors	spatial resolution	spectral resolution	Row & Path	Date of Acquisitions	Source
Land Sat 8 (OLI_TIRS)	30M	12 band	169/055	2019/05/16	Earthexpoler

- Structural plan of the town in digital format (CAD format), was obtained from Jimma town land administration and Use office was used. CAD format of the structural plan was changed to shape file format in GIS environment in order to generate spatial location of the identified criteria for residential housing development like (Urban center, roads network, rivers/ streams, airport site and proposed residential area).

- Cadastral map of the town in digital format (shape file format) that was obtained from Jimma town land administration and Use office were used to identifying spatial location of restricted criteria for residential housing development.

Table 7: Types of Geo spatial data and sources.

Data Types	Sources of Data
DEM	ASTER Global DEM website:
Landsat 8 (OLI) satellite Image of 2019	Downloaded from Glovious
Structural plan (digital format)	Jimma town land administration and Use office
Cadastral map (digital format)	Jimma town land administration and Use office

Records and reports from various publications was accessed through the internet and reviewed to identify the main criteria for residential housing development and knowledge gaps on suitability modeling and measures that can be put in place. A more significant aim in reviewing literature was to identify techniques used in similar studies and possible factors to incorporate in this analysis.

3.2.1.2. Methods of data Analysis

After collecting all necessary data, data analysis and processing was implemented by measuring distance, buffering, reclassifying and overlaying of different thematic layer using Arc GIS10.3 ERDAS imagine and QGIS 2. Furthermore, some simple statistical methods, such as percentage, graphic and tabulation were employed for the analysis and interpretations of data. Geospatial data was analyzed according to the following procedures:

3.2.1.2.1. GIS Analysis

Based on the overall research design, its main analyzing procedures are followed by the GIS Multi criteria evaluation. The following subsection is showed process of overall GIS analysis of the study.

I. Multi Criteria Evaluation (MCE) Analysis.

A. Determining suitability criteria and Factors

The development of urban residential housing development is influenced by numerous factors. These include physical, socio-economic and environmental quality and amenities. (Chapin and Kaiser, 1978). The first step that was taken in this analysis was to collect all of the data that would be needed to meet all of the criteria. The criteria must be identified and include factors and constraints. Thus the criteria were selected based on extensive literature survey and stake holder opinion. Thus 25 experts were selected and interviewed from different institutions in different professions like town planners, architects, surveyors, environmentalist, and Administrators to derive criteria for residential housing development. Thus for the purpose of ensuring the maximum society's benefits the present study considered the real urban situations of the study area with two main criteria, eight sub-criteria and ten constraint criteria were used to supports the identification of potential sites for housing development in Jimma town. The two main criteria that was used for this study is Environmental and Economic criteria. Environmental criteria further sub divides into sub criteria those include: Flood area, Distance from airport, Land-uses/land-cover and waste disposal site. Economic criteria also further sub divides into sub criteria; those include: Slope, Accessibility to road, population density, and Proximity to urban center.

B. Standardize the factors/criterion scores

After identifying the main criteria for residential housing development the next necessary step is to set operations-functions in GIS, which are necessary for specifying the land suitability. Euclidean distance operation was performed for all vector formats of the identified criteria like River, road, airport, waste disposal site, urban center and existing residential area, Euclidian distance operation also performed for all constraint criteria. Then, both factors and constraint criteria were reclassified based on expert opinion and literature data. Accordingly all of the factors criteria were re classified in the classification system from 1 to 5 class value; where the value 1 shows the unsuitable and value 5 shows the highly suitability (Table 9). Re classified operation also performed for all of constraint criteria accordingly each criteria were reclassified the value of 0 to 1, where the value of 0 indicates restrictions of that space, and the value 1 indicates that there are no restrictions. The detail of this section was presented in result and discussion part.

Table 8: Suitability Class and definition

Suitability Class	Class Value	Definition
Not Suitable	1	This is attributed to sites with characteristics imposing certain constraints, which cannot be overcome or technically excluded for development
Less Suitable	2	A level for sites with characteristics imposing constraints, which can be overcome, but by massive investment.
Moderately Suitable	3	This is for factors with many criterion indicators. It denotes sites with constraints but where the investment is higher than in the suitable class.
Suitable	4	Sites with characteristics, which can be overcome by moderate investment.
Highly Suitable	5	Areas with characteristics imposing no significant constraints for development.

Source: FAO's (1976).

Table 9: Suitability factors/criterion scores

Factors/Criteria	Class range	Score	Suitability Class	GIS Operation
Slope	$< 5^0$	5	High suitable	Reclassify
	5^0-8^0	4	Suitable	
	8^0-15^0	3	Moderate suitable	
	15^0-25^0	2	Less suitable	
	$>25^0$	1	Unsuitable	
Roads accessibility	<250m	5	High suitable	Buffer
	250m-500m	4	Suitable	
	500m-1000m	3	Moderate suitable	
	1000m-2500m	2	Less suitable	
	>2500m	1	Unsuitable	
Distance from air port	<1000	1	Not Suitable	Buffer
	1000m-1500m	2	Less suitable	
	1500m-2000m	3	Moderate suitable	
	2000m-2500m	4	Suitable	
	>2500	5	High suitable	
Distance from River/Stream	<30m	1	Not Suitable	Buffer
	30-50m	2	Less suitable	

	50-70m	3	Moderate suitable	
	70-90m	4	Suitable	
	>90m	5	High suitable	
Land Use	Vacant land	5	High suitable	Classification
	Bush/eclupitas	4	Suitable	
	Farm land	3	Moderate suitable	
	Forest	restricted	Restricted	
	Built up	restricted	Restricted	
	Wetland	restricted	Restricted	
Distance from urban center	<1km	5	High suitable	Buffer
	1km-3km	4	Suitable	
	3km-5km	3	Moderate suitable	
	5km-8km	2	Less suitable	
	>8km	1	Unsuitable	
Distance from waste disposal site	<1000m	1	Not Suitable	Buffer
	1000m-1500m	2	Less suitable	
	1500m-2000m	3	Moderate suitable	
	2000m-2500m	4	Suitable	
	>2500	5	High suitable	
Population Density	4 p/ha-20 p/ha	5	Highly suitable	Quarry, merge
	21 p/ha-40 p/ha	4	Suitable	
	41 p/ha-50 p/ha	3	Moderate suitable	
	51 p/ha-80 p/ha	2	Less suitable	
	>80 p/ha	1	Unsuitable	

Source: Compiled by Author

Table 10: Constraint criterion scores

Restricted Factor/Criteria	Restricted Buffer	Suitability score	Suitability Class
High Electric Power Line	<40 m	0	Restricted
	>40 m	1	Suitable
Industrial Park	<40 m	0	Restricted
	>40 m	1	suitable
Wetland	<40 m	0	Restricted
	>40 m	1	suitable
Military Camp	<30 m	0	Restricted

	>30 m	1	suitable
University	<30 m	0	Restricted
	>30 m	1	suitable
Distance from Airport	<1000	0	Restricted
	>1000	1	suitable
West disposal	<1000	0	Restricted
	>1000	1	suitable
River/Stream	<30 m	0	Restricted
	>30 m	1	suitable

Source: Compiled by Author

C. Assigning Weight for Criteria

A weight can be defined as a value assigned to an evaluation criterion which indicates its importance relative to other criteria under consideration. Assigning weights of importance to evaluation criteria accounts for the changes in the range of variation for each evaluation criterion and the different degrees of importance being attached to these ranges of variation (Kirkwood, 1997).

Pair wise Comparison Method The method involves pair wise comparisons to create a ratio matrix. It takes pair wise comparisons as input and produced relative weights as output. The pair wise comparison method involves three steps:

1. **Development of a pair wise comparison matrix**: The method uses a scale with values range from 1 to 9

2. **Computation of the weights**: The computation of weights involves three steps. The first step is the summation of the values in each column of the matrix. Then, each element in the matrix should be divided by its column total (the resulting matrix is referred to as the normalized pairwise comparison matrix). Then, computation of the average of the elements in each row of the normalized matrix should be made which includes dividing the sum of normalized scores for each row by the number of criteria. These averages provide an estimate of the relative weights of the criteria being compared.

3. Estimation of the consistency ratio: The aim of this is to determine if the comparisons are consistent or not. It involves the following operations:

a) Determine the weighted sum vector by multiplying the weight for the first criterion times the first column of the original pair wise comparison matrix, then multiply the second weight times the second column, the third criterion times the third column of the original matrix, finally sum of these values over the rows.

b) Determine the consistency vector by dividing the weighted sum vector by the criterion weights determined previously.

c) Compute lambda (λ) which is the average value of the consistency vector and Consistency Index (CI) which provides a measure of departure from consistency and has the formula below:

$$CI = (\lambda - n) / (n-1)$$

d) Calculation of the consistency ratio (CR) which is defined as; $CR = CI / RI$

Where RI is the random index and depends on the number of elements being compared

D. Weighted Index Overlay Analysis & preparation of Suitability Map

After assigning the weight for each factor Weighted Index Overlay Analysis was applied to obtain the potential area of residential housing development. In this aspectall the criterion maps will be overlaid in the form of Boolean operations within the GIS environment using map algebra operations and final suitability map was prepared by using the following formula,

$$\mathbf{S = \sum w_i x_i \times \prod c_j}$$

Where;

S – is the composite suitability score

X_i – factor scores (cells)

W_i– weights assigned to each factor

C_j – constraints (or Boolean factors)

$\sum$ -- sum of weighted factors

$\prod$ -- product of constraints (1-suitable, 0-unsuitable)

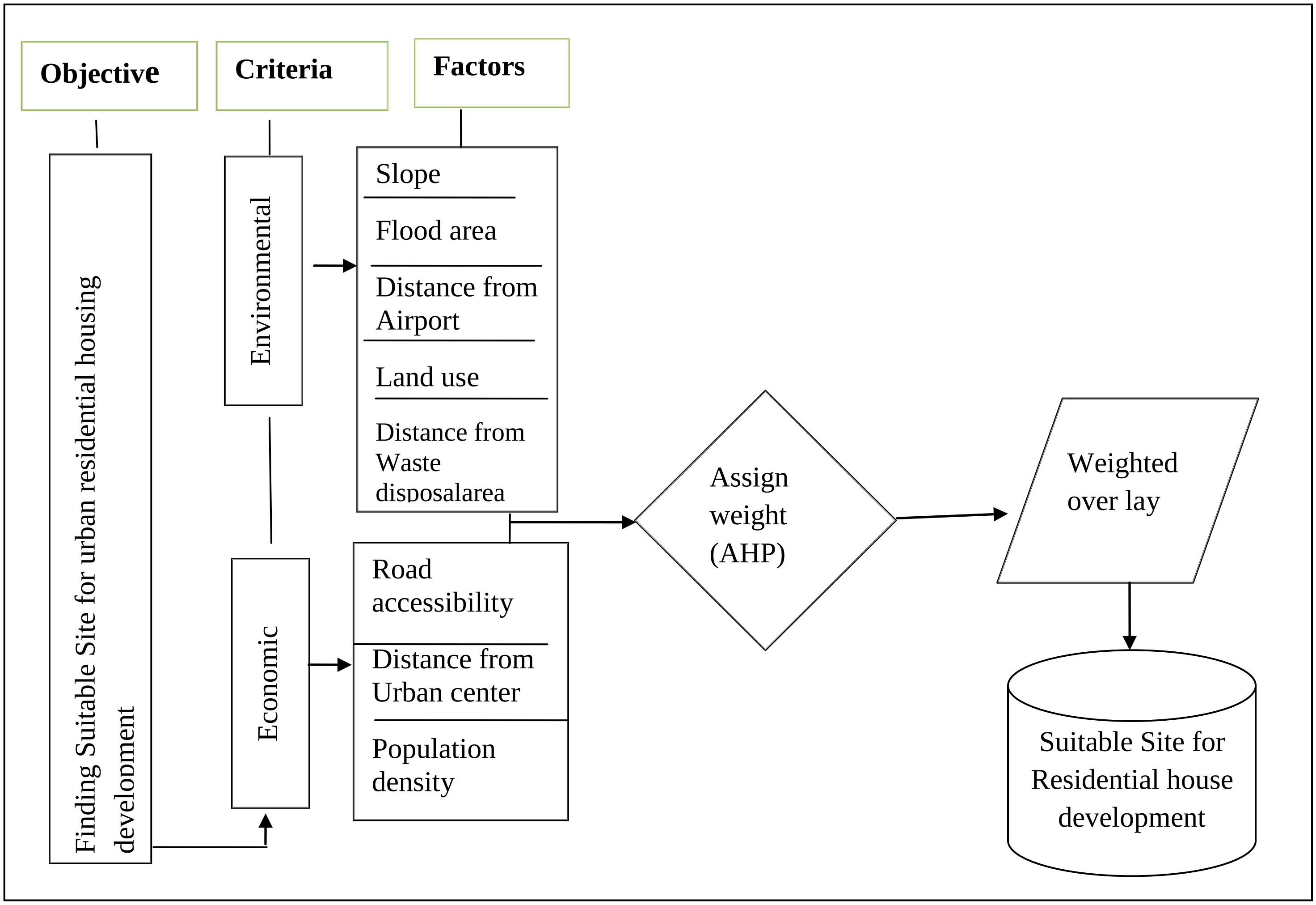

Figure 8: weighted linear combination procedure of housing development site identification

E. Accuracy and Reliability assessments.

Based on the result obtained from the final suitability map there was the validation of the result by taking a selected site of suitable site by using hand held GPS. The evaluations of the suitability of existing, proposed and potential site of residential areas was identified by overlaying high resolution satellite of the study area and the final suitability map.

II. LU/LC Classification Analysis.

The 2019 images which are in WGS84 projection have been re-projected in to the country's datum and projection (Adindan). This is mainly because datum and projection conflict would undoubtedly limit the use of various themes (layers) at time.

Supervised classification method was used in ERDAS imagine to obtain LU/LC of the study area, the study area was classified in to Six main LU/LC types, a total of 90 training site was collected from field by using hand held GPS (15 point for each land use) to aid land use classification.

1. Built-up: It includes all man-made structure which are used for different purposes and activities, e.g. residential, institutional, commercial etc,
2. Vacant land: This is mainly non built-up land without any land use activity or land cover.
3. Agricultural land: the area used for producing
4. Forest land: It consists of lands on which trees grown natural forms.
5. Bush land: is the land use in which plantation trees like eclupites and other small trees are dominated
6. wetland

After classification of satellite images, the accuracy of the classified image was performed. One of such a method is the use of a confusion matrix which is produced from the random sample of individual pixels/clusters compared to known cover conditions over the same pixel areas. In this regards, a total of 90 ground truth (15 points for each land use) was collected from the field to aid the accuracy assessment of classified image. The overall accuracy of the classified image of 2019 was; 84% with kappa coefficient of 0.84 (Appendix 3).

III. Analysis of Evaluating the Proposed Residential Housing development.

The vector format of future residential housing development was extracted from the master plan of the town. Before analyzing, the final suitability map that was in raster format converted to vector format in order to overlaying in GIS environment with the proposed residential housing.

The analyzing process was performed after intersection tools of Geo-processing detecting the two overlapping area then the proposed site was evaluated in each six suitability class (Restricted, unsuitable, less suitable, moderately suitable, suitable and highly suitable)

3.2.2. Software and Instruments

Arc GIS 10.3 version developed by ESRI, ERDAS 15.1 version developed by ERDAS Inc., and QGIS 2.1 was used for the study. The GIS software with the version of 10.5 was used for digitization, spatial analysis and layout of different criteria map. ERDAS IMAGINE 15.1 software is used in order to performing Geometric correction and generating LU/LC map of the study area. QGIS 2.1.software was used for weighting and rank different factors maps within and among each other based on the logic developed by Saaty (1977) under the analytical hierarchy process (AHP). The Software and Instruments required and its source used for this research was describe in the following Table 3

Table 11: Software and Instruments

No	Types of Materials	Description	Source
1	Instrument	Garmin GPS 60	Jimma Zone Land administration and Use office
		Digital Camera	
2	Software	Arc GIS 10.5	Jimma University,;GIS lab
		ERDAS 15.1	
		QGIS	

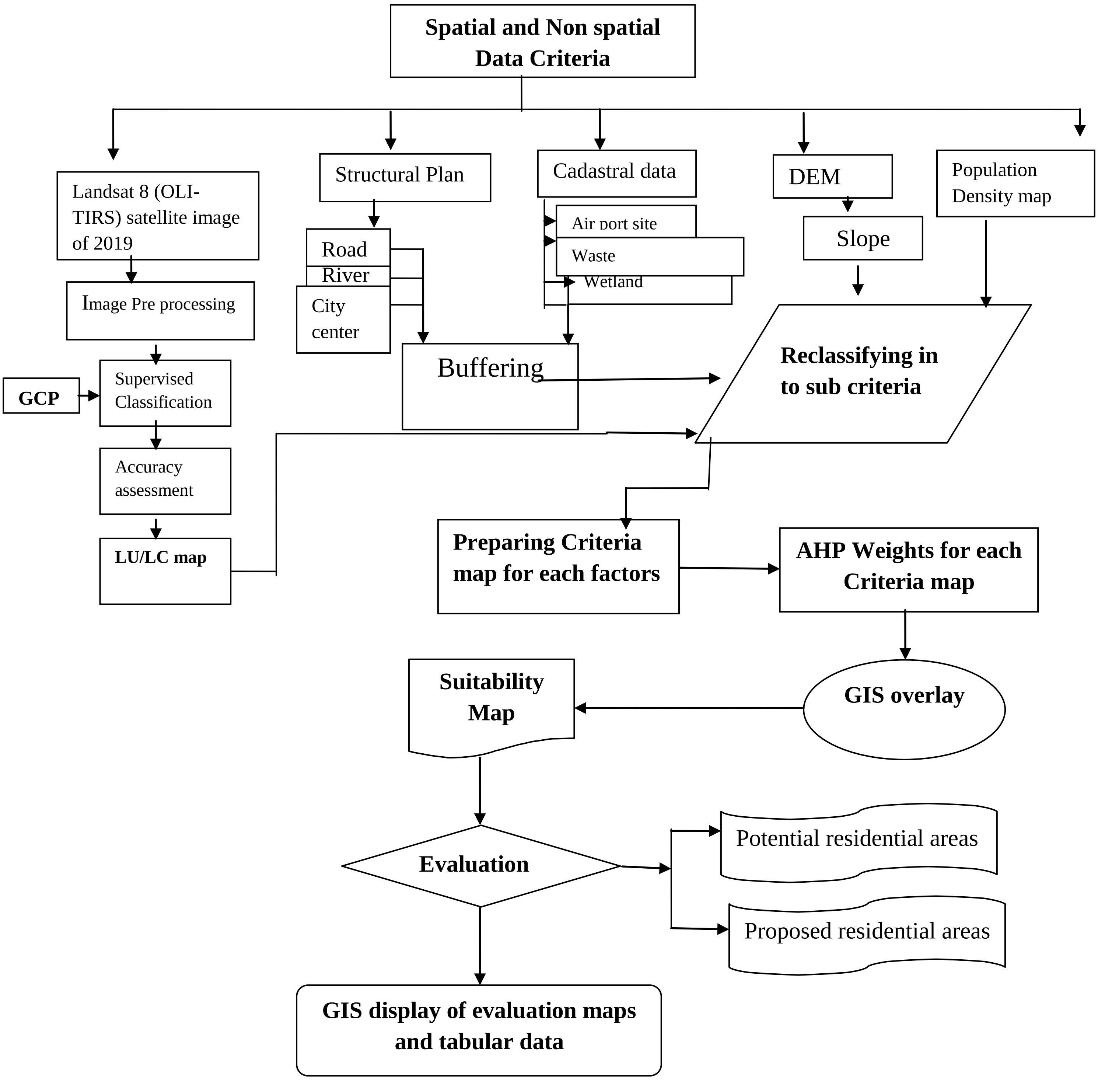

Figure 9: Flowchart of Methodology

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. The Current status of Residential Housing development in Jimma town

Currently the overall urban land use planning activity of South West Oromia region was condacted by under Oromia Urban planning institute of the South West region urban planning district. The head Office of the district located in Nekamte town. The planning district prepares the structural plan of the town in 2008. The structural plan of the town contains both existing and proposed residential area. Thus to examine the status of residential housing development of 2008 of the study area un structured interviewing was conducted with experts of Jimma town land administration and use office. Additionally field observation also carried out

Accordingly, the interviewed expert strongly suggested that there is a planning gap for residential land use suitability assessments by planning team. One of the main planning gap of residential land use planning is raise due to the planning team impossible to gather and interpret all the necessary information or factors that are relevant for residential housing development for the effective functioning of an urban land-use planning system this problem raise due to the planning team did not incorporate multi professionals from different displine. Because of this existing land use analysis of the area was identified by only two-three professionals like town planners, Architecture and surveyor involved in analyses. The analyzing process was performed on field level by recording and manual sketching of existing land use which is time consuming and difficult to cover un accessible area of the town. During interviewing with experts suggest that the planning team did not use the planning tools like GIS and remote sensing data like high resolution satellite imagery for identification of LU/LC of the town thus there is a case for un appropriate recommendation of existing LU/LC of the area which is impact on the proposed residential planning of the town. For instance in 2008 structural plan of the town there is a case in which existed forest area of the town recommended as for future residential housing development (Figure 7).

Urban residential housing development also needs care full assessments of physical condition of the area like slope, thus it is important to identify slope condition of the area using remote sensing data like Digital elevation model (DEM). Because it caver all parts of the town, provide precise and more accurate Slope data in GIS environment; But the planning teams of 2008 did not use DEM data to generate Slope condition of the study area while planning the residential housing development. As a result there is a case in which residential housing development of the study area proposed in high steep slope area of > 25^{o} in the structural plan of 2008 that is difficult to provide social infrastructure to the area like road, water pipe line and others.

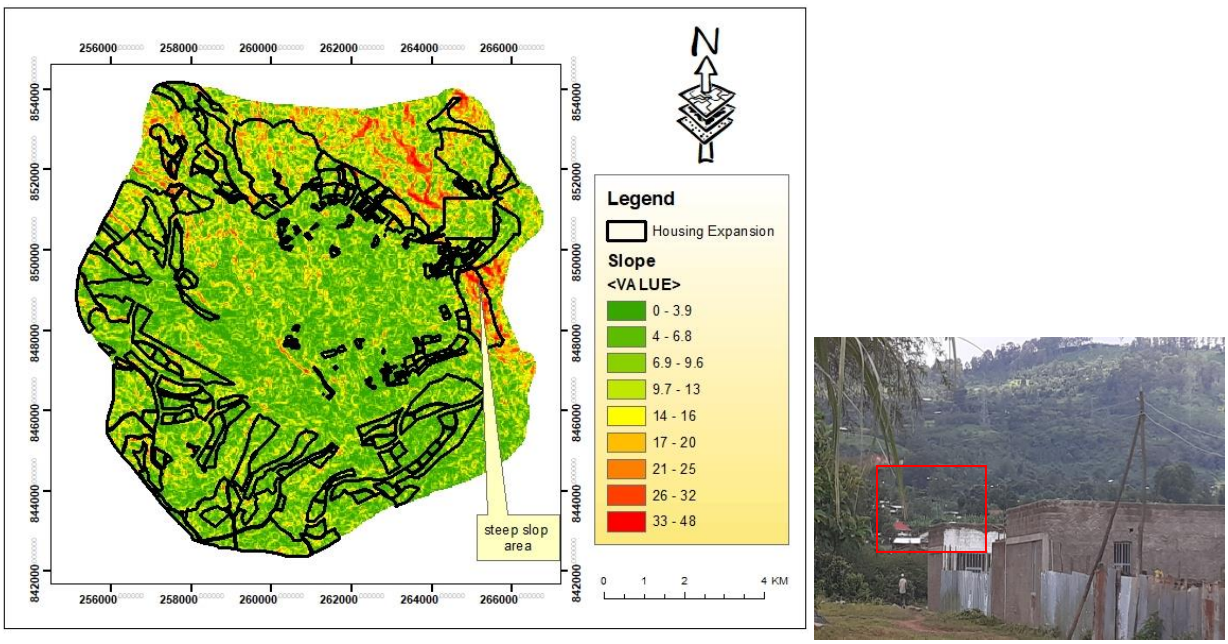

Figure 7: Residential area proposed on high slope

During field observation it is observed that there is residential housing development legally or illegally built adjacent to the main Streams/Rivers in which those streams is not restricted with a defined distance of buffer in 2008 structural plan. As a result most of residential housing developers built their house very close to Rivers/Streams; thus most of the residents has encountered with periodic flooding during rainy seasons. These problems mainly rise due to careful assessments of all existing streams/Rivers of the study area by planning team. For example Kore River is the main river in mendera kochi kebele that drain from north eastern to central part of the town; but the structural plan only buffered with 10m in each sides of the rivers which is below the standard of plan regulation that is any river/stream at least 30m buffer in each sides of the rivers.

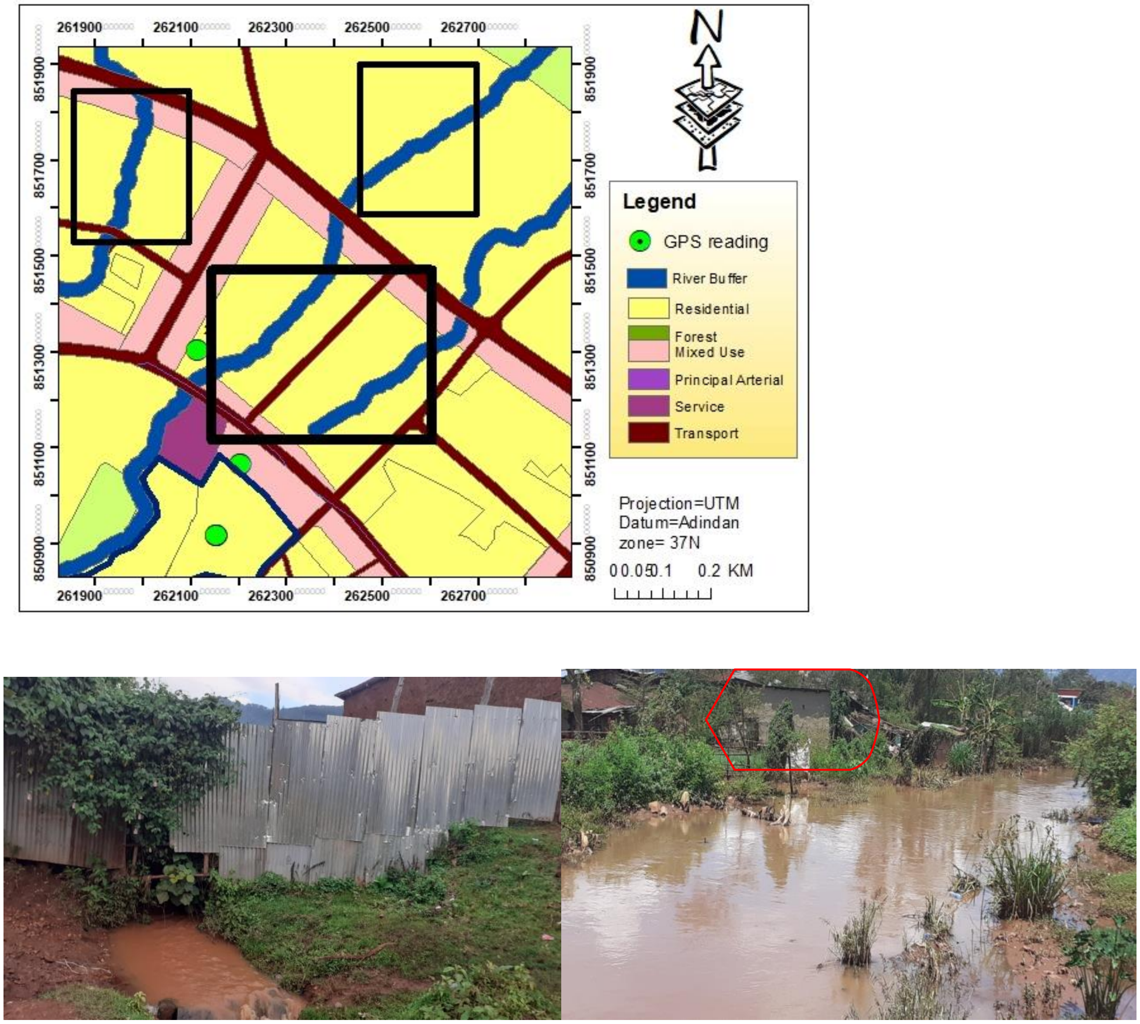

Figure 8: Residential area proposed on adjacent to the main Streams/Rivers

Part of the residential area also proposed on environmentally sensitive area mainly wetland which located in Mendera kochi and Bacho Bore kebele of the town. By taking the GPS reading of that wetland at field level it is prove that the area was recommended for residential area in the structural plan of the town. The wetland in the area may have environmental benefits like water purification, ground water recharge, climate moderation, runoff reduction and habitat for many lives. However, during field observation it is observed that there is extensive house building by draining the existing wetland and the land use is unsuitably proposed on the area, limiting the above benefits that the town can get from the wetland.

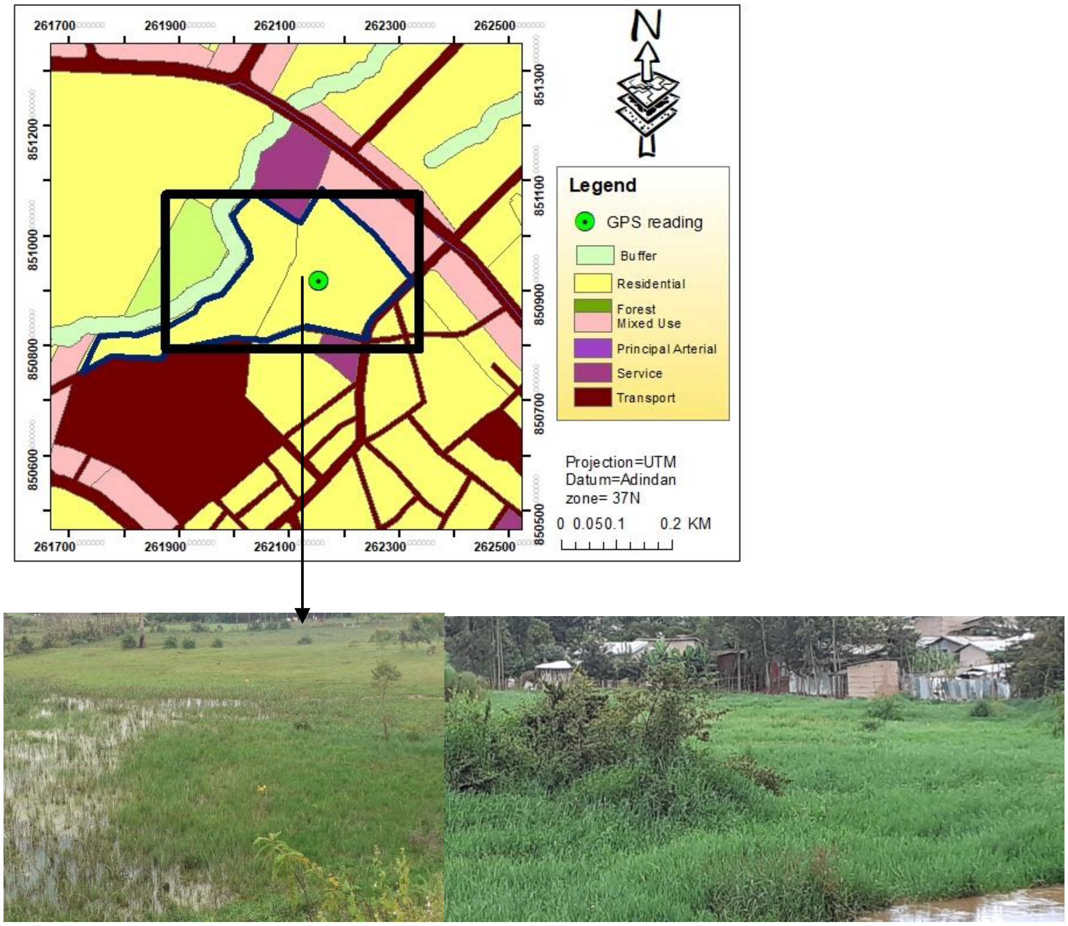

Figure 9: Settlement proposed on wetland

during field observation it is also observed that the supply of residential housing land in the town is not well developed in terms of social infrastructures like roads; most of the site has no roads to connect with the main roads while other sites has too narrow roads which is not penetrate cars for the residences even during fire hazard (figure 12). It is also observed that some residential housing built adjacent to the main roads on each side of the cannels of the roads. In the structural plan the plan can not restricted a defined distance between road and residential area which may serve for green area.

Figure 10: Improperly proposed road

It is also observed that, part of newly constructed Jimma Industrial park lie on the proposed residential area. According to the standard of the master plan there is a green or buffer zone of at least 50m-100m should be preserved between housing areas and heavy industries; but the plan did not say anything about this (Figure 13). As a result when the industrial park becomes operational the surrounding residences face a challenging impact.

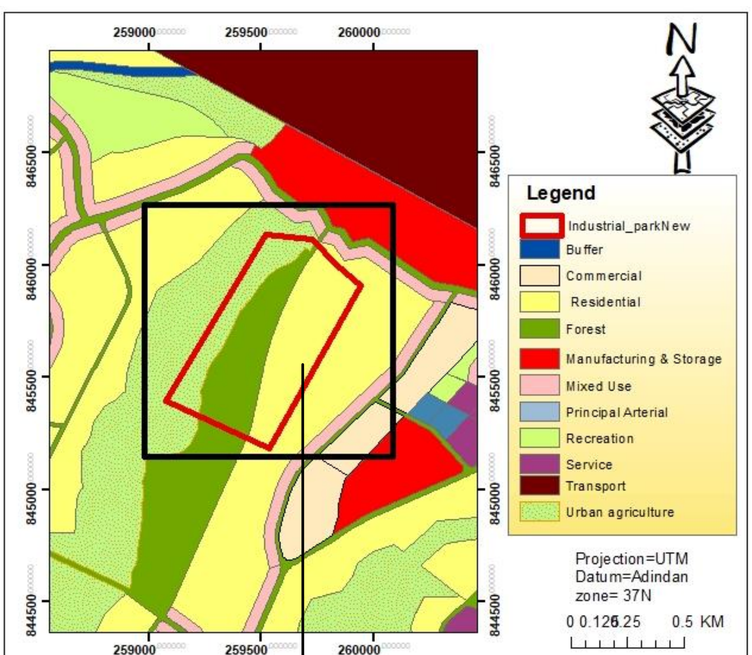

Figure 11: Industrial park constructed in proposed residential site

Solid waste dump site is one of the environmental component that the planning process should pay due attention while planning for residential area. However it is observed from the structural plan of the town the planning team propose both the previous and the newly constructed waste disposal site as residential area.

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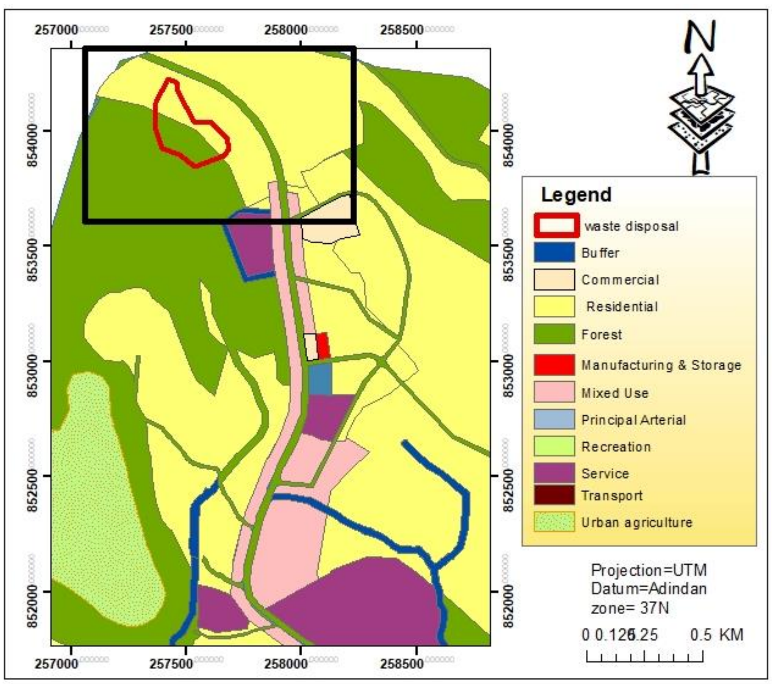

Figure 12: Proposed Residential site on existing waste disposal site

In general the land use planning of the study area, even though the preparation of the plan has the lion shares, some of the external and internal factors contributed for the short falls of the planning approaches have been observed. The external factors affecting the quality of the residential plan specifically the environmental plan units are lack of community, investors and private participation as well as with shortage of commitment of officials. These resulted in a limited level of awareness that leads to unrealized plan execution.

In addition, interest conflict among primary stake holders like community, investors, religious and others was also resulted in giving biased data that directly has been affect the quality of the prepared structure plan of the town. Moreover, the internal factors that cast a shadow image on the quality of the Structure plan were the experience and skill gap of the plan preparation team that caused for the proposal of existing wetland site for residential land, existing industrial area for settlement and proposing residential area on slope greater than 25% and high altitude where not suitable for the intended use.

On the other hand, as most scholars assured, land use planning for residential and others needs multi professional skills that mainly affected the quality of the proposed plan. However, it is observed that from interviewing with the experts there is shortage of multi professional particularly environmental planner and related fields like GIS and Remotesensing experts while the town plan has been prepared. These resulted, possibly less consideration have been given to the environmental components during plan preparation.

4.2. Identifying criteria for residential housing development in Jimma town

In order to identify the main criteria that were considered while planning for suitable site for urban residential housing development in Jimma town; literature data concerned with residential housing planning and Expert opinion were used. Thus unstructured interview was conducted with experts of different institutions in different professions like town planners, architects, engineers, quantity surveyors, environmentalist, and administrators. The result obtained from Interview indicated that; LU/LC, Slope (land form), distance from River/Stream, distance from air port, distance from waste disposal site, Road accessibility, proximity to City centers, Soil, Geological factors, population density, Land value and distance from Social amenities like schools and health post where identified as the main criteria for urban residential housing development (Table 12).

Table 12: Expert response on Criteria for residential housing development.

Criteria	No of experts	%
Slope	25	100
LU/LC	25	100
Road accessibility	25	100
Distance from city center	20	80
Distance from Airport	25	100
Distance from Waste disposal	25	100
Population Density	22	88
Distance from Rivers/ Stream	25	100
Distance from Social amenities like Schools and health post	20	80
soil	10	40
Geological factors like fult line	17	68
Land slide prone area	17	68
Land value	10	40
Aspect condition	10	40

Table 12 above indicated that, all of the interviewing experts (100%) tell as; slope, LU/LC, Road accessibility, distance from waste disposal, Airport and city centers as the main criteria that was considered while planning for suitable residential housing development. Whereas 88% and 80% of interviewing experts tell as population density and distance from social amenities are the criteria for residential housing development. Soil, Aspect and Land value consider as the criteria for residential housing development that was forwarded by 40% interviewing experts.

But, this study considered all of the identified criteria that were listed by experts except Soil, Geology, Aspect, distance from Social amenities like Schools and health post and land value criteria due to 60% of the experts did not agreed as the main criteria. Literature survey pointed out that the criteria for urban residential settlement was seen from Factor criteria and Restriction criteria. Accordingly the factors criteria is further categorized in to Environmental factors (Slope, and distance from River/Stream, LU/LC, distance from air port, and waste disposal site) and Economic Criteria (Road accessibility, population density and proximity to town centers) were the main criteria and selected and give priority weights. The restriction criteria include a buffer of high electric power line, Wetland, River/stream, higher education institution, Industrial park and military camp. Suitability of each criterion is discussed as below.

4.2.1. The Suitability of Factor Criteria

4.2.1.1. Suitability of Road Accessibility.

Road accessibility is one of the most important parameters for urban residential settlement since it provides linkage between the settlements. Transportation and accessibility to transport network is a important infrastructure facility that determines overall success of the residential activities. The distance to an existing road is crucial because it significantly affects moving costs. Hence, the roads are an important factor in housing development because their presence represents human activity. The result obtained from available literature indicated that at any rate, the road accessibility is the most important factor and any housing development project must be confined within 250m -1000m radius. The more the site is closer to the street the more likely suitable for residential house because of transportation access with short distances. For this particular study, Expert opinion and available literates was used to re classify the road accessibility based on the level of suitability to develop residential housing development. Accordingly residential housing development site is unsuitable if distance from existing roads is greater than 2500m. The distance starting from 1000m-2500m from the road is considered as less suitable for residential housing development, where as the distance between 500m-1000m from the existing road is moderately suitable, and the distance between 250m-500m from existing road is suitable. If the site belongs to less than 250m from existing roads the site is highly suitable for residential housing development (Table 13).

The expert opinion in categorizing class range of road accessibility for residential housing development is similar to other works. See for example, Rizah, 2014 in his study on land suitability location analysis for housing development in Cosovo city considered road accessibility as the main criteria and the study classify the road in to five sub criteria based on distance, accordingly, an area which is located less than 0.25km from existing road is highly suitable for residential housing development, 0.25- 0.5km suitable, 0.5- 1.0km moderate suitable, 1.0-2.5km less suitable and >2.5km from existing road is unsuitable for residential housing development

Table 13: Reclassified distance from road and area coverage of suitability levels

Factor/ Criteria	**Class range**	**Suitability score**	**Suitability Class**	**Area (Ha)**	**Percent of total area (%)**
Roads accessibility	<250m	5	highly suitable	7041.78	64.22
	250m-500m	4	Suitable	2595.28	23.67
	500m-1000m	3	Moderate suitable	1128.51	10.29
	1000m-2500m	2	Less suitable	165.33	1.51
	>2500m	1	Unsuitable	33.75	0.31
	Total			10566.65	100

Table 13 above indicates that, 64.22. % of the study area is highly suitable for residential housing development in terms of road accessibility; while the smallest proportions of the study area 0.31% of the study area is unsuitable for residential housing development in terms of accessibility of road (Table 16 Figure 14). The remaining 23%, 10.29% and 1.51% of the study area is suitable, moderately suitable and less suitable for urban residential housing development taking proximity to road as criteria. The road network proximity suitability map of the study area is clearly indicated in the (Figure 14below).

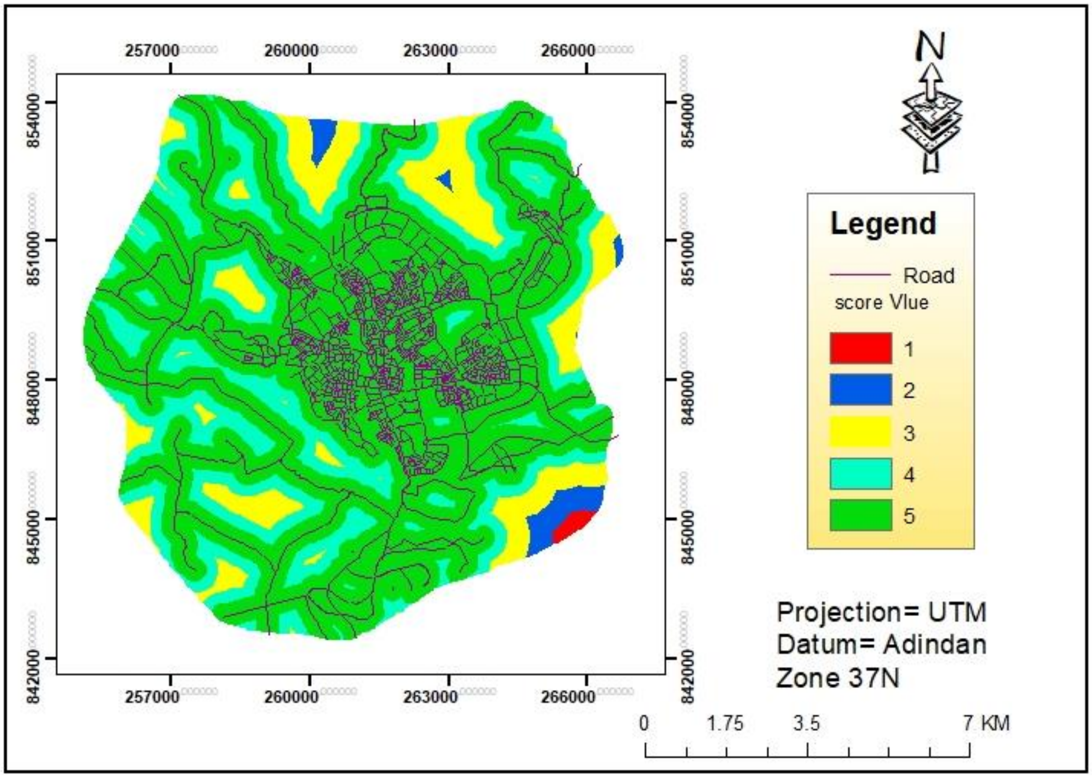

Figure 13: Reclassified distance from road map

4.2.1.2. Suitability of Slope

Different researchers consider areas with low slopes are highly suitable for urban residential housing development (e.g Alshabi, *et al.*, 2006, Huang, 2019 and Weldmeriam and Igulu, 2014). As far as the topography of the study area is considered, since, steeper slope area eventually increases cost of construction, it is difficult to provide social infrastructures like road, water and it is highly susceptible for land slide and run off. Therefore, this study considered the flat and gently slopes as highly suitable for residential housing development as opposing the land with steep slope. Based on the Expert opinion and available literature the slope of the study area reclassified based on the suitability level for residential housing development. Accordingly, an area having the slope rise of less than 5^0 is highly suitable for residential housing development, where as an area having the slope rise of greater than 25^0 is unsuitable for residential housing development. Residential housing development is suitable, moderately suitable and less suitable if the slope raise is between 5^0-8^0, 8^0-15^0 and 15^0-25^0 respectively. These slope classification parameters used for residential housing development for this study also similar to the researchers (e.g. Rizah, 2014., Kevin, 2010., Omar and Raheem, 2016 and Weldmeriam and Igulu, 2014).

Table 14: Reclassified distance from road and area coverage of suitability levels

Factor/ Criteria	Class range	Suitability score	Suitability Class	Area (Ha)	Percent of total area (%)
Slope	$< 5^0$	5	highly suitable	2940.11	27.82
	5^0-8^0	4	Suitable	2674.66	25.31
	8^0-15^0	3	Moderate suitable	3691.57	34.94
	15^0-25^0	2	Less suitable	1105.62	10.46
	$>25^0$	1	unsuitable	154.64	1.46
	Total			10566.6	100

Table 14 above indicates that, 27.82% and 25.31% of the study area has highly suitable slope class for residential housing development, where as majority of the study area falls under the slope class of 8^0-15^0 that was moderately suitable for urban residential housing development which covers 34.94 % of the total study area. The slope value greater than 25^0 rise has the least coverage (1.4%) of the study area has unsuitable slope class for residential housing development.

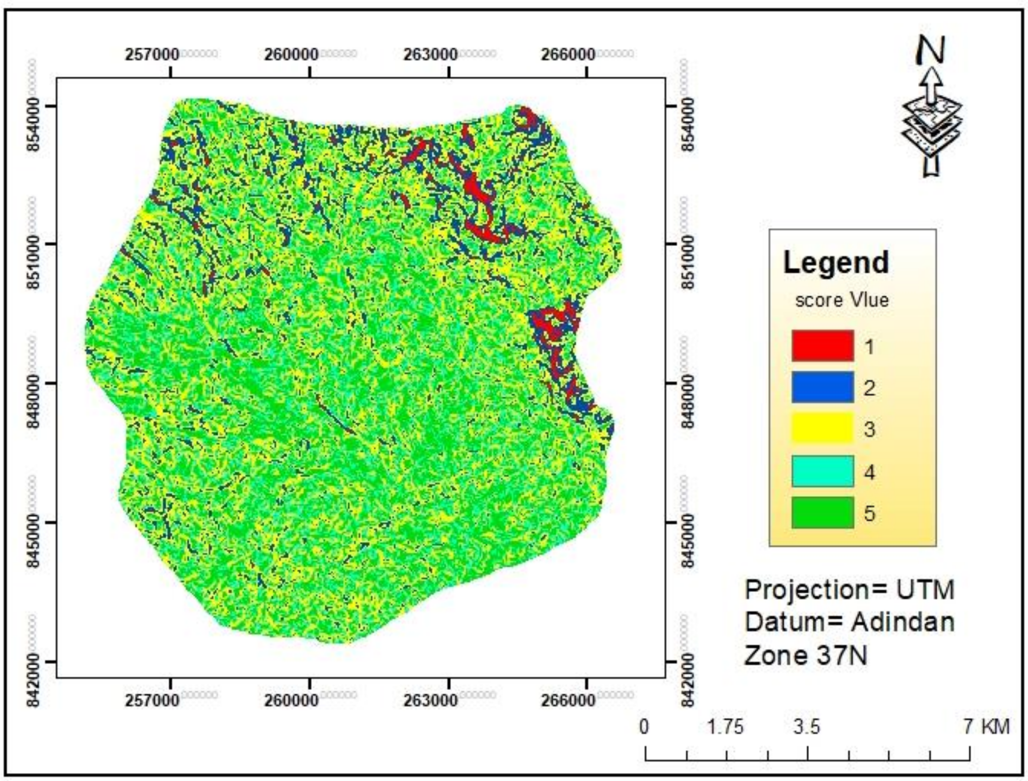

Figure 14: Reclassified Slope Map

Figure 15 above indicated that, the Central, South, Southwest part of the town is highly suitable slope class for residential housing development, while the Northern and Eastern periphery of the study area has the least suitable slope class for urban residential housing development. During field observation it is observed that there is high level of housing development in hilly areas of the study area having the slope of >25^0 rise. The residents of those area facing a great challenges like run off, landslide and social infrastructure like road, water, and electricity supply.

4.2.1.3. Suitability of Distance from Rivers and streams

From the goal of safety the potential suitable site for residential housing development area should be free from risk aroused by river flooding during rainy seasons. Hence, Awetu, Dololo, Boye, Kore and Kitto are the main stream of the study area that drains into Gibe River. According to the regulation of the structural plan of the city, no any development is permitted within 30 meter buffer in both sides of rivers, this is mainly for safeguarding the health of the stream from domestic pollutant that was endanger for aquatic bio diversity and avoiding the risky of flood sheet during rainy season. Thus, the distance far away from rivers/streams channels is more suitable for urban residential housing development. The result obtained from expert opinion and structural plan regulation the distance of greater than 90m from the main Rivers/streams is highly suitable for urban residential housing development, the distance of 70m-90m from Rivers/Streams channels is suitable for residential housing development , the distance between 50m-70m from Rivers/Streams channels moderately suitable, 30m-50m less suitable and if the distance less than 30m from Rivers/Streams channels are the unsuitable for urban residential housing development.

Expert opinion regarding to buffered distance of Rivers/streams for residential housing development is similar with the work of other researchers like (Mu, 2006, Seid, 2007 and Kevin, 2010).

Table 15: Reclassified distance from Stream/River and area coverage of suitability levels

Factor/ Criteria	Class range	Suitability Score	Suitability Class	Area (Ha)	Percent of total Area (%)
Distance from River/Stream	<30m	1	unsuitable	402.58	3.81
	30-50m	2	Less suitable	527.47	4.99
	50-70m	3	Moderate suitable	213.6	2.02
	70-90m	4	suitable	504.58	4.78

>90m	5	highly suitable	8918.36	84.4
Total			10566.6	100

Table 15 above indicates that, about 84.4 % of study area highly suitable distance from existing Rivers/streams for residential housing development, While 3.81% of the study area is unsuitable distance from existing rivers/streams for urban residential housing development. The remaining 4.78%, 2.02% and 4.99% of the study area is suitable, moderately suitable and less suitable distance from existing rivers/streams for residential housing development.

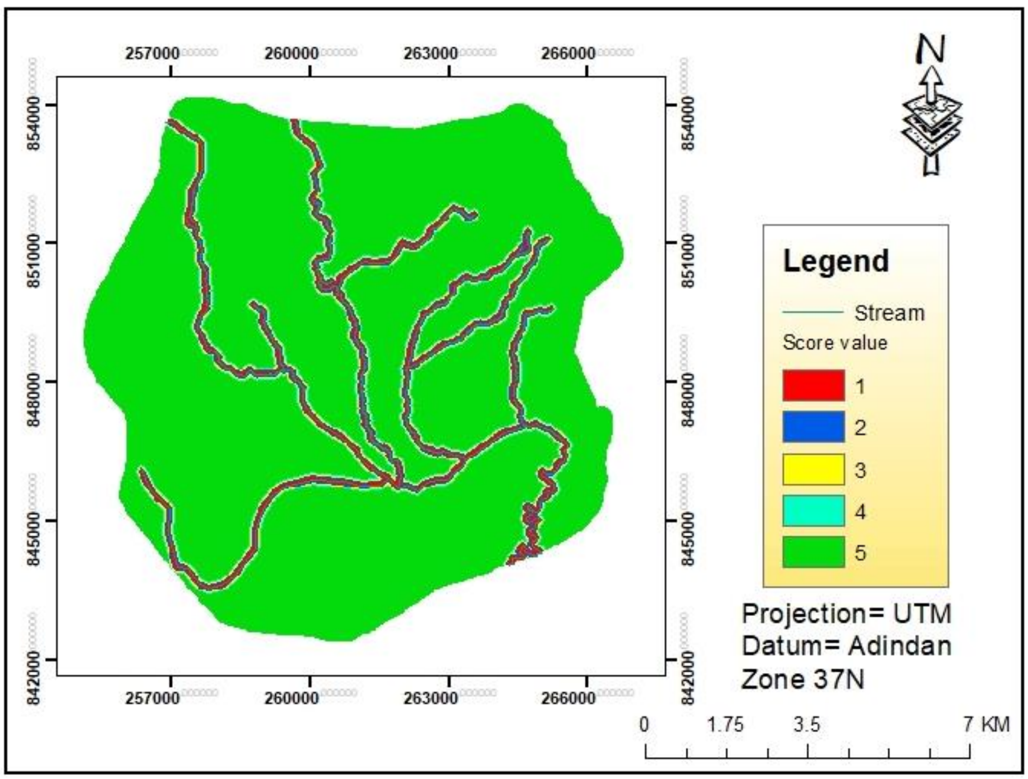

Figure 15: Reclassified River/Stream Map

4.2.1.4. Suitability of Distance from Airport

Different studies uses distance from air port as criteria while planning for residential housing development (Omer, 2001, Weldmeriam and Igulu, 2016). Expert opinion during interview indicated that far site from existing airport station is suitable for urban residential housing development this is manly to minimize noise disturbance of aircraft during landing and takeoff operation. The candidate suitable site for residential housing development should be far away from airport sites with a minimum buffer distance of 2.5 km away from the airport (Weldmeriam and Igulu, 2016). In the study area there is one international airport which is called Jimam Abba Jifar International Air port. To evaluate suitable distance from existing airport expert opinion were used accordingly, the distance less than 1000m from airport station is unsuitable for residential housing development while, the distance greater than 2500m from airport has highest suitable for residential housing development (Table 16). The expert opinion regarding to buffer distance for airport is similar to the work of Weldmeriam and Igulu, 2016.

Table 16: Reclassified distance from Airport and area coverage of suitability levels

Factor/ Criteria	Class Range	Suitability Score	Suitability Class	Area (Ha)	Percent of total Area (%)
Distance from Air port	<1000	1	Unsuitable	628.06	5.94
	1000m-1500m	2	Less suitable	649.93	6.15
	1500m-2000m	3	Moderate suitable	796.44	7.54
	2000m-2500m	4	Suitable	954.65	9.03
	>2500	5	High suitable	7537.50	71.33
	Total			10566.6	100

Table 16 above indicates that; the distance less than1000m from existing airport which cover 5.94% of the study area was excluded from the sitting processes for residential housing development due to the fact that there is a sound pollution by aircraft around that area thus it has unsuitable for urban residential housing development. On the other hand, the distance greater than 2500m from existing airport which account 71.33% of the total study area was highly suitable due to the fact that there is no impact of sound pollution by air craft. 9.03 %, 7.54% and 6.15% of the total study areas were suitable, moderately suitable and less suitable for urban residential housing development respectively in terms of distance from airport

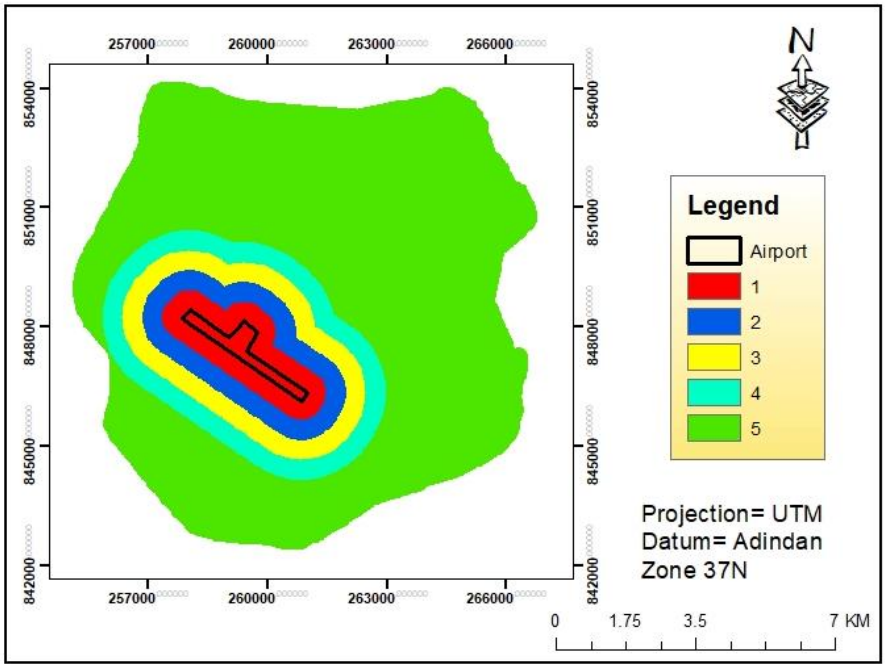

Figure 16: Reclassified Slope map

Figure 17 show that the North, North east and the center part of the town is extremely suitable while the West-Central part of town is the unsuitable for urban residential housing development.

4.2.1.6. Suitability of Distance from Waste Disposal Site

In the study area there is one solid waste disposal site which is under construction in the way to Jimma-Aggaro main road thus the site considered as criteria for residential housing development. For residential settlement development, the logarithmic relationship shows that distances too close to waste disposal areas receive a lower rank and are thus unsuitable for residential settlement development (Abdulhasan et al., 2019). This is because if the distance is too close to waste disposal site, the landfill can infect the inhabitants with different types of diseases or bad odors which affect/restrict the normal day to day activity of the residents. Expert opinion indicated that residential housing development is unsuitable within the distance of less than 1000m from existing waste disposal site in contrary to this housing development is highly suitable within a distance of greater than 2500m from existing waste disposal site (Table 17).

Table 17: Reclassified distance from waste disposal and area coverage of suitability levels

Factor/Criteria	Class range	Suitability score	Suitability Class	Area (Ha)	Percent of total Area (%)
Distance from west disposal site	<1000m	1	unsuitable	194.2	1.84
	1000m-1500m	2	Less suitable	145.6	1.38
	1500m-2000m	3	Moderate suitable	184.4	1.75
	2000m-2500m	4	suitable	230.82	2.18
	>2500	5	High suitable	9811.57	92.85
	Total			10566.6	100

Table 17above indicates that, about 92.85% % of the total study area belongs to highly suitable distance from the current waste disposal site for urban residential housing development. While, 1.84% of the study area is unsuitable for urban residential housing development due to it is nearest to the current waste disposal site. The remaining 2.18%, 1.75% and 1.38% of the study area is suitable, moderately suitable and less suitable distance from waste disposal site for urban residential housing development.

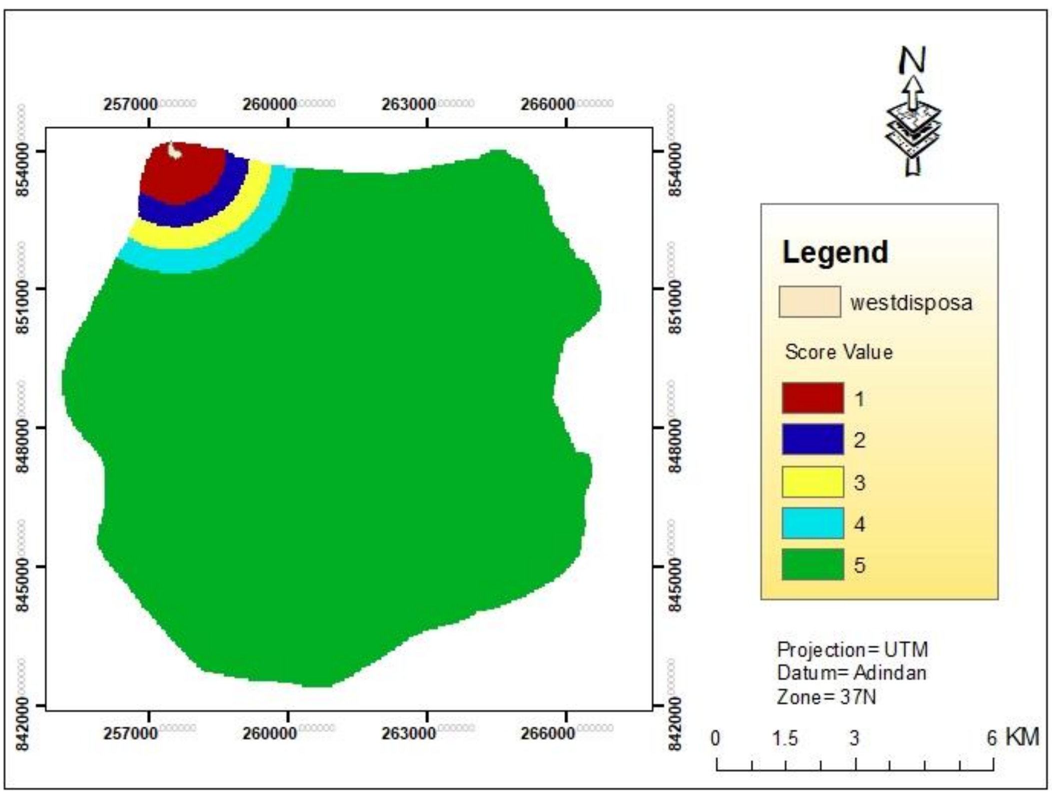

Figure 17: Reclassified waste disposal map

Figure 19 above indicates that, south, south eastern, south western, North eastern and the center part of the town is highly suitable for urban residential housing development in terms of distance from waste disposal site. While, the North edge part of the town is unsuitable for urban residential development.

4.2.1.7. Suitability of Land Use/Land Cover

The LULC of the study area was analyzed by using landsat 8(OLI-TRIS) image of 2019). The supervised classification method was employed for generating the LU/LC of the study area. The land use of the study area classified in to six dominant LU/LC classes those are; Forest, Bush, Vacant, Farm, Built- up area and wetland. The result obtained from the classified Image show that; the dominant land cover of the study area within this period is Bush land which account 26.87% of the total study area. The other dominant land cover class is Vacant, Farm land and Built up area which account 23.33%, 22.64% and 21.34% respectively. While; 2.02% and 0.3.81% of the area during this period is covered with Wetland and Forest land respectively this takes the lowest percentage share as compared to the other land cover classes in the study area (Figure 20 and Table 18)

Table 18: LU/LC of the study area

Lu/LC	Area (ha)	Percent of total Area (%)
Forest land	403.01	3.81
Bush land	2464.71	23.33
Wetland	213.01	2.02
Vacant land	2839.14	26.87
Built up area	2254.47	21.34
Farmland	2392.24	22.64
Total	10566.6	100

After classification of satellite images, the accuracy of the classified image was performed. One of such a method is the use of a confusion matrix which is produced from the random sample of individual pixels/clusters compared to known cover conditions over the same pixel areas. In this regards, a total of 90 ground truth (15 points for each land use) was collected from the field to aid the accuracy assessment of classified image. The overall accuracy of the classified image of 2019 was; 80% with kappa coefficient of 0.80 (Appendix 3).

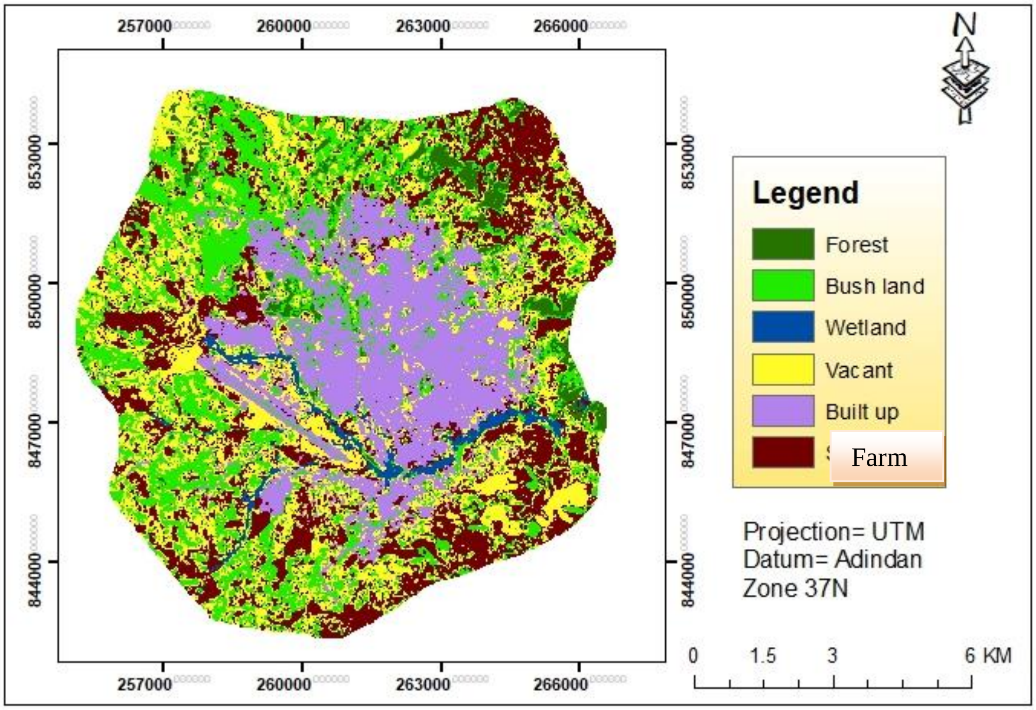

Figure 18: 2019 LU/LC Map of the study area

The literature (e.g. Lwasa, 2005 ; Dominic, 2011 and Godfrey, 2012) tells us that it is advisable to select land occupied by Vacant for urban residential settlement planning other literature like Al-shalabi, et al, 2006 and Weldemariam and Iguala, 2016 Farm land and Bush land gives the highest Priority while planning for urban residential settlement respectively. In this study the suitability of each LU/LC for urban residential housing development considered based up on master plan regulation, Expert opinion and literature data. Accordingly, Vacant and Bush land are considered as highly suitable and suitable LU/LC types for urban residential housing development which account 26.87% and 23.33% of the study area respectively. While 27.1% of the study area restricted for urban residential housing development those LU/LC types are Forest and wetland since those land use types has the highest environmental sensitivity as a result of this master plan regulation of the country prohibit those land use types for other purpose. The other LU/LC types which are restricted for future urban residential housing development is Built up LU/LC types since this LU/LC type has already developed before it is considered as restricted land use for future residential housing development. Farm land consider as moderately suitable for future urban residential housing development which account 22.64% of the total study area (Table 19 and Figure 21).

Table 19: Reclassified LU/LC and area coverage of suitability levels

LU/LC	Suitability Score	Suitability Class	Area (ha)	Percent of total Area %
Forest land	0	Restricted	403.01	3.81
Bush land	4	Highly Suitable	2464.71	23.33
Wetland	0	Restricted	213.01	2.02
Vacant land	5	Highly Suitable	2839.14	26.87
Built up area	0	Restricted	2254.47	21.34
Farmland	3	Suitable	2392.24	22.64
	Total		10566.6	100

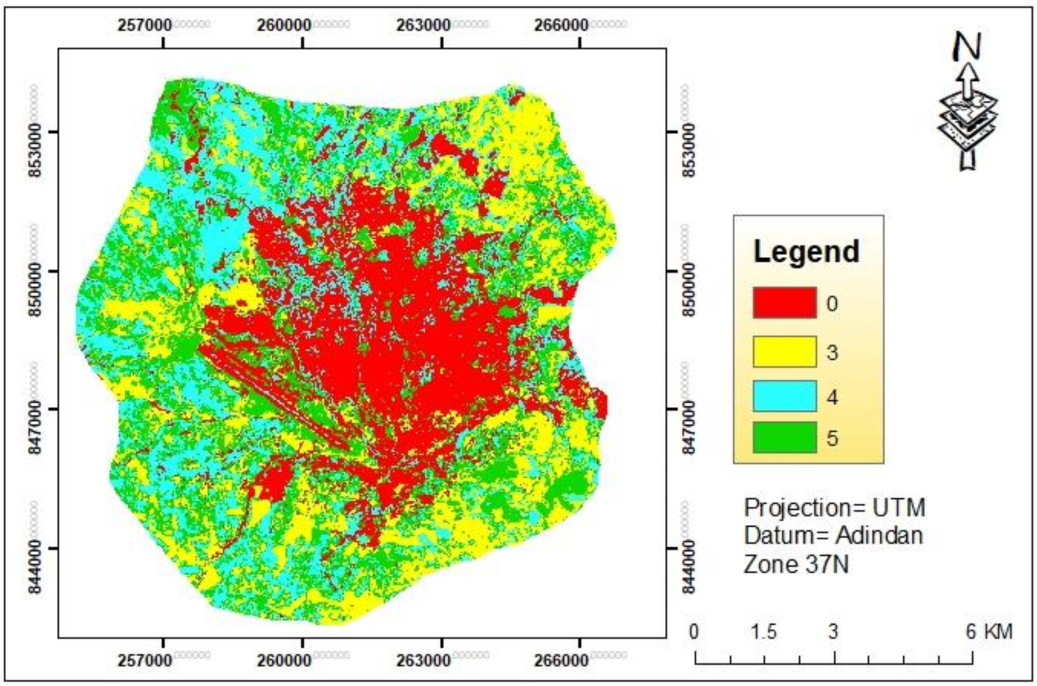

Figure 19: Reclassified Map of LU/LC

4.2.1.8. Suitability of distance from City Center

Mostly urban centers are an area in which different public service, commercial service and market activity was performed in which the residence of the town uses this area in day today activity. On that base people prefer to live in close proximity to town centers which give higher accessibility to them. In this way proximity to the town centers could be considered as a most important factor to evaluate locational suitability of future residential housing development of the study area. The area is high potential to expansion of offices and it affects to more demand for residential use. Available literature also show that the area within 3km distances from the main urban center of the town highly suitable for residential housing development while the distance greater than 6km from city center was unsuitable for residential housing development (Ekanayake, 2010, Al-shalabi, et al, 2006 and Weldemariam and Iguala, 2016)

Accordingly, this study considers more proximity to urban center as potential areas for future residential housing development. Thus urban center of the study area was extracted from structural plan of the town then the suitability level was considered based on expert opinion (Table 20).

Table 20: Reclassified distance from urban center and area coverage of suitability levels

Factor/ Criteria	**Class Range**	**Suitability Score**	**Suitability Class**	**Area (Ha)**	**Percent of total area(%)**
Distance from Urban center	<3Km	5	Highly suitable	4546.47	43.03
	3km-4km	4	suitable	2719.96	25.74
	4km-5km	3	Moderate suitable	2500.92	23.67
	5km-6km	2	Less suitable	507.47	4.8
	>6 km	1	Unsuitable	291.76	2.76
	Total			10566.6	100

Table 20 above indicates that, about 43.03% % of the total study area is belongs to highly suitable for urban residential housing development, due to proximate to urban center; While 2.76% of the study area is unsuitable for future urban residential housing development in terms of proximate to urban centers. The remaining 25.74%, 23.67% and 4.8% of the study area is suitable, moderately suitable and less suitable for future urban residential housing development in terms of proximate to urban centers.

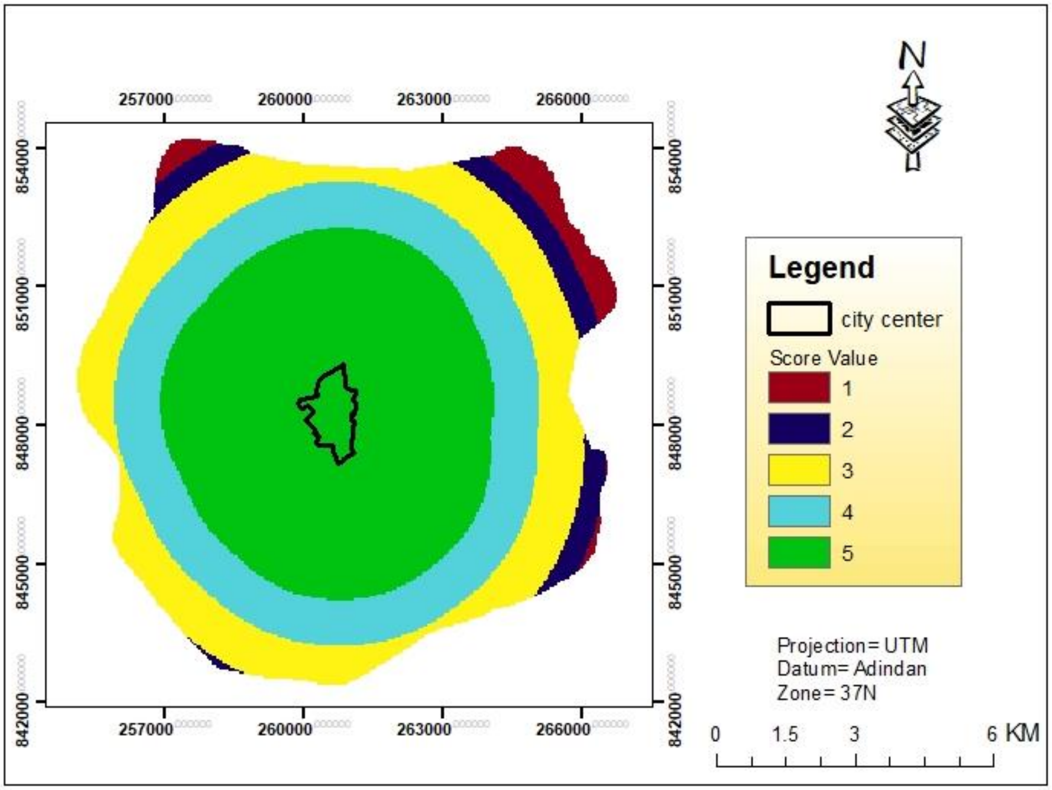

Figure 20: Suitability Map of Distance from City center.

Figure 22 above indicates that, the central part of the study area has the highest suitable for residential housing development due to it is nearest to urban center. While, the corner edge of north eastern part of the town has unsuitable for future residential housing development because the site is belongs to more than 6km far from urban center which is difficult to access social and commercial service.

4.1.1.8. Suitability of Population Density

Population density considered as one of the most important factors which influences the determination procedure of suitable locations for residential purpose. Population Density has direct relationship with residential suitability. The literature (e.g. Ekanayake, 2010; Dominic, 2011; Godfrey, 2012 Al-shalabi, et al, 2006 and Weldemariam and Iguala, 2016) tells us that it is advisable to select Low density areas have much potential for Residential housing development. Based on that argument, population density considered as one of the criteria considered in this study. The population density of the study area presented in (Table 21bellow).

Table 21: Population density of the study area

Kabele	Total Population	Area (Km2)	Population Density (Popn/Km2)
Bosa Kito	20373	5.1541	3953
Becho	36410	5.146	7075
Aweytu Mendera	17398	1.0623	16378
Bosa Addis ketema	14078	2.9729	4735
Furdisa	5249	12.027	436
Ginjo	29522	7.5438	3913
Ginjo Guduru	14931	1.8742	7967
Hermata	11737	0.4445	26405
Hermata Mentina	14187	0.8547	16599
Hermata Merkato	11409	3.5743	3192
Mendera Kochi	18832	2.4148	7799
Jiren	4043	8.2895	488
Mentina	14187	0.4689	30256
Seto Semero	13787	18.8166	733
Bore	7601	15.3475	495
Kofe	6864	19.6045	350
Total	240608	105.5958	2279

Source: Jimma town Adminstration

According to the above table, Kofe, Furdisa, Bore, Jiren and Seto Semaro kable has the lowest population density when compared to other kabele and having population density of 350,436,495,488 and 733person /km2 of land respectively. In the other hand Mentina, Hermata, Hermata Mentina and Aweytu Mendera kebele has the highest population density. Available literature and expert opinion shows that an area having population density of less than 20 person /ha is highly suitable for residential housing development while an area having a population density of greater than 80 person /ha is unsuitable for residential housing development (Table 22).

Table 22: Reclassified distance from urban center and area coverage of suitability levels

Class Range	Suitability Score	Suitability Class	Area (Ha)	Percent of total area (%)
400p/km2-2000 p/km2	5	Highly suitable	7404.58	70.14
2001 p/km2-4000 p/km2	4	Suitable	1628.38	15.42
4001 p/km2-5000 p/km2	3	Moderate suitable	811.57	7.69
5001 p/km2-8000 p/km2	2	Less suitable	431.28	4.09
>8000 p/km2	1	Unsuitable	281.33	2.66

Table 22 above indicated that 70.14% of the study area is highly suitable for urban residential housing development in terms of population density; while about 2.66% of the study area is un suitable for future residential housing development because the area is characterized by densely populated area and developing additional residential housing to those area make the area overcrowded and impact on the existing social utility.

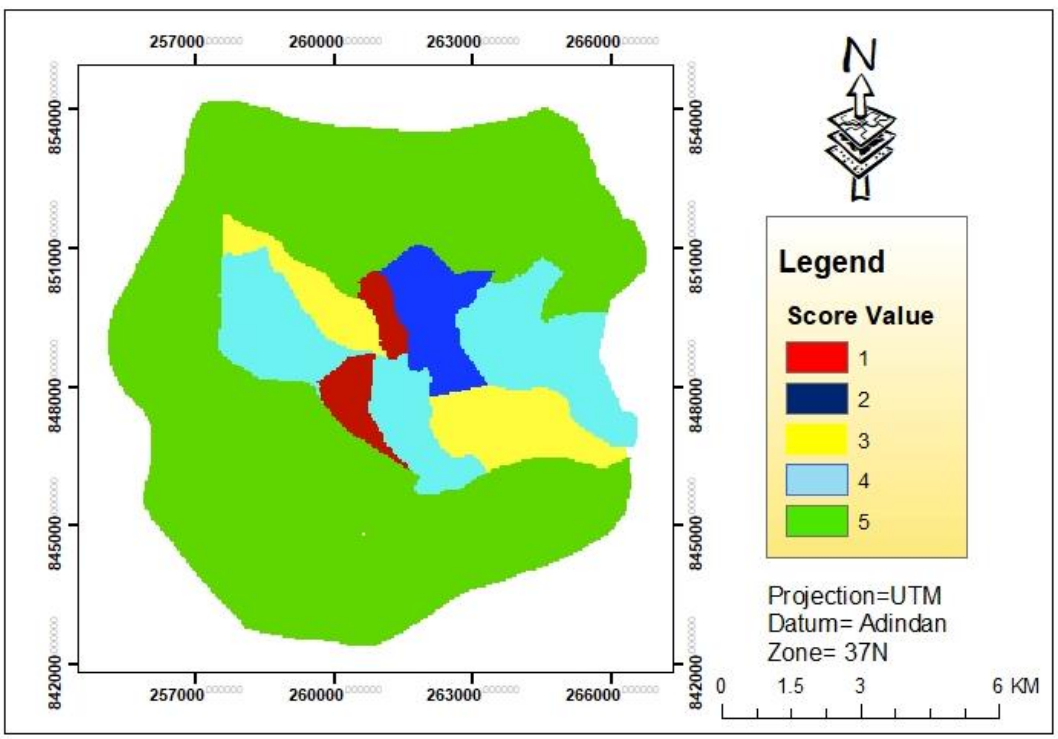

Figure 21: Suitability of Population Density Map.

4.1.2. Constraint factors

The constraint factors for future residential housing development in the study area were identified based on expert opinion and available literature data. Accordingly 10 factors were identified as constraint factors for future residential housing development; those are High Electric power line, Wetland/ swampy area, Military camp, University, Industrial park, River/Stream, Road, Waste disposal site, Airport, forest land and existing built up area. For each constraint criteria a minimum distance of buffer was made based on the master plan regulation of the country, expert opinion and literature data (Table 23). for example according to the master plan regulation of the town no any development activity was under taken within a distance of 40m and 30m from high power electric line and wetland. Therefore a buffer of 40m and 30m was made for high power electric line and wetland. A buffer of 15m was made for each side of roads for footpath, cannel service road side greenery thus 15m distance from the road restricted for residential housing development. A buffer distance of 16m was developed for industrial park, military camp and university. The constraint maps were produced for each factor by merging each individual theme within the study area. This procedure created a constraint map for each theme containing only two classes represented by 1"s (for suitable land) and 0"s (for restricted land).

Table 23: Constraint criteria and areal coverage

Restricted Factor/Criteria	Restricted Buffer	Suitability score	Suitability Class	Area (Ha)	Percent of total Area (%)
High Electric Power Line	<40 m	0	Restricted	64.08	0.6
	>40 m	1	Suitable	10502.59	99.4
Industrial Park	<40 m	0	Restricted	628.99	5.95
	>40 m	1	suitable	9937.6	94.05
Wetland	<40 m	0	Restricted	134.05	1.27
	>40 m	1	suitable	10432.54	98.73
Military camp	<30 m	0	Restricted	61.47	0.58
	>30 m	1	suitable	10505.13	99.42
University	<30 m	0	Restricted	346.41	0.71
	>30 m	1	suitable	10220.18	21.09
Airport	<1000	0	Restricted	2139.52	20.25
	>1000	1	suitable	8427.07	79.75

West disposal	<1000	0	Restricted	194.2	1.84
	>1000	1	suitable	10372.39	98.16
River/Streem	<30 m	0	Restricted	577.85	5.47
	>30 m	1	suitable	9988.74	94.35
Road	<3m	0	Restricted	1077.95	10.20
	>3m	1	suitable	9488.65	89.80
Built up area		0	Restricted	2254.47	21.34
		1	suitable	8312.12	78.66

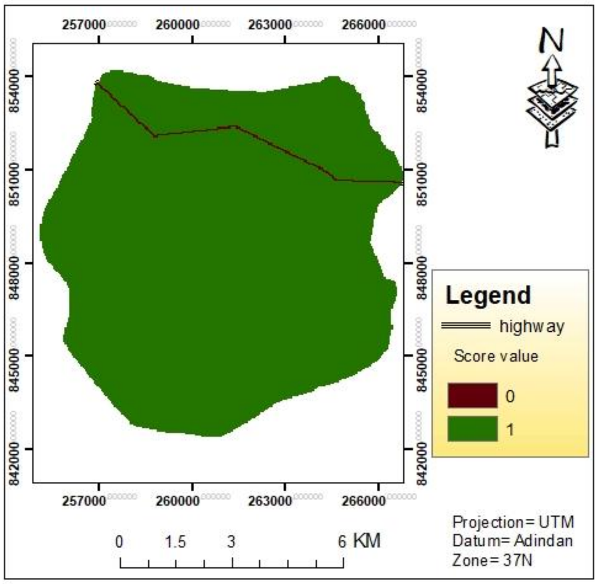

Figure 22:Con. map of High Electric Power Line

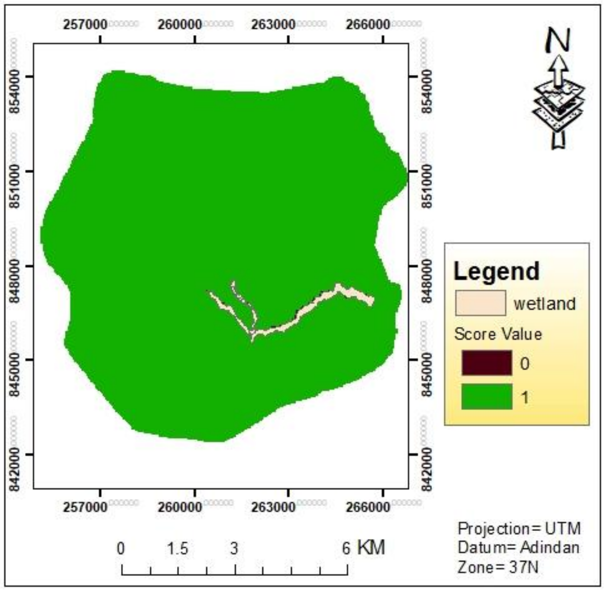

Figure 23:Constraint Map of Wetland

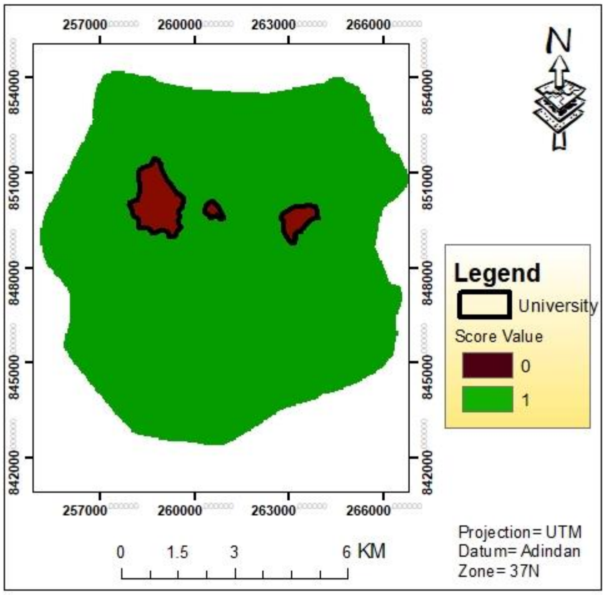

Figure 24: constraint map of university

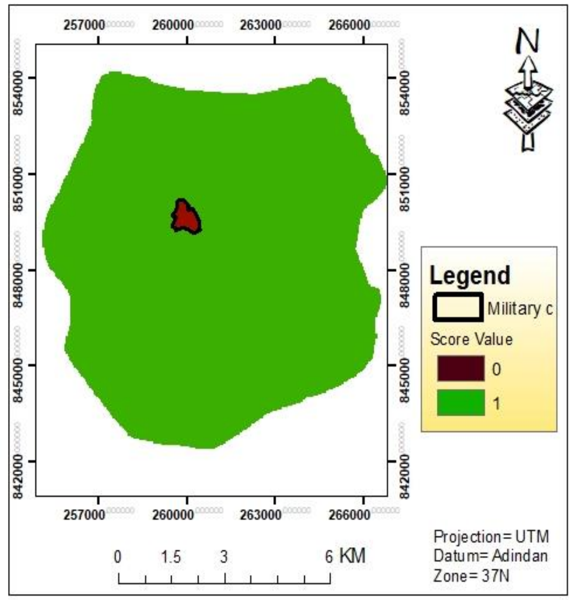

Figure 25 constraint map of Military camp

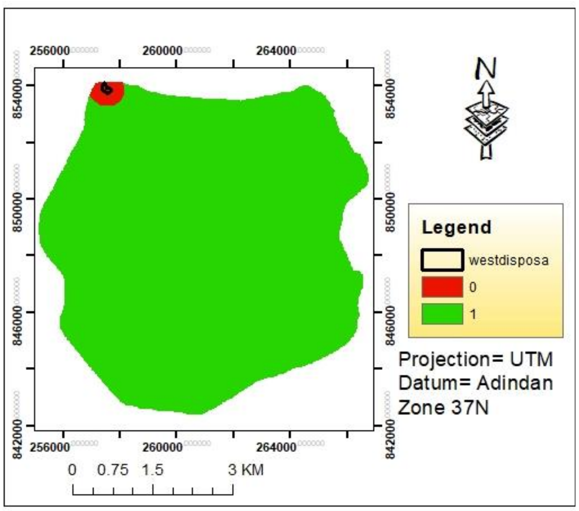

Figure 26:Constraint Map from wastedisposal

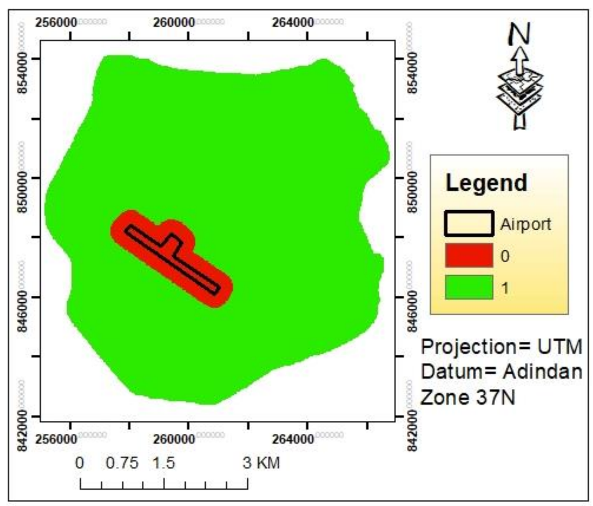

Figure 27:Constraint Map from Airport

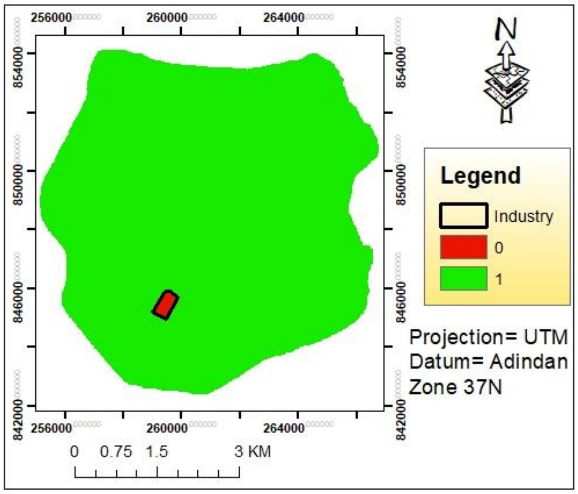

Figure 28: Constraint Map from Industrial park

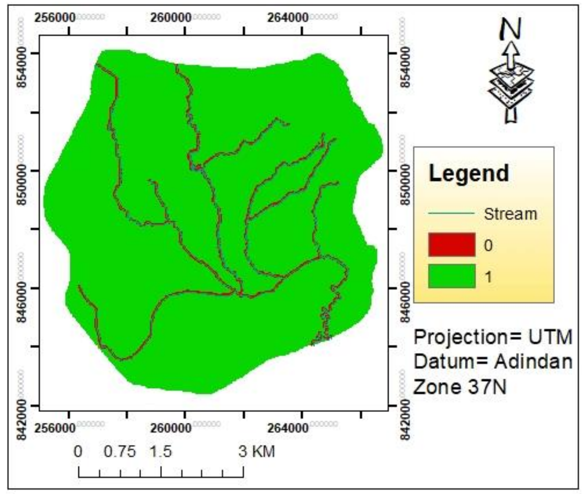

Figure 29:Constraint Map from stream

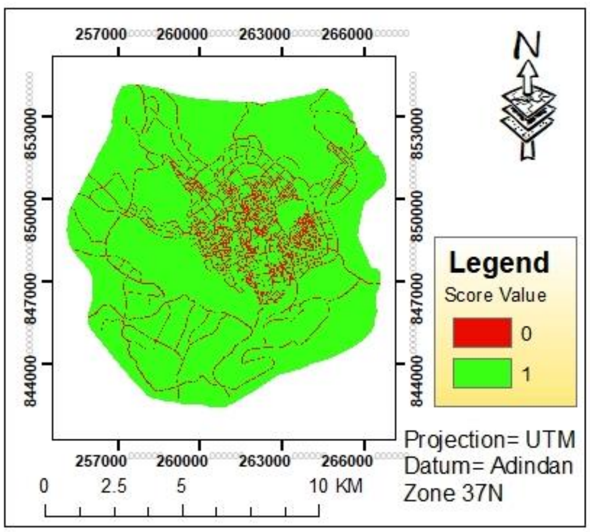

Figure 30:Constraint Map from Road

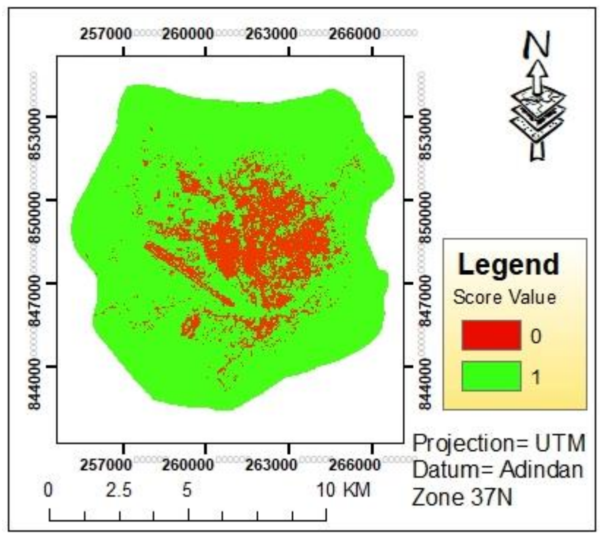

Figure 31:Constraint Map of Built up area

The final constraint map was performed in GIS environment by multiplying each constraint creation map in raster calculator.

([Reclassified buffer of high electric power line])* ([reclassified buffer of Industrial park])* ([reclassified buffer of wetland])* ([reclassified buffer of university])* ([reclassified buffer of airport])* ([reclassified buffer of waste disposal])* ([reclassified buffer of river]) * ([reclassified buffer of Road]) * ([reclassified Built-up area])

The result obtained from the suitability of constraint model indicated that about 35.57% of the total study area is restricted/constraint for future urban residential housing development, while the largest proportion of the study area (64.43%) is suitable for future urban residential housing development (Figure 34).

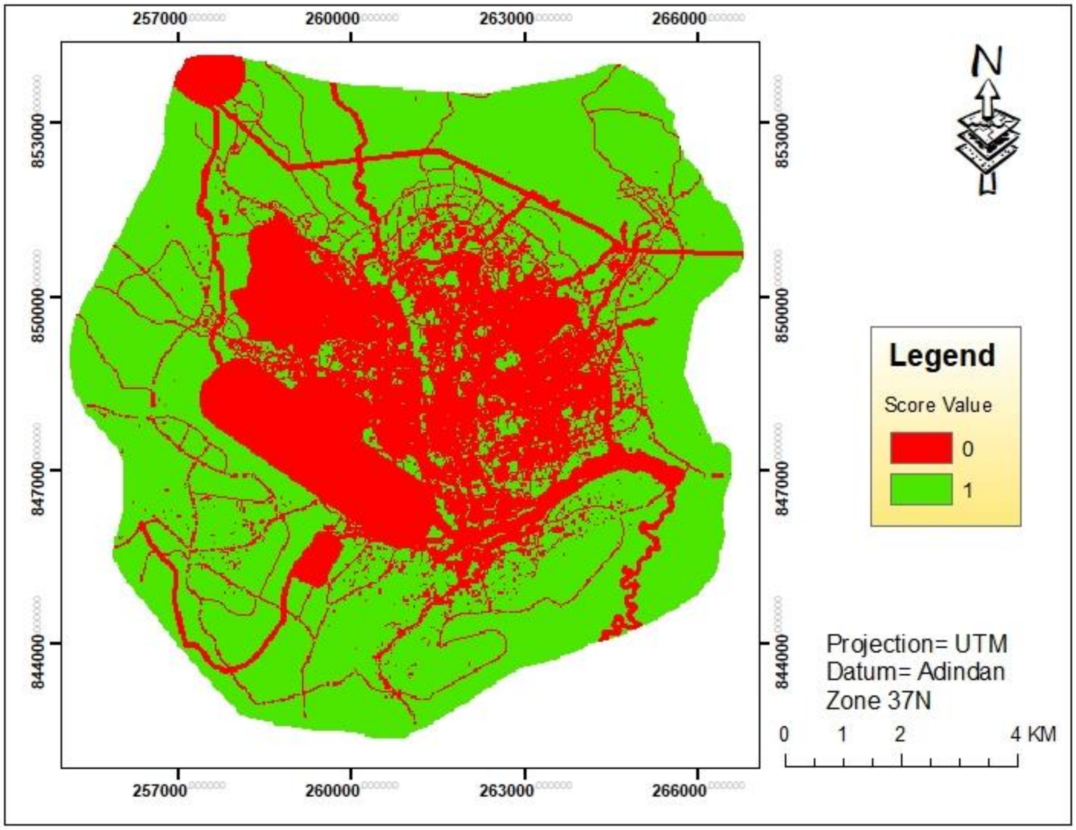

Figure 32: Final constraint map

4.3. Identifying Suitable site and generating potential Suitability map for future residential housing development in the study area.

After identifying the main criteria and sub crateria for future residential housing development in the study area the next most important steep is identifying and mapping the potential area for future residential housing development. To identify and mapping the final suitability map of the study area the following min procedures discussed below;

4.3.1. Assigning Weight criterion

After preparing the criterion maps for each criteria in suitability model the next step is to calculate weights for this criterion maps. To do this expert opinion were used to derive weights for each criterion and Averaged judgments of experts were then specified in the final pair wise comparison matrices and used to calculate weights of criteria. Accordingly the weights for eight main criterion were calculated based on AHP method in QGIS.A pair wise comparison matrix was constructed, where each criterion was compared with the other criteria, relative to its importance, on a scale from 1 to 9 (Table 24). The result obtained from pair wise comparison and expert judgment indicated that that LU/LC, Slope, and distance from City center are score the highest weigh when compared to other criteria which is 0.33, 0.227 and 0.156 respectively. While, distance from airport and population density and are score the lowest weight when compared to other criteria that is 0.034 and 0.034 respectively (Table 24 and appendix 3).

Table 24: Weights of the criteria using pair wise comparison matrices

	LU/LC	SL	DC	RA	DR	DW	DA	PD	Weight
LU/LC	1	2	3	4	5	6	7	9	0.33
SL	0.5	1	2	3	4	5	6	7	0.227
DC	0.333	0.5	1	2	3	4	5	6	0.156
RA	0.25	0.333	0.5	1	2	3	4	5	0.107
DR	0.2	0.25	0.333	0.5	1	2	3	4	0.073
DW	0.167	0.2	0.25	0.333	0.5	1	2	3	0.05
DA	0.143	0.167	0.2	0.5	0.333	0.5	1	3	0.034
PD	0.111	0.143	0.167	0.2	0.5	0.333	0.5	1	0.024

Where: LU/LC- Land use land cover
SL- Slope
DC- Distance from City center
RA- Road Accessibility.
DR- Distance from River
DW- Distance from Waste disposal
DA- Distance from Airport
PD- Population density.

If CR< 0.10, the ratio indicates a reasonable level of consistency in the pairwise comparison, however, if CR ≥ 0.10, the values of the ratio indicates inconsistent judgments (Saaty, 1980). In this study CR = 0.028 which is less than 0.10, so the weight which given for each criteria were more reasonable.

4.2.2. Weighted liner combination (WLC)

After assigning of weight for each criterion in AHP the WLC with 1 to 5 scales has been executed in Raster calculator tool of spatial analysis in Arc GIS to identify potential sites for future residential housing development for factor criteria by the following formula.

Suitability map= Σ [Criteria Map * Weight] *[Aggregated Constraint Criteria)

Suitability Map = ([re classed LU/LC] * 0.33) + ([re classed Slope] * 0.227) + ([re-classed distance from City center] * 0.156) + ([re-classed Road accessibility] * 0.061) + ([re classed distance from river* 0.073]) + ([re classed distance from Waste disposal* 0.05]) +([re classed distance from Airport] * 0.034) + ([re-classed Population density]* 0.024)) *(Final Constraint Map)

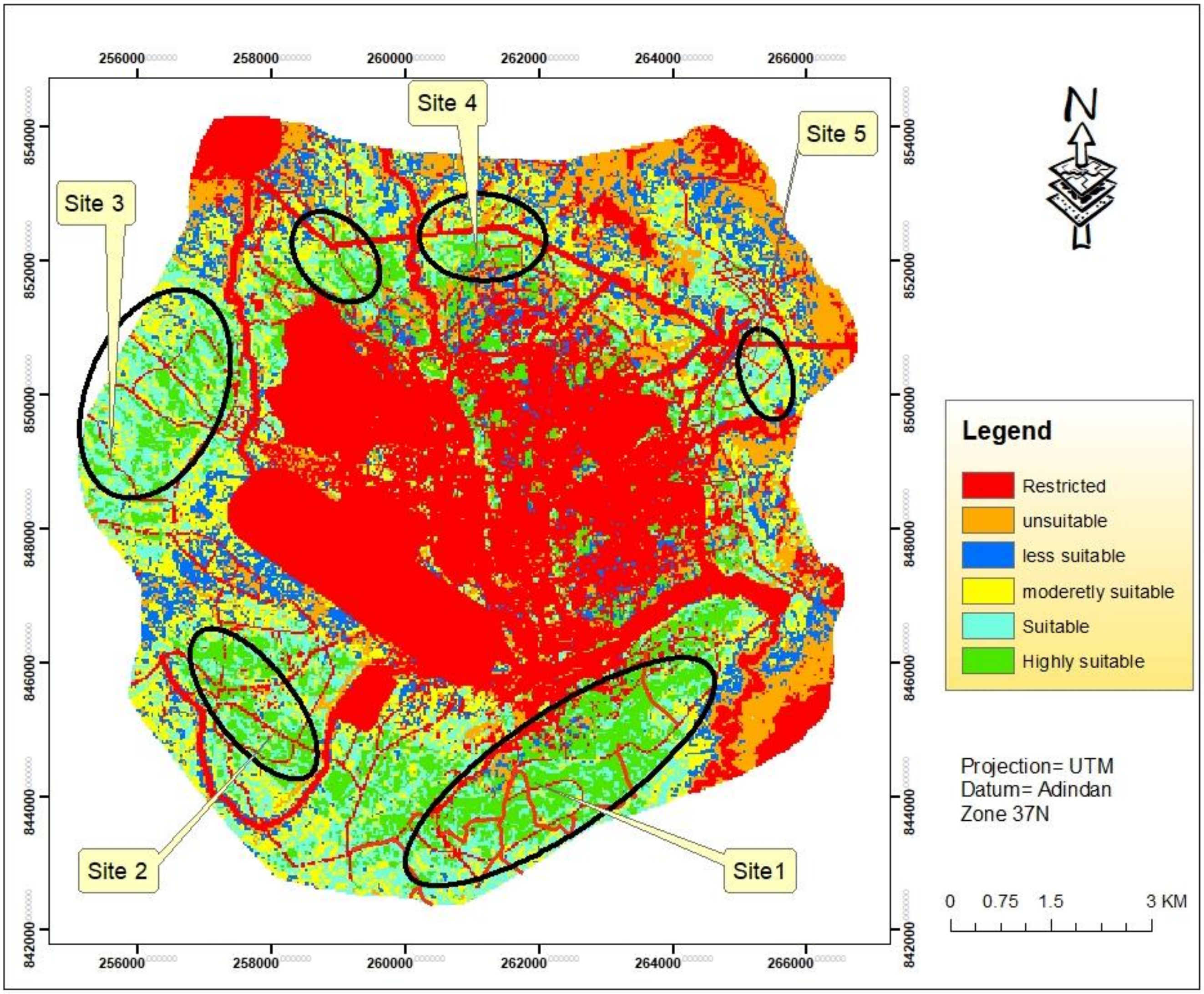

Figure 33: Potential Residential housing development Suitability Map

Figure 35illustrates that, Suitable areas for residential development in the study area. According to the classification, the suitable lands are identified as the land which range from highly suitable to the moderately suitable. Accordingly, the Southern, South west and north western part of the study area is suitable for feature residential housing development. In the other hand, unsuitable areas for future urban residential settlement were found in corner edge of North Eastern, South eastern and Central part of the study area.

The final suitability index map shows that, five potential sites were identified for future urban residential housing development in the study area. The site is belongs to three suitability class that is highly suitable, suitable and moderately suitable which account 11.81%, 14.87% and 13.44%, of the total study area respectively (Table 25). Because, the region satisfies the criteria used in this study.Whereas; about 38.78%, 11.43% and 9.67% of the total study area was restricted, unsuitable and less suitable for future residential housing development of the study area.

Table 25: Final Suitability and area coverage of suitability levels

Class	**Suitability Index**	**Area (ha)**	**Area Coverage (%)**
0	Restricted	4097.59	38.78
1	Unsuitable	1208.2	11.43
2	Less suitable	1021.28	9.67
3	Moderately Suitable	1420.56	13.44
4	Suitable	1571	14.87
5	High suitable	1247.96	11.81

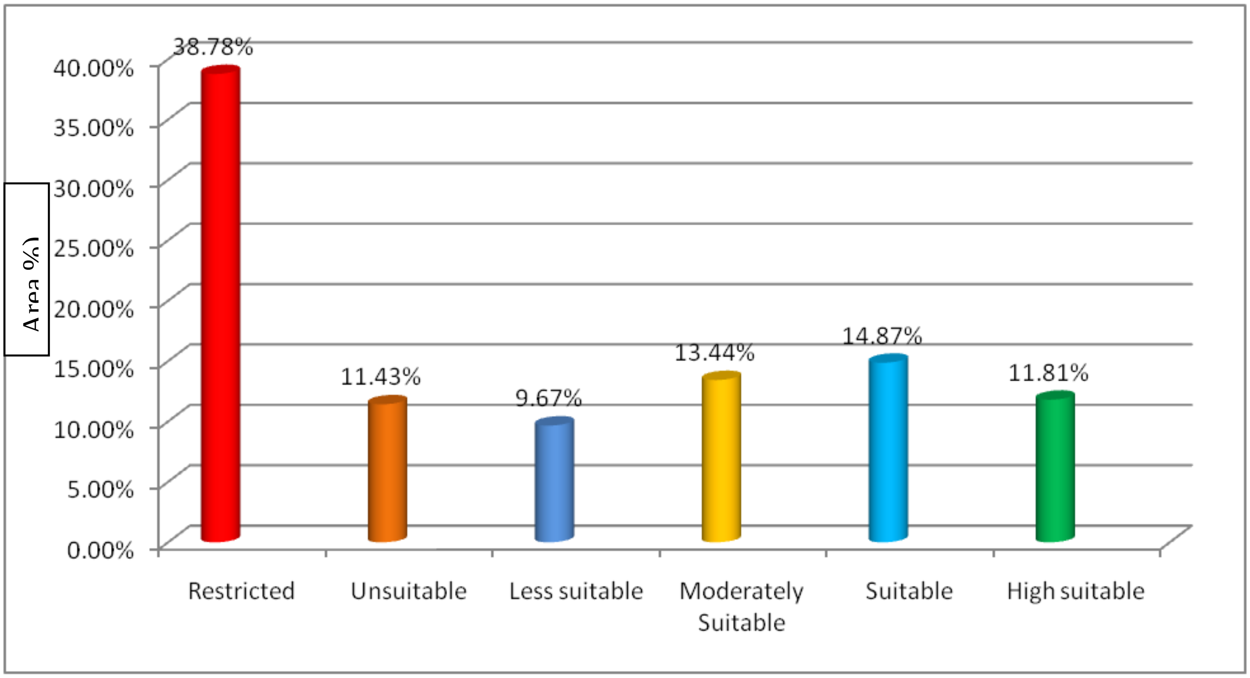

Figure 34: Land allocation pattern

Figure 33 above indicated that, five major alternative sites were classified as highly suitable, suitable and moderately suitable for future urban residential development within the existing boundary of the town. The suitability of each site was verified at field level by using hand held GPS (Garmin 60), the analysis of field observation and suitability of each site discuses as below:

Site 1: Situated in the Southern periphery of the town and consists of 1738.34 ha of land. This site is located in Bore and Bacho Bore kebele. The site is characterized by flat slope that is 0-8%slope rise, Vacant and Bush (eucalyptus) and farm land are the dominant LU/LC of the site. This site is bounded by Wetland in northeastern and Gibe River in southeastern with restricted buffer of 30m.

Figure 35: Suitability picture

Source: Field observation

Site 2' is situated in the Ssouthern and SouthWestern part of the town and consists of 610.7592ha of land. This site is located in Kofe kebele. Field observation were conducted in order to proofing the site, the site is characterized by flat slope of 0-8%. Bush (eucalyptus), Agro forestry farming and rain feed agriculture are the main dominant LU/LC of the site. In north part the site was bounded by the newly constructed industrial park.

Figure 36: Suitability picture

Source: Field observation

Site 3' is situated in Western part of the town and consists of 497.2 ha of land. This site is located in Furdisa kebele. Field observation were conducted in order to proofing the site, the site is characterized by flat-Gentle slope, the majority of this site is dominated by Bush (eucalyptus) Farm land and Vacant land are the main LU/LC of the site. Dystric Nitosols are the main soil types of the site. the site is belongs to about 1.3km far from Techno campus of Jimma university at west.

Figure 37: Suitability picture

Source: Field observation

Site 4 is situated in Northern part of the town and consists of 403.7 ha of land. The majority of site is belongs to Seto Semaro kebele. Field observation were conducted in order to proofing the site, the site is characterized by flat-Gentle slope, the majority of this site coverd by eucalyptus tree and Vacant LU/LC types and the site is located 1.5 km away from the newly constructed west disposal site. High electric power lines and Seto stream crossing site with restricted buffer of 40m and 30m respectively.

Site 5 situated in Northern-Eastern part of the town and consists of 232.25 ha of land. The site is belongs to Jiren and Ginjo kebele . Field observation was conducted in order to proofing the site, the site is characterized by almost Gentle slope, the majority of this site is covered by eucalyptus tree, Vacant and agro forestry farming types of LU/LC.

4.4. Evaluating the suitability of Proposed Residential housing development

Since the structure plan for 2008 was available, an evaluation of the proposed residential areas was done in relation to the suitability map. According to the structural plan about 3334.94 ha of land proposed for future residential housing development (Figure 40).

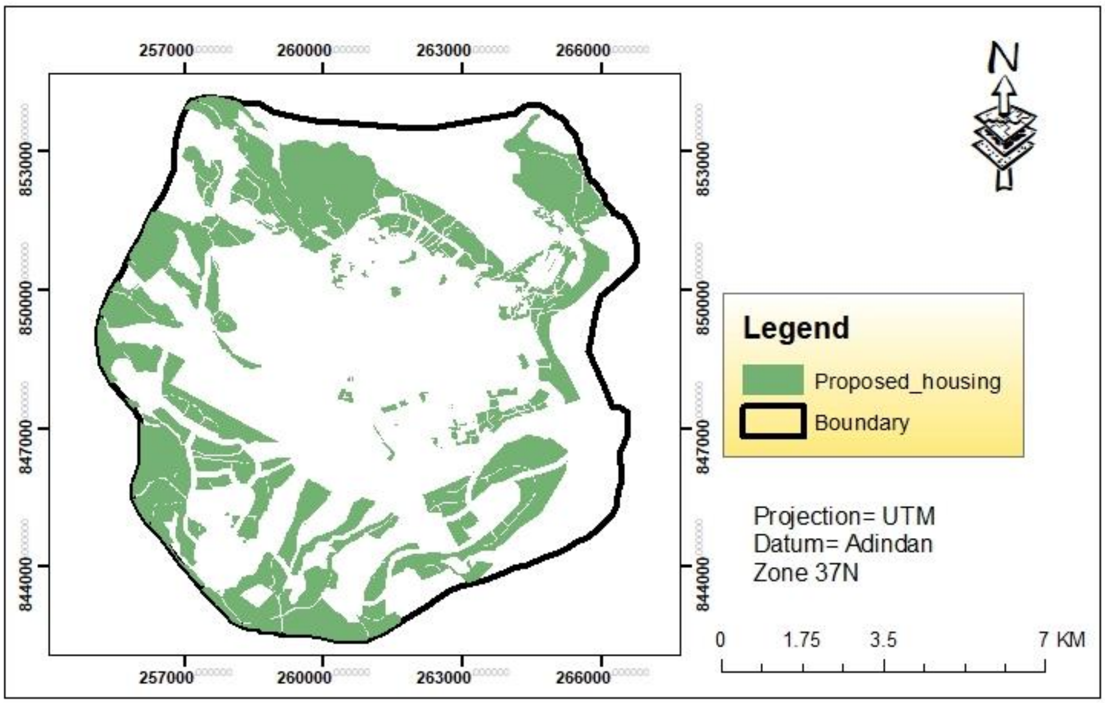

Figure 38: Proposed residential map

The suitability of the proposed site for residential housing development was performed after intersection tools of Geo-processing detecting the two overlapping areas of proposed residential housing and the final suitability map, and then the proposed site for residential housing development by municipality was evaluated in each six suitability class (Restricted, unsuitable, less suitable, moderately suitable, suitable and highly suitable). Table 26 shows the area of proposed residential development in relation to the final suitability map

Table 26: suitability of the proposed residential housing and area coverage

Suitability Class	Area (ha)	Area (%)
Restricted	629.42	19.03
Unsuitable	308.41	9.32
Less Suitable	395.7	11.96
Moderately Suitable	590.56	17.85
Suitable	632.08	19.11
Highly Suitable	752.26	22.74
Total	3308.43	100.01

The result of overlay indicated that most areas about 22.74% and 19.11% of the proposed residential housing development by municipality of the town belong to in highly suitable and suitable class respectively. About, 17.85 % of the proposed residential housing development of the study area moderately suitable for residential housing development. While 11.96 % of the proposed site belongs to in less Suitable class where as about 9.32% of the proposed residential site is belongs to unsuitable class for residential housing development, finally about 19.03% of the proposed site for residential housing development belongs to the restricted class of the final suitability map of this study.

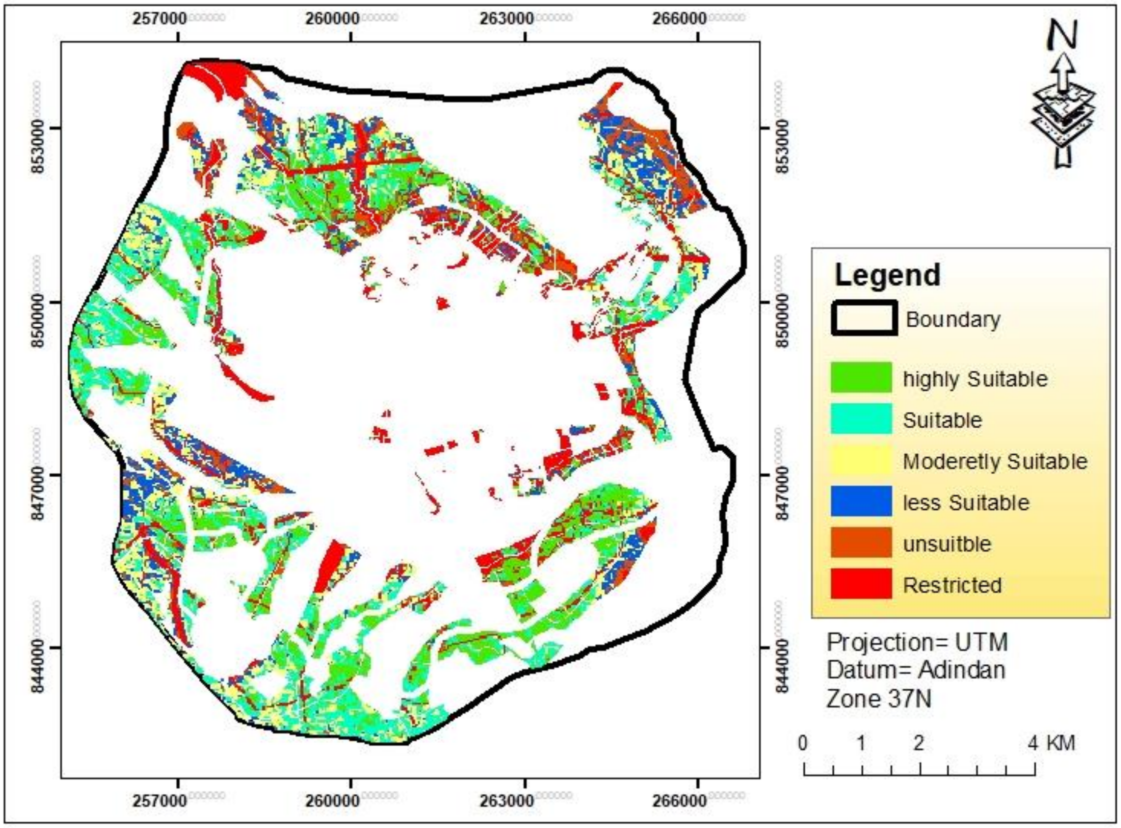

Figure 39: Suitability Map of proposed residential area

Figure 40 above indicated that, the proposed residential housing development in Northern part of the town planned on restricted area of waste disposal, restricted buffer of high electric power line , stream and wetland that are high risky for residence to lead normal life in those place. It is also that the proposed residential housing development by municipality t in north eastern part of the town proposed on unsuitable class of suitability map since the area is characterized by steep slope of land form which is difficult to provide social infrastructure, high risky for flooding and landslide. Small proportion of the proposed residential housing development by municipality in northern, southern and north eastern parts were proposed adjacent to waste disposal, airport site and high slope proposed on less suitable class of the final suitability map. Figure 41 also show that the majority of proposed site for residential housing development in Southern, Western periphery and Northern part of the town proposed on highly suitable, suitable and moderately suitable class of the final suitability map thus those site proposed in appropriate way for residential housing development since the site fulfill criteria used under this study for housing development.

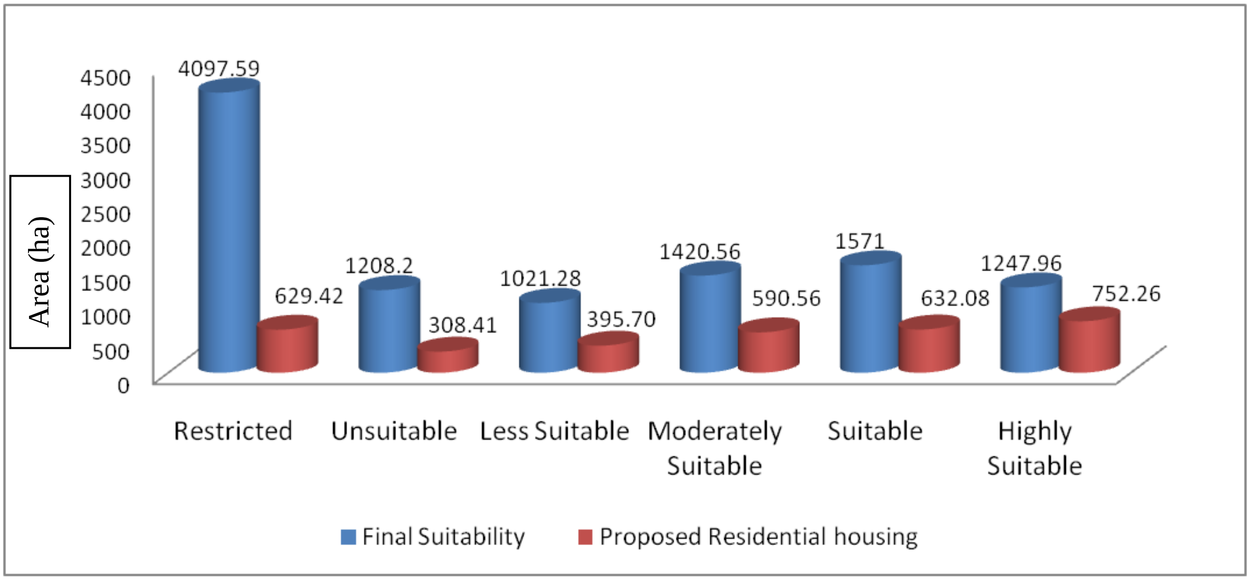

Figure 40: Suitability comparison of proposed and potential residential areas

As shown in figure 41 about 1247.96 ha of land of the study area is highly suitable for future residential housing development but from this potential area only 752.26 ha (60.27%) of land is proposed for future residential housing development by municipality, this indicated that about 39.72% of highly suitable potential class of future residential housing development of the study area proposed to others land use unit like manufacturing, storage and principal artery. The figure also indicated that about 1571ha and1420.56ha of land is potentially suitable and moderately suitable for future residential housing development respectively But from this potential area only 40.22% and 41.5 % of potentially suitable and moderately suitable class is proposed to future residential housing development this indicated that about 59.88% and 58.5% of this class was proposed for other land use types. Finally the study found that about 1208.2 ha and 4097.59 ha of land are restricted for future residential housing development respectively but the municipality proposed 308.41ha and 629.42 of land for residential housing development on unsuitable and restricted area for feature residential housing development respectively.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Residential housing development suitability analysis for urban areas is necessary to overcome the problem with land availability against drastic growth of urbanization. The residential development has created the most crucial issues for the urban development of the country. Identification of most suitable or suitable land is very much important since it makes the life space for people. Therefore evaluation of locational suitability of the residential development is most important to the country for getting highest and best use of the land as well as environmental and social improvements.

Selection of optimal location for residential use from various land use is important in urban areas. Requirement of potential land and the current residential related issues is very important in suitability analysis. Therefore it is very much important to have GIS based Multi Criteria Evaluation for land suitability analysis before beginning of any development. The future development decisions are not taken place without any proper of land suitability.

The internal factors that cast a shadow image on the quality of the current residential housing development plan preparation were the experience and skill gap of the plan preparation team that caused for the proposal of existing wetland site for residential land, existing industrial area for settlement and proposing residential area on slope greater than 25^0 rise which is difficult for provision of social infra structure.

Hence, the study used eight environmental and economic factors which have principal effect on site selection for urban residential housing development based on expert knowledge and available literature. The criteria includes, Slope, LU/LC, Road accessibility, Distance from Airport, Waste disposal site, proximity to City center and Population density as determining factor in order to find appropriate site for residential housing development of the study area. The weight of each factors was assigned based on expert based opinion.WLC were used to develop the final suitability map in GIS environment. The finding of the study illustrated that about 2899.35 ha (27.44%), 1247.9 ha (11.83%), 1942.09 ha (18.38%), 1483.68 ha (14.04%),1733.98

ha (16.41%), 1259.61 (11.92%) of the total urban landscape of the study area is Restricted, less suitable, moderately suitable, suitable and highly suitable for future residential housing development in study area respectively. Five potential sites were identified for future residential housing development having suitability class of highly suitable, suitable and moderately suitable in Kofe, Bore, Furdisa, Jiren,Ginjo, Seto Semaro, Mendara Kochi and Becho bore kebele.

The evaluation existing proposed area for residential housing development by municipality was evaluated with the final suitability map of this study. The result reviled that most areas about 22.74% and 19.11% of the proposed residential housing development by municipality of the town belong to in highly suitable and suitable class respectively. About, 17.85 % of the proposed residential housing development proposed by municipality is belongs to moderately suitable for residential housing development. While 11.96 % of the proposed site belongs to in less Suitable class where as about 9.32% of the proposed residential site is belongs to unsuitable class for residential housing development, finally about 19.03% of the proposed site for residential housing development proposed restricted class of the final suitability map of this study.

5.2. Recommendations

Based on the main finding of the study the following recommendation was forwarded;

- In Ethiopia in order to better spatial urban land use planning and supplying safe and comfortable land for urban residential housing development for urban residents the way of planning should be shifted from the previous rudimentary subdivision layouts to GIS-MCE and AHP technology.
- The town administration, particularly the land administration ad use office of the town should be revising the current structural plan in general and the proposed residential housing development of the town specifically in regard to the final suitability map of this study.
- Housing developers as well as the respective authorities of the town should consider the areas highly suitable for residential development.
- The finding of this study assist the city administration to supplying suitable, safe and comfortable site for residential housing development for the residence of the town. The findings of the study also assist various stakeholders those who are participating in purchasing of the lease land for residential housing development to understand the nature of the suitability of the site
- City administrator should Conserve environmental sensitive areas like forests, wetland, catchments of water bodies and areas with slope greater than 20% as well as restrict pollutant activities with buffer zone while supplying land for residential housing development.
- In this study only considers 8 environmental and economic criteria to select the potential site for future residential housing development of the study area , As to the residential development, we should also consider the other ecological factors such as ground water level, land slide prone area, fault line as well as socio economic factors, such as distance from School, Hospital and others; thus it is recommended that the other researchers and the planners should keep in more touch with each other, work together to carry out some researchers of the relevant specially and make up the foundational data

- Suitability analysis can be applied not only to find the suitable locations for residential purposes but also for commercial, recreational, industrial and educational locations. Therefore further research can be carried out find the suitable locations for commercial, recreational, industrial, urban greenery and educational uses within the study area.

- To carry out a suitability analysis using GIS required proper spatial data base. Therefore responsible authority of the town should take action to maintain "Updated Spatial Data Base" in proper manner.

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Appendix

Appendix 1: Interview questionnaire on Expert's Opinion

This interview questions are designed purely for academic purpose and to come up with appropriate recommendation regarding to Site selection for residential housing development in Jimma town. so, Your voluntary participation and truthful responses have great values for identifying the main criteria that was considered for residential housing development and the corresponding weight of each criteria. Thus; I request you forward the answer of the questions confidently.

Fill the table with the comparing the factors importance. So according to your Preference what is your desired factor to select the suitable land / house for Residential activity.

Example;

When you consider factor proximity is "**First Important"**then mark the suitability scale of the able as follows

Main Criteria	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th
Slope		√												
LU/LC	√													
Road accessibility			√											
Distance from city center				√										
Distance from Airport							√							

1. **What is your preference factor?**

Main Criteria	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th
Slope														
LU/LC														
Road accessibility														
Distance from city center														
Distance from Airport														
Distance from Waste disposal														
Population Density														

Distance from Rivers/ Stream														
Distance from Social amenities like Schools and health post														
soil														
Geological factors like fult line														
Land slide prone area														
Land value														
Aspect condition														

2. What is your Preferences Sub factor?

1. Road accessibility

Sub crateria	**1st**	**2nd**	**3rd**	**4th**	**5th**
within 50m					
within 250m-500m					
within500m-1000m					
within1000m-2500m					
Greater than2500m					

2. Slope rise

Sub criteria	**1st**	**2nd**	**3rd**	**4th**	**5th**
within 5^0					
within 5^0-8^0					
within 8^0-15^0					
within 15^0-25^0					
greater than 25^0					

3. Distance from Rivers/Stream

Sub criteria	**1st**	**2nd**	**3rd**	**4th**	**5th**
within 30m					
within 30-50m					
within 50-70m					
within 70-90m					
greater than90m					

4. Distance from Airport.

Sub criteria	**1st**	**2nd**	**3rd**	**4th**	**5th**
within 1000					
within 1000m-1500m					
within 1500m-2000m					
within 2000m-2500m					
greater than2500					

5. Distance from Airport.

Sub criteria	**1st**	**2nd**	**3rd**	**4th**	**5th**
within1000m					
within 1000m-1500m					
within 1500m-2000m					
within 2000m-2500m					
greater than 2500					

6. LU/LC

Sub criteria	**1st**	**2nd**	**3rd**	**4th**	**5th**
Forest land					
Bush land					
Wetland					
Vacant land					
Built up area					
Farmland					

7. Distance from city Center

Sub criteria	1st	2nd	3rd	4th	5th
within 3Km					
within 3km-4km					
within 4km-5km					
within 5km-6km					
greater than 6 km					

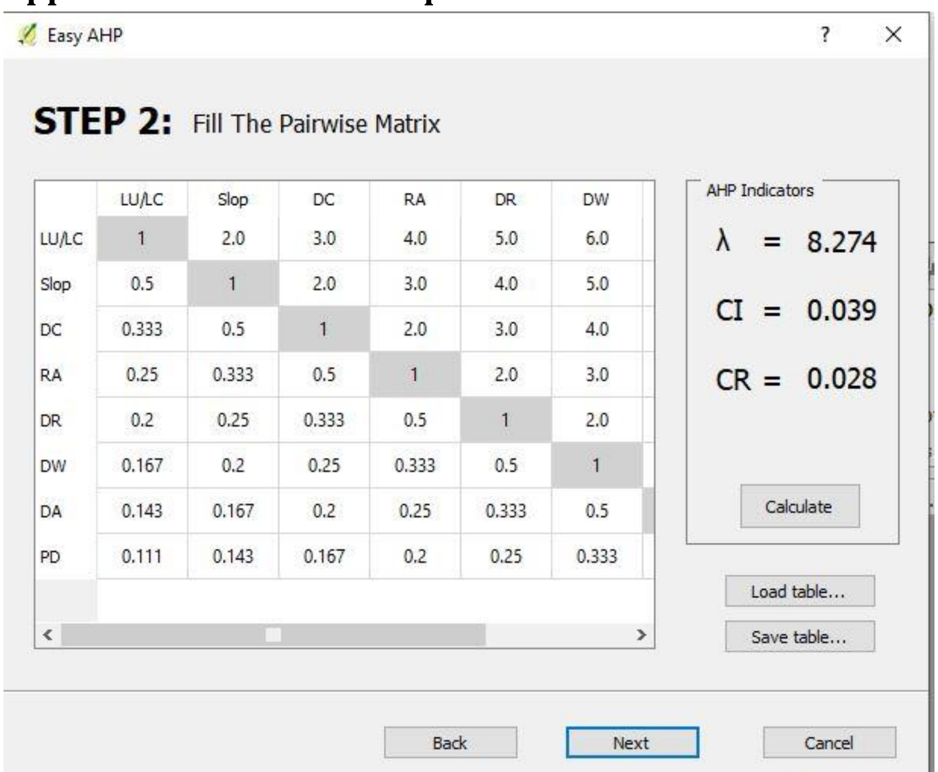
8. Population Density

Sub criteria	1st	2nd	3rd	4th	5th
4 p/ha-20 p/ha					
21 p/ha-40 p/ha					
41 p/ha-50 p/ha					
51 p/ha-80 p/ha					
>80 p/ha					

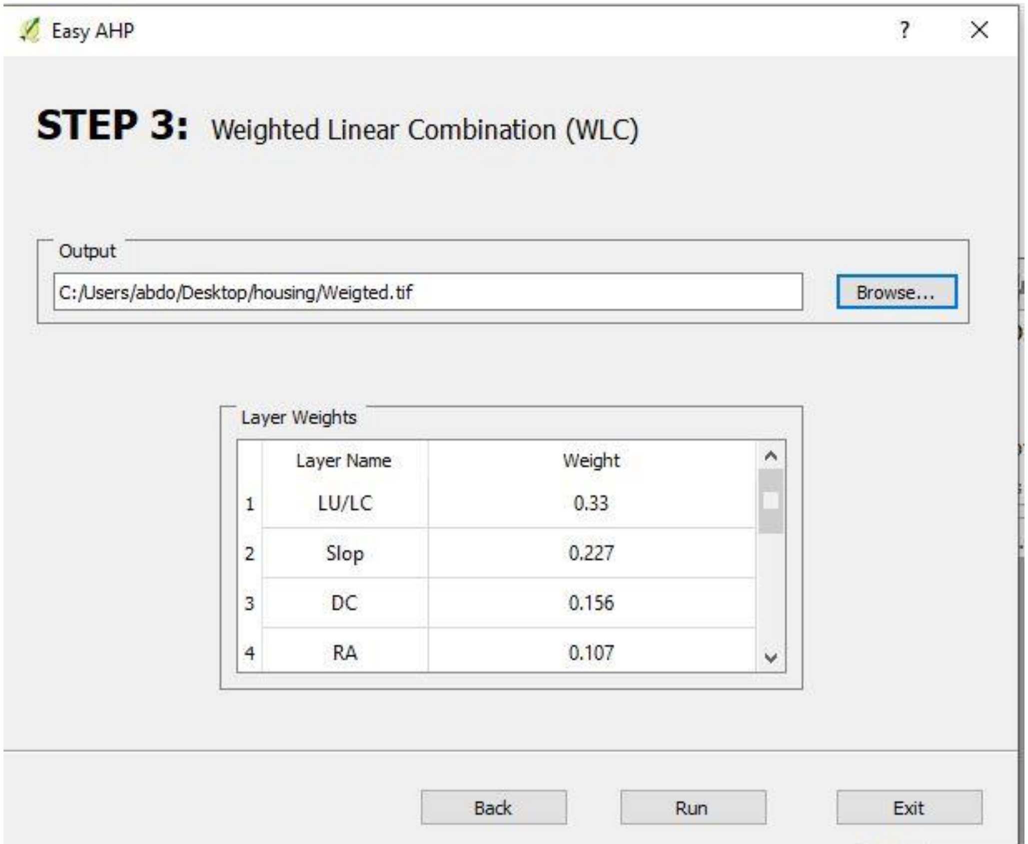
Appendix 2: result of LU/LC accuracy assessments.

		Ground Truth							user accuracy
Classified in Satellite Image as	LU/LC category	Forest land	Buh land	Vacant	Farm land	wateland	Built-up	Total	
	Forest land	13	2	0	0	0	0	15	86.66
	Bush land	2	12	1	0	0	0	15	80
	vacant	0	1	11	1	1	1	15	73.33
	Farm land	0	0	2	11	2	0	15	73.33
	wateland	0	0	1	0	14	0	15	93.33
	Built up	0	0	1	3	0	11	15	73.33
Total		15	15	16	15	17	12	90	
Producer accuracy		86.67	80	68.75	73.33	82.35	91.66	180	

Appendix 3: Pair wise comparison of Criteria



Appendix 4: weighted linear combination (WLC)



Appendix 4: Final Suitability Map