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Urban Land Use Suitability Assessment for Sustainable Residential Development in Mertule Mariyam Town, Ethiopia: A GIS based Computing Approach

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INSTITUTE OF LAND ADMINISTRATION

Department of Land Administration and Surveying

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By:

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August, 2022

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A Thesis Submitted to

The Institute of Land Administration, Bahir Dar University, in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Geomatics

Advisor:

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Declaration

This is to certify that the thesis entitled “Urban Land Use Suitability Assessment for Sustainable Residential Development in Mertule Mariyam Town, Ethiopia: A GIS based computing Approach”, submitted in partial fulfillment of the requirements for the degree of Master of Science in Geomatics Department of Land Administration and Surveying, Bahir Dar University, is a record of original work carried out by me and has never been submitted to this or any other institution to get any other degree or certificates. The assistance and help I received during the course of this investigation have been duly acknowledged.

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DEPARTMENT OF LAND ADMINISTARTION AND SURVEYING

Approval of Thesis for Defense

I hereby certify that I have supervised, read, and evaluated this thesis titled "Urban Land Use Suitability Assessment for Sustainable Residential Development in Mertule Mariyam Town, Ethiopia: A GIS Based Computing Approach" by Zenebe Endalew Asrat prepared under my guidance. I recommend the thesis be submitted for oral defense.

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Approval of Thesis

As members of the board of examiners, we examined this dissertation/thesis entitled “Urban Land Use Suitability Assessment for Sustainable Residential Development in Mertule Mariam Town, Ethiopia: A GIS Based Computing Approach” by Zenebe Endalew Asrat. We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of “Masters of Science in Geomatics”.

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Acronyms and Abbreviations

AHP	Analytical Hierarchy Process
ANRS	Amhara National Regional State
CSA	Central Statistics Authority
DEM	Digital Elevation Model
EPRDF	Ethiopian People Revolutionary Democratic Front
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
GIS	Geographic Information System
GPS	Global Positioning System
LSA	Land Suitability Analysis
LULC	Land Use and Land Cover
m.a.s.l	meter above sea level
MCA	Multi-Criteria Analysis
MCDM	Multi-Criteria Decision Making
MCE	Multi-Criteria Evaluation
MUDHC	Ministry of Urban Development and Housing Construction
NGO	Non-Governmental Organization
SPSS	Statistical Package for Social Science
SRTM	Shuttle Radar Topographic Mission
UBT	University for Business and Technology
UN	United Nation
USGS	United States Geological Survey
WHO	World Health Organization of the United Nations

Abstract

Urbanization and urban population have dramatically increasing in many developing countries. Ethiopia is also experiencing with high rate of urbanization and growth of population. These high rate of urbanization require sustainable land use allocation for housing development and other functions. Housing is basic human need, which has evolved from simple shelters to modern housing units. However, affording housing is a challenge due to inefficiencies in the allocation/planning and management of the land. Hence, the main objective of this study was to assess urban land-use suitability for sustainable residential development using a GIS-based computing approach. A mixed research approach and survey research design were applied to provide a comprehensive analysis of the research. Both spatial and socio-economic primary and secondary data were used for this study. Primary data were collected using survey Questionnaires, Focus Group Discussion and interview data. Spatial data were collected from United States Geological Survey, Global Mapping Viewer website. Simple random for selecting household respondents and purposive sampling techniques for selecting expert respondents were used. The quantitative data were analyzed using descriptive statistics. Then, the weighted overlay multi criteria evaluation technique was used to assess sustainable residential development area through Analytical Hierarchy Process pairwise comparison method. The final suitability map indicated that 8.44%, 52.95%, 24.84%, 13%, and 0.77% of the total areas are highly suitable, suitable, moderately suitable, marginally suitable and unsuitable for housing development respectively. Though most of the areas are suitable for residential housing, affordable residential housing is a challenge due to lack of immediate response for legal housing association, high compensation payment, lack of urban land use planning, corruption, lack of responsibility and accountability. All these hamper the affordability of housing and the sustainability of land use. Taking into account the results, this research recommends the uses of land use suitability map for sustainable housing development in the town.

Keywords: *Housing development, Site selection, Analytical Hierarchy Process, Geographic Information System, Land use for residential development*

Chapter One

1. Introduction

1.1. Background of the Study

In the past few decades, urbanization and urban population growth have dramatically increased in many countries. According to the United Nations (2011) report, the world urban population is projected from 52% in 2011 to reach 67% by 2050. When zooming in to the developing countries, the proportion of urban will rise from 47% in 2011 to 64% by 2050 (Gezahagn, 2013). According to Gezahagn (2013), in Africa, the urban population is expected to triple from 414 million in 2011 to 1.2 billion by 2050. During the 1990's, only 22 % of the East African population exist in urban areas which is the lowest compared to 33 %, 38 %, 45 %, and 55 % of West, Middle, North, and Southern Africa regions, respectively (Kempe, 2017).

In Ethiopia about 20% of the total population currently lives in urban areas, which has ranked as one of the least urbanized countries in sub-Saharan Africa (Abebaw, 2021). Despite this low level of urbanization, however, the country has one of the highest rates of urbanization, which is estimated at 4.5% (MUDHC, 2014). This is also much higher than the average growth rate of the total national population, which is estimated at 3 % per annum (Jahangeer, *et al*., 2018). The level of urbanization has been only 6 % in 1960, which has increased to 11% in 1984, 14% in 1994, and 17.2% in 2013 and it projected to reach 30% by 2025 (MUDHC, 2014).

The consequence of these high rate of urbanization created different challenges including; rising housing prices, increased housing shortage, the problem for the accessibility of infrastructure development, increased housing demand, incompatibility of housing demand and supply, the existence of all kinds of inflation, and there is a wide range of legal and illegal housing land grabbing (Rob *et al*., 2019).

The challenges of unplanned urbanization and the need for affordable housing are common in all urban areas in Ethiopia. Mertule Mariyam town among those highly affected urban areas due to high rate of population growth. According to the Mertule Mariyam town administration report (2022) report between (2006-2022), shows that the total population of the town increasing by 69% from the year 2006 to the year 2022 and the total population of the town are 29,721 and 50,159 respectively. The total population of the town increased by 30.93% from the year 2013 to 2020 and the total population of the year is 34,024 and 44,550 respectively.

Due to this, there is lack of residential plots that are given by municipalities due to the increase of population in the urban areas.

Housing is a basic human need, which has evolved from simple shelters to modern housing units. A housing unit refers to a dwelling structure that may be occupied by one or more households or maybe used partly for living and partly for commercial purposes (Terefe and Yanyi, 2015). In many developing countries around 40% of urban residents are living in rental housing units (Brown and King, 2005). For instance, in Ethiopia, 39% of the owner-occupied housing units and about 40% of the urban housing units are rented from private households (Abebaw, 2021). The implication for living in rental housing are; it reduces the source of income or reduce savings, it undermines the right to freedom, monthly income may be less than the amount of pay for housing rent, rent increase over time, lower-income households live in lower quality housing and high-income households live-in high-quality housing. The rise in housing rent affects residents' daily necessities and service consumption such as; telecommunication and transportation consumption, education, culture and entertainment consumption, and food consumption. Also, about 60 % of the urban areas are estimated to be slum devoid of basic services (MUDHC, 2014). Moreover, recent urban growth has been unprecedented, mainly as a result of rural-urban migration, resulting in growing welfare and housing problems for the new urban poor, and increasing urban unemployment (Eskedar, 2012).

Land-use suitability analysis for the development of an urban area is necessary to sustain the problem of continuous movement to cities/towns with limited availability of land (Firsew, 2018). It also supports for sustainable development of the town by providing different alternative planning systems. Site selection and development involves a wide range of actions with social, environmental, and to assess the existing housing condition and identify a potentially suitable site for residential development using GIS-based computing approach (Weldemariyam and Iguala, 2016).

GIS is a powerful tool to perform site selection and land suitability analysis by integrating different data sources. It is also vital for planners and decision-makers to make effective land use planning for evaluating the best land areas for housing development. It is important for analyzing, retrieving, displaying, or visualizing spatial data for the support of making good decision making. The main decision-making for urban land use allocation for sustainable

development is Multiple Criteria Decision-Making Analysis through Analytical Hierarchy Process techniques for residential development (Florentino and Walter, 2021).

1.2. Statement of the Problem

The sustainability of urban land use is highly depending on the nature of land use allocation, planning, utilization and management of the land. The assessment of the suitability of land use can be done both in the existing land uses (e.g., residential areas) and areas for future development. Residential land use demands more land than any uses and it is the most significant land use in the context of space needs (Shuaib, 2005). Due to high rate of urbanization, the need for land for housing development always rises and it needs to monitor the direction of urban expansion to avoid a conflicting interest of different land-uses (Hanibali *et al*., 2011).

Housing is one of the necessities for human beings (Eskedar, 2012). For a long time, however, affordable housing is a critical problem for the millions of poor people in the developing countries. This is mostly connected to inefficiencies in the land use allocation. According to Mohammed *et al*. (2006), the selection of housing land involves a complex array of complex factors drawing from physical, demographical, economic, policies, and environmental disciplines. However, the previous study mainly focuses on physical suitability conditions for housing development.

According to Weldemariyam and Iguala (2016), there are eleven criteria used for selecting a potentially suitable site for housing development such as; land-use/land-covers, built-up, slope, flood sheets, road, aspect, airport, railway, soil, population density, and proximity to urban center. The research conducted by Madurika & Hemakumara (2017), used five criteria for selecting a suitable site for residential development such as; Elevation, population density, land use, land-use zoning, and available facility (accessibility to roads, schools, hospitals). In this study eight criteria were used for selecting and evaluating sustainable residential development of the town such as; Land use/Land Cover, Slope, Road distance, River distance, population density, social service area distance, religious area distance, and Soil type.

As discussed in the background section, the population of Mertule Mariyam town and the need for land for housing are increasing dramatically from time to time. These require effective land use allocation, planning and management. In Mertule Mariyam town, however, there is no

research done previously to evaluate the existing urban land use allocation strategies and land suitability analysis for future housing development.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of the study is on how to evaluate or assess urban land-use suitability for sustainable residential development using a GIS-based computing approach.

1.3.2. Specific Objectives

- To evaluate the impacts of the existing/current urban land use allocation and housing development strategies/frameworks in Mertule Mariyam town.
- To analyze the land use/ land cover map of the study area.
- To identify the dominant factors or criteria for sustainable housing development in the town administration.
- To identify/propose a potentially suitable site for sustainable housing development of the town.

1.4. Research Questions

To realize the above-stated objectives the following research questions were formulated:

- What are the impacts of the existing/current urban land use allocation and housing development strategies/frameworks?
- What is the land use/ land cover map of the study area?
- What are the main factor that affects the urban land-use suitability assessment of the study area?
- How many percent of the area are potentially suitable for sustainable housing development of the town?

1.5. Significance of the study

The result of the study is important to protect environmental safety of the community through locating a potentially suitable site for housing development. It also shows the present land use/land cover map of Mertule Mariyam town for the purpose of selecting suitable residential development. The study identified terrain slope, distance to road and distance to river are the main factor that affect construction of the house in the town. Hence, the findings of the study

will be very useful for planners, municipality experts, land use planning activities, urban land management, policy and decision makers to make rational on residential housing development of the town. Furthermore, this work will be used as source of information for those researchers who intend to do similar or related research.

1.6. Delimitation/scope of the study

This study was conducted in Mertule Mariyam town administration, located 184 Km from Bahir Dar city, a capital of Amhara National Regional State and located 364 Km from Addis Abeba. Thematically, the study focused on evaluating the current land use allocation development strategies and identifying potentially suitable sites for housing development using a GIS-based computing approach. The study conducted based on the consideration of economic, environmental, and social considerations.

1.7. Organization of the Study

This study consists five chapters. The first chapter presents the introductory part, which describes the background of the study, statement of the problem, objectives of the study, research questions, significance of the study, scope of the study, and organization of the paper. The Second Chapter discuss the empirical and theoretical literature related to this study. The third chapter describes the study area and research methodology. The fourth chapter presents the results and discussions parts of the study. The final chapter presents the conclusions and recommendations.

Chapter Two

2. Review of Related Literature

2.1. Theoretical Literature

2.1.1. Land Suitability Assessment and Site Selection

According to FAO (1990) interpretation "land suitability evaluation" is an assessment process that takes into account the performance of the land when used for a specified purpose. Identifying and putting into practice the future alternative land uses to best meet the needs of the people while protecting and preserving the resources for the future is the main objective of the systematic assessment of land use. The assessment process is guiding towards the optimal use of land through the provision of important information regarding the opportunities and constraints in the use of a given land. In addition, the assessment process then determines the suitability of land for a specific use through land suitability analysis considering land properties and user needs (Florentino and Walter, 2021).

Site search and selection is a major element in the process of creating a supportive housing project in which units of housing are being developed. It also involves a wide range of actions with social, environmental, and economic dimensions. These can result in a wide range of impacts, all of which play a role in the long-term health and security of people and communities recovering from disaster. The long-term impacts of site selection and development decisions need to be defined, considered, and addressed. Likewise, any opportunities that improve the overall well-being of disaster survivors beyond pre-disaster conditions should be maximized wherever possible (Charles, 2010).

Site selection plays an important role in sustainable development. Using land efficiently and under the site's suitability for the intended purposes is a fundamental precept of ''smart'' growth or sustainable development. It requires fewer inputs of energy and materials and generates fewer negative outputs such as water and air pollutants. Site selection or analysis of suitability is a type of analysis used in GIS to identify the best place or site for something (Zeyin, 2020).

According to John (2009), site planning is responsive to inherent environmental constraints reduces construction costs, allows the continuation of critical environmental processes, and

protects essential natural and cultural amenities. Also, sustainable site planning is important to minimize negative development impacts by respecting the landscape's natural patterns, and processes. Sustainability is all about; the integration of schools, community facilities, employment, transport, and amenities with the housing development process in a timely, cost-effective way.

Site planning is a multiphased activity to ensure that land is utilized in ways that are functionally efficient, beautifully attractive, and environmentally sustainable. In addition to the construction of buildings, walkways, or other structures, sustainable site development often involves the restoration and enhancement of the site's ecological infrastructure (James, 2008).

2.1.2. Housing Development

According to Usman (2020), housing is defined as any type of permanent shelter for a man/woman, which gives him/her identity. Housing is defined as the space that one can call his/her privacy and shelter. Housing is a multi-dimensional concept that refers to the activity, a process of residing, as well as to the objects of dwellings and their environment (UN-Habitat, 2013). This definition includes housing as both an activity and a commodity or material object and considers not only the physical structure of the housing but its immediate environment, suggesting a health component of housing.

According to Sheibani and Harvard (2013), various schools of thought have differed in their definition of housing and they defined housing based on theoretical understandings other than political ideologies. Thus, Sheibani and Harvard believe that housing definitions can be influenced by political ideologies. They believe that housing emanates from the fundamental material needs of man and political ideologies shape the way the political systems respond to this need of man. It is also obvious that the house is one of the most necessities of life for humans along with food, water, and clothing (Terefe and Yanyi, 2015). Moreover, housing refers to a 'package of services; public facilities, access to employment and to other services as well as to the dwelling structure itself (Usman, 2020).

The WHO (1984), defines healthy housing based on the definition of adequate shelter by UN-Habitat to mean "a home, a place which protects privacy, contributes to physical and psychological well-being and supports the development and social integration of its inhabitants, a central place for human life" (Usman, 2020). Housing is an essential need affecting the well-being of all citizens. Accordingly, providing adequate and affordable

housing is a core national policy objective, especially given its impact on inequalities. Lower-income households typically live in lower-quality housing; on which they spend a greater share of their disposable income (Tadashi and Jonathan, 2021).

According to Usman (2020), the housing sector plays an important role in the socio-economic development of countries, and it is an important tool for the economic development and well-being of people.

2.1.3. Components of Housing

The UN-Habitat (2013) identified components of housing in the form of key inputs in the housing delivery process. Such as; land, building materials, finance, labor, and infrastructure (Usman, 2020). These inputs affect the delivery in terms of the quality of the housing delivered, the supply, and even the affordability of housing. It is obvious to claim that the high cost of these inputs reduces the ability of households or individuals to afford housing and its maintenance.

2.1.4. Sustainable Residential Development

Sustainable development encompasses the three basic variables which are essential for human beings: economic development, social equity, and the preservation of the environment (Samson and Alok, 2012). As defined by Samson and Alok (2012) sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable residential development in urban areas must form part of urban nodes which have employment opportunities, community facilities including education, childcare, religious, vacation, retail facilities, and adequate transport links (Tadashi and Jonathan, 2021).

According to Sayed and Hakan (2020), the range of relevant national policies in Eskisehir can be distilled into a series of high-level aims for successful and sustainable residential development in urban areas. Housing developers, their design teams, the planning system, and the community they serve, share a common goal to create high-quality places which Prioritize good transportation facilities, deliver the quality of life on the residents, provide a good range of community and support facilities, present an attractive and well-maintained appearance, easy to access for all, promote the efficient land use, minimize greenhouse gas emissions, and Promote social integration.

A. Personal safety

The ability to live with a feeling of comfort and safety in the residential area is an essential component of sustainable communities. The design of the built environment can contribute to this by creating a sense of security and ownership within residential areas. Good design is essential in a residential area in giving a sense of personal safety by providing a clear demarcation between private and public/communal spaces through appropriate boundary treatment, clear and direct routes through the area for pedestrians and cyclists with safe edge treatment, maintaining clear sightlines at eye level and clear visibility of the route ahead (John, 2009).

B. Traffic Safety

According to John (2009), the roads and streets around the residential areas should be safe for people to drive, cycle, walk, and in certain situations to play in. International research has shown that appropriate design of the built environment can substantially reduce the risk of pedestrian/ vehicle crashes. The introduction of traffic calming measures increases the use of the street by pedestrians and improves child pedestrian safety. The new development area must be safe from natural hazards and disasters; therefore, areas with a certain vulnerability should be avoided in future development (Sayed and Hakan, 2020).

C. Flooding risk

The location of major new residential development will be determined by the development plan, and increase the impact of climate change and the potential for increased incidences of flooding or increased rates of coastal erosion are factors that must be considered in this process. In addition, at a local level, the planning process can further mitigate the potential for flooding by promoting sustainable approaches to urban drainage and through the design and layout of new development. Residential areas may contain a variety of land uses including dwellings, parking areas, shops, schools, and other community facilities. It is thus important when assessing the disposition of uses in a residential layout in areas where there is a potential for flooding to locate the least vulnerable uses in the highest risk areas (Sayed and Hakan, 2020).

2.1.5. Site-Planning Process

Site planning is the art of arranging the external physical environment to support human behavior. It lies along the boundaries of architecture, engineering, landscape architecture, city

planning, and it is practiced by members of all these professions. And also, site plans locate structures and activities in three-dimensional space and, when appropriate, in time. Sustainable site planning protects and restores degraded natural and cultural resources and minimizes negative impacts of development on the environment (James, 2008).

2.1.5.1. Evaluating Site Suitability

According to James (2008), selecting the most suitable site available for a development or redevelopment project has potential benefits that includes improved function of the proposed land uses, greater suitability for the site's users, enhanced aesthetics, fewer negative environmental impacts, reduced construction, operation, and maintenance costs. The first step to evaluate site suitability is preplanning. In this this step it include clarify project objectives and requirements and determine the site selection criteria. The second step is data collection and analysis, under this it consists identify potential sites, evaluate each site's suitability, rank the alternative sites, and test project feasibility.

2.1.6. Criteria Used for Residential Development Site Selection

The process of site suitability requires the identification of the appropriate locations for a particular land use activity by considering physical resources (slope), natural resources (soil type, and rivers), and existing land use and development (manmade facilities such as transportation systems, existing urban residential area (Zeyin, 2020).

The appropriate criteria were used for this study are:

1. Topography

The most important elements in topography are relief/slope and elevation. Ideally, a new settlement site should be designed to match the existing topography, with the location and orientation of roads, housing blocks, and community structures adjusted to fit the form of the land. However, there is usually a considerable push to make post-disaster settlement sites as economically and spatially efficient as possible, leading to a grid layout and minimal consideration of topography (Charles, 2010). Topography is an important factor in most land planning decisions. Consequently, having a topographic survey of the site is often essential (James, 2008).

1.1. Slope

The slope represents the gradient of an area expressed either in percent or in degree. It is computed as the vertical increase divided by the horizontal increase (Baykedagn et al., 2019).

When considering land for future development the suitability depends on the slope of topography to great extent. It is a significant factor; it has economic implications during the establishment of any urban infrastructure usually a gentler ground is preferable to the steeper surface. In Mertule Mariyam town, to determine the appropriate slope, the FAO classification are used, and to generate the terrain slope map, an STRM data used as an input data set. The urban area should be located on relatively flat land because areas with steep and high slopes are prone to landslides. Due to issues such as flooding, erosion, as well as the cost of construction, steep slopes should be avoided (Sayed and Hakan, 2020). Therefore, based on FAO (2006) classification an area with a slope between 2% -15 % is suitable for residential development and greater than 30% the area is unsuitable.

2. Land use/land cover

Land cover describes the physical state of the earth's surface and immediate subsurface in terms of the natural environment (such as vegetation, soils, surfaces, and groundwater) and the man-made structures (e.g., buildings) and the term Land use itself is the human employment of a land-cover type (Morka, 2020).

Also, Qihao (2010), stated land cover can be defined as the biophysical state of the earth's surface and immediate subsurface, including soil, topography, and surface groundwater), and man-made buildings. In other words, it describes both natural and human-made coverings of the earth's surface. According to Sayed and Hakan (2017), land use refers to the socio-economic use that is made of land for different purposes such as agricultural use, commerce, residential use, recreational area; at any place, there may be multiple and alternative land uses. It reflects the character of a society's interaction with its physical environment, a fact that becomes obvious when it is possible to see different economic and social systems occupying similar environments. The term land cover describes the types of resources/features present on the surface of the earth (Bereket, 2021). A single class of land cover may support multiple uses, whereas a single land use may involve the maintenance of several distinct land covers (Qihao, 2010).

3. River Distance

The presence of physical hazards reduces the suitability of a site. For Selecting safe housing lands, it is recommended to avoid the risks deriving from water flooding in the rainwater season

whether from adjacent streams or other channels or low-land. The longer the distances from these water bodies (rivers) the safer the sites will be, so that distances from the rivers were calculated by spatial analysis techniques and reclassified according to their preferences (Sayid, 2007).

4. Soil Type

According to Weldemariyam and Iguala (2016), the soil class may be categorized under Vertisols soil type which is a high content of wide clay minerals, Cambisols are soils with an initial stage of soil formation or weakly developed soils relating to their parent material. Luvisols are soils whose dominant characteristic is a marked textural differentiation within the soil profile, with the surface horizon being depleted of clay and with the accumulation of clay in a subsurface. Ntisolin the world reference base for soil resource is a deep, red well-drained soil with a clay content of more than 30% and a blocky structure. Thus, the soil class was reclassified based on their properties and suitability for housing development. Soil type is a key factor for determining suitable areas for residential development.

5. Road Distance

Evaluation of accessibility to public infrastructure in terms of distance from a particular location using particular transportation must be taken into consideration while selecting a suitable site for housing development (Weldemariyam and Iguala, 2016). According to Sayed and Hakan (2020), the distance from the major road between 200-2000 meters is suitable for residential development, to get transport access within a short distance.

6. Population density

Population density is one of the criteria for selecting suitable site selection for sustainable housing development. It is directly associated with the comfortability of living (Huiping and Yuan, 2019). Therefore, the population density of residential areas is an important factor in urban residential land suitability analysis. Because as the population increase, there will be lack of infrastructures and it also creates unhealthy environment.

7. Distance from Social Service Area

This is one of the main criteria for evaluating and developing the future sustainable residential house suitability using GIS based computing and Multi-Criteria Decision-Making method. Accordingly, the social service area distance is nearest to the residential housing development, it was better to easy accessibility of transportation, health institutions, schools, administrative areas, water supply areas etc. However, social service area is farthest from the residential area development it suffers; high transportation cost, labour and time was occurred.

8. Distance from Religious Area

This is also one of the main criteria for sustainable residential land suitability assessment towards the nearest and farthest from the religious areas. Thus, the residential area development is nearest to the religious area it is highly suitable and farther from the religious area it is unsuitable.

2.1.7. GIS-Based Site Suitability Analysis

Geospatial technologies like Geographical Information Systems (GIS) and Remote Sensing are important tools and provide methodologies to combine different data source that are required to land-use suitability analysis (Huiping *et al*., 2019). It can be combined with different types of information to help with better decision-making and is also a high-quality visualization tool. A multi-criterion evaluation (MCE) can compare each factor according to its importance and generate weights for each factor. Therefore, incorporating MCE methods into GIS is the most common method for generating a final suitability map. In terms of applications, GIS-based MCE has been applied in selecting the best site for urban residential land. Suitability analysis in a GIS context is a geographic or GIS-based process used to determine the appropriateness of a given area for a particular use (Jahangeer, *et al* 2018).

GIS and remote sensing technologies have become more advanced in their capabilities and have become very popular in the past few decades for land-use suitability analysis, land-use planning, and other land-related spatial studies (Florentino and Walter, 2021). GIS provides a powerful set of tools for interpreting and evaluating spatial information for decision-makers (Zeyin, 2020). It also stated that GIS is used for identifying location suitability of areas and resource inventories of resources according to environmental concern. Most decision support situations consider multiple decision criteria (Helmut et al., 2013).

2.1.7.1. Multi-Criteria Analysis (MCA)

Sustainability assessments require the management of a wide variety of information types. Multi-criteria analysis (MCA) has been regarded as a suitable set of methods to perform sustainability evaluations as a result of its flexibility and the possibility of facilitating the discussion between stakeholders, and analysts (Firsew, 2018).

2.1.7.2. Multi-Criteria Evaluation (MCE)

According to Seyid and Hakan (2020), GIS-based multi-criteria site suitability analysis involves geographical representation and classification of appropriate parameters based on their relative importance and suitability score. The GIS-based multi-criteria decision-making process is practiced by defining goals, determining and standardizing criteria/factors, determining a weight for each factor, aggregating the criteria, and validating (Baykedagn et al., 2019). Multi-Criteria Evaluation is the process of applying a decision rule to a set of alternatives in decision theory. A decision rule is a method for combining criteria to arrive at a specific evaluation, as well as comparing and acting on those evaluations (Abraham, 2021). GIS and Multi-criteria evaluation (MCE) have been globally recognized for their outstanding capacities in spatial decision support systems in site suitability analysis (Weldemariyam and Iguala, 2016).

2.1.7.3. Analytic Hierarchy Analysis

According to Maher (2015), Analytical Hierarchy Process, which was developed by Saaty, is currently one of the important techniques for analyzing land suitability analysis. It 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. It has also 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. According to Abraham (2021), the Analytic Hierarchy Process (AHP) is a maths and psychology-based system for organizing and analyzing complicated decisions. By quantifying its criteria and alternative options, and relating those elements to the overall goal, AHP provides a rational framework for a needed decision.

According to Huiping *et al*. (2019) AHP is also a structured approach that can be used for complex cases of making decisions that include competing criteria. The weights of factors in AHP can commonly be identified by using driven knowledge and driven data. The weights of

factors can also be calculated by using a questionnaire given to specialists who have considerable experience in the field of urban growth and can then be determined by using pairwise comparison method to measure their relative importance vis versa one another.

2.1.7.4. Given Weights for each Criterion

Weighting in suitability analysis refers to assigning a numeric value to each factor to recognize its relative importance and is usually expressed in percent format (Madurika and Hemakumara, 2017). By applying the Satty Analytical Hierarchy Process, it can be determined through a method that is the pairwise comparison matrix in the Analytic Hierarchy Process (AHP) method.

Table 2.1: Nine-point weighting scale for a pairwise comparison matrix

No	Description Preference	Scale
I	Equally important	1
II	Equally to Moderately important	2
III	Moderately important	3
IV	Moderately to strongly important	4
V	Strongly important	5
VI	Strongly to very strongly important	6
VII	Very strongly important	7
VIII	Very strongly to extremely important	8
IX	Extremely important	9

Source: Saaty, 1980

2.1.8. Land Suitability Analysis

Land suitability analysis is the process of determining the fitness of a given tract of land for a defined use (Abraham, 2021). In other words, it is the process to determine whether the land resource is suitable for some specific uses and determining the suitability level. To determine the most desirable direction for future development, the suitability for various land uses should be carefully studied to direct growth to the most appropriate sites.

Land suitability analysis (LSA) is an analysis that is based on a combination of many GIS operations and functions for assessing the land suitability locations for certain developments,

in this case for residential development (Rizah and Florim, 2014). It is the process of determining the eligibility of a certain land tract for a particular user according to specific requirements, preferences, or predictors of some activities (Huiping *et al*, 2019). It is also defining urban residential land suitability analysis is designed to determine and locate the best potential sites for land planning. The main of this study will be to identify the most suitable settlements for residential development after the land use planning is done.

Site suitability is the process of understanding existing site qualities and factors that will determine the location of a particular activity (Haymanot, 2009). The purpose of selecting potential areas for high-rising construction depends upon the relationship of different biophysical & socioeconomic factors like slope, soil; accessibility, etc. The analysis may also determine how those factors will fit into the design process to evaluate site suitability.

It is the method of understanding existing site qualities and factors that will determine the location for a particular activity. It involves the detailed investigation of the natural resources and processes that characterize a site and include mapping techniques including GIS tools that help in processing the geographical database that displays the areas of the site, suitable for various planning objectives and alternatives (Santanu and Shrijana, 2015). Land-use suitability analysis using the weighted overlay method leads to more rational urban planning decision-making (Sayed and Hakan, 2020). In this method, manipulation of the overlay process is allowed by assigning different weights for each input layer, so the factors that play a more critical role will have a more significant impact on shaping the outcome of the overlay analysis.

The selection of suitable sites is based upon a specific site of local critics. The characteristic of a site (e.g., present land use, slope, distance to road, river, DEM, etc.) to assess the overall sustainability, scoring, and weighting system is applied to the various aspect of suitability (Haymanot, 2009).

As land-use suitability is a multidisciplinary approach, it incorporates different domains of science, and thus increasingly more criteria have been used in the analysis which is weighted indicative of their relative importance on the optimal growth conditions for the specific land use (Florentino and Walter, 2021). Suitability maps are usually the result of a suitability analysis. They display the spatial distribution of the determined values in a graphical form (Helmut et al., 2013).

2.2. Empirical Literature

2.2.1. Housing in the Global World

Strong demand for housing will continue with the number of homes in Ireland possibly rising from its current level of 1.8 million to over 2.5 million by 2020. With the majority of these houses to be built in urban areas, it is vitally important that this is achieved in a way that supports the development of sustainable, integrated neighborhoods within our cities, towns, and villages (John, 2009).

The National report on "Housing in Ireland" (2004), identified the essential characteristics of a sustainable neighborhood, including the importance of providing essential facilities within walking distance of new homes.

According to El-hadj et al., (2018), Ireland's population is projected to grow to around 5.3 million by 2020. The majority of new households formed during that period will need to be accommodated in urban areas. In India, the share of urban population in total population has been increasing from 20% in 1950s to touch almost 30% now. More ever, among all class cities, the cities with already large population have a major share of total population and are experiencing further growth. The formulation of housing stock in the country has not been adequate to the need of population. There has been a gap, of the order 5-10 million, between houses occupied and the number of households, which indicates the number of homeless households (Ramakrishna, 2006).

2.2.2. Housing in Africa

Since 1950, the urban proportion of the world's population has risen rapidly and this trend is expected to continue well into the foreseeable future. Nearly two-thirds of the urban dwellers in the world reside in the Third World. The proportion of the population residing in urban areas in Africa is projected to increase from approximately 34 percent in 1990 to 57 percent by 2025 with significant variation in the level of urbanization among the regions. In 1990, approximately 22 percent of the East African population resided in urban areas compared to 33 percent, 38 percent, 45 percent, and 55 percent for West Africa, Middle Africa, North Africa, and Southern Africa, respectively. This range and rank order is projected to be maintained through 2025, although at a higher level. The percentage urban is projected to vary from 47 percent in Eastern Africa to 74 percent in Southern Africa (Kempe, 1998).

The consequence of the rapid urbanization process and inadequate urban planning are increased pressure on urban infrastructure and resources, growing housing deficits resulting in more people living in slums, urban sprawl in major accumulations, and accelerating loss of agricultural lands (El-hadj et al., 2018).

The rapid urbanization rates and lack of urban planning have resulted in very large housing deficits, defined as the difference between the number of households and the number of permanent dwellings.

Table 2.2: Percentage of African population projection in urban areas by region, 1990-2025

Region	1990	1995	2000	2005	2010	2015	2020	2025
Africa	33.9	37.3	40.7	44	47.4	50.7	53.9	57.1
East Africa	21.8	25.4	29	32.5	36	39.6	43.2	46.8
Middle Africa	37.8	41.6	45.6	49.5	53.4	57	60.4	63.6
Northern Africa	44.6	47.9	51.2	54.5	57.7	60.7	63.6	66.3
Southern Africa	54.9	58.2	61.3	64.2	66.8	69.3	71.6	73.8
Western Africa	32.5	36.1	39.8	43.6	47.3	51	54.6	58

Source: United Nations, World Urbanization Prospects, 1990.

Despite such overall rapid urbanization, the least developed African countries (Burkina Faso, Burundi, Ethiopia, Guinea-Bissau, Malawi, Mali, Niger, Rwanda, and Uganda) are characterized by particularly low levels of urbanization. All of these countries had fewer than 20 percent of their populations living in urban areas in 1990. In Burundi, for example, only 5.5 percent of the population is urban and it is projected that it will still be under 20 percent urban in 2025. Current urban growth rates are high for every region in Africa but much more so in East Africa.

2.2.3. Housing in Ethiopia

Ethiopia is the second-most populous country on the African continent. The 2014 Ethiopian Population and Housing Census disclosed that at least 15 million residents are living in the urban centers and this number, according to the forecast of the UN, doubled by the year 2020, making the Ethiopian urban population the second largest in the region surpassed only by Nigeria (Samson and Alok, 2012). At present, 21% of Ethiopia’s 112 million residents live in

urban areas (23.5 million people). Although significantly below the sub-Saharan average of 40.4%, Ethiopia's urban population is expected to grow considerably over the next few decades: The Central Statistical Agency of Ethiopia (CSA) projects that the urban population will increase to 42.3 million by 2037, growing at 3.8% per year, while the World Bank projects this growth at a higher rate of 5.4% per year. Ethiopia's current urban housing stock has several characteristics that make urgent action important – both to support residents' well-being and to create sustainable cities. These characteristics include; a housing market historically dominated by owner-occupiers a highly fragmented, informal, and closed rental market; overcrowding and low-quality housing conditions; and fast-growing, increase housing demand that outpaces the provision of affordable housing (Tadashi and Jonathan, 2021).

Ethiopia, like many of its East African neighbors, is experiencing rapid urbanization and facing both policy challenges. Poor quality and often overcrowded living conditions are the major housing challenges experienced by urban households. In general, housing quality in Ethiopia is lower than in neighboring countries. An estimated 70–80 percent of the urban population lives in what might be considered slums, according to a commonly accepted international definition, because the units lack durability, adequate space, access to safe water and sanitation, or security of tenure. Around 80 percent of dwellings in urban areas are made from wood and mud (also known as Chika-bet construction), while two-thirds of all urban housing units have only earthen floors, another indication of very low-quality housing. The main drivers of the urban housing shortage are low incomes, an insufficient supply of serviced land, and unrealistically high and costly standards (World Bank, Ethiopia Economic Update II (2013).

Housing finance since the transition in 1991, the EPRDF government has sought to introduce a more market-oriented approach to housing development. With the introduction of the urban land lease holding Proclamation in 1993, the government defined leasehold as the tenure form of choice. Land to be used for social services and low-cost houses may be leased free of charge (Proclamation No. 80/1993). The Addis Ababa City Government's Urban Land Lease Holding Regulation No. 3/1994 declared that urban land should be used for business activities and residential construction. In addition to the land lease law, other measures have contributed to the liberalization of the housing market. Subsidies on the sale of building materials have been removed and interest rates for housing construction have been set at market rates, etc. (Regulation No. 3/1994) (Madurika & Hemakumara, 2017).

According to the Mertule Mariyam town administration municipality office report (2021), there are 3517 legal residential housing units and around 625 illegal housing units exist before 2014. The rural kebele of the town administration has 3134 housing units. After 2014 there are a lot of housing associations for getting a residential plot of land. Those are;

Table 2.3: Number of housing associations from 2014-2019

Year	Total number of Association	Number of Individuals
2014	41	716
2015	38	689
2016	33	636
2017	49	1020
2018	36	705
2019	44	812
Total	241	4578

Source: Mertule Mariyam Municipality office, 2021

2.2.4. Application of remote sensing and GIS for residential development

GIS has been applied in many disciplines including geography, forestry, urban planning, and environmental studies. Particularly, in suitability analysis, GIS has a great role in the multi-criteria decision-making process (Mathias, 2016). GIS is a decision support computer-based system for collecting, storing, presenting, and analyzing geographical spatial information. It is a technology for handling geographic data in digital form and satisfying the ability to preprocess data from large stores into a form suitable for analysis, including operations such as reformatting, change of projection, and generalization. It also has direct support for analysis and modeling, so that form of analysis, calibrations of models, forecasting, and prediction are all handled through instructions to the GIS and used for post-processing of results including reformatting, tabulation, report generation, and mapping (Ziyen, 2020). GIS could be applied nearly for all research that involves land-based spatial analysis and modeling (Weldemariyam and Iguala, 2019).

The previous studies such as; Mohammed *et al*., 2006, Hemakura and Madurka (2017), Weldemariyam and Iguala (2016), they are not covered all the physical, economic, environmental and social criterias for selecting sustainable housing development. They are mostly focused on the physical and economic factors. However, this study covered most of the those criterias including demography by selecting parameters from each criteria that is comptable to Mertule Mariyam town. In this regard, Mohammed *et al*., 2006 mostly uses

physical criteria and in some extent they used some economic criteria such as slope, aspect, elevation, LULC, and road accessibility. They are not considered Soil type, population density, distance from social service area, distance from river and distance from religious area. Weldemariyam and Iguala (2016), used eleven criteria which are not covered by this study like flood sheets, aspect, distance from airport and proximity to urban center in Dire Dewa city.

The research conducted by Madurika and Hemakumara (2017) also used five criteria including demography. However, they are not considering aspect, Slope, soil type, and distance from religious area for residential house suitability analysis.

2.3. Conceptual framework

Suitable site selection considers eight criterias from physical, economic, social, demographic, and environmental aspects. The criteria used in Mertule Mariyam town are the terrain slope, distance to river, distance to road, land use land cover, population density, distance to religious areas, distance to social service areas, and soil type. There is a linkage between problem identification, site selection, data organization, data analysis method, criteria used for residential development, and suitability analysis for residential development. The Multi-Criteria Decision-Making method is a powerful tool for deciding the potentially suitable site selection for sustainable residential development. The primary and secondary data was collected from the field by using Handheld GPS and from research papers, documents, reports, books, magazines, and from different journals respectively by organizing the required data. The data was organized and analyzed by using GIS and Remote Sensing software in the form of maps, tables, and figures. The main aim of this study was to produce a potentially suitable site for residential development.

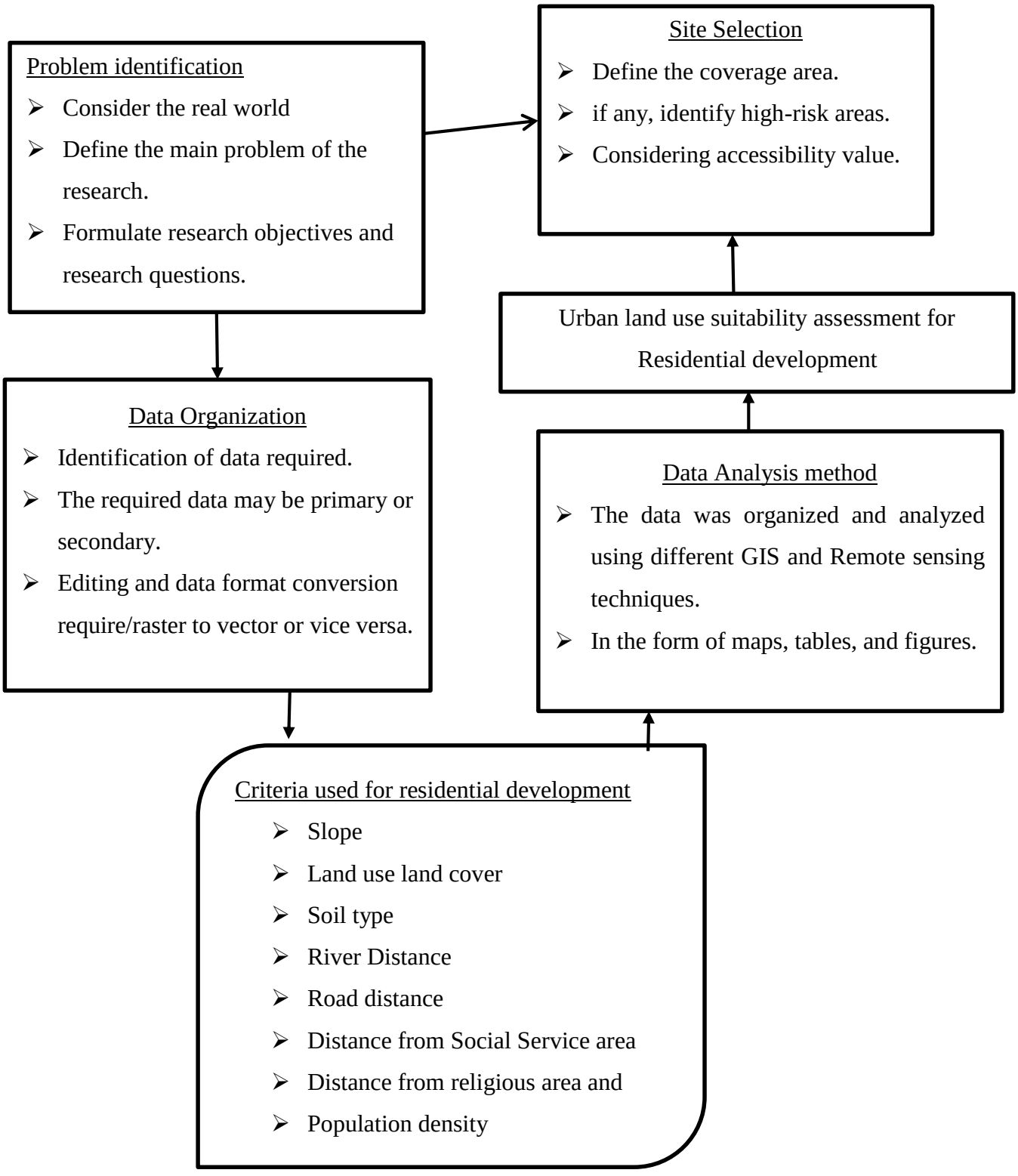

Figure 2.1: Conceptual framework

Chapter Three

3. Research Methodology

3.1. Location and Description of the Study Area

3.1.1. Location

The study was conducted in Mertule Mariyam town administration, which is one of the Woreda town administrations in East Gojjam Administrative Zone of Amhara National Regional State. It is located between 10°42’ and 10°45’N and 37°51’ and 37^0 49’E with an altitude of 2500 m.a.s.l (Joel & Ashenafi, 2008). According to the Woreda Administration report (2021), the town is located 197 km from Debre-Markos (the Zone’s capital), 184 km from Bahir Dar (the region’s capital), and 364 km from Addis Ababa. The study area is bordered on the south by Enarji enawuga, on the west by Goncha siso enesie, and on the north and east by Abay River. The geographical map of the study area is presented in figure 3.1.

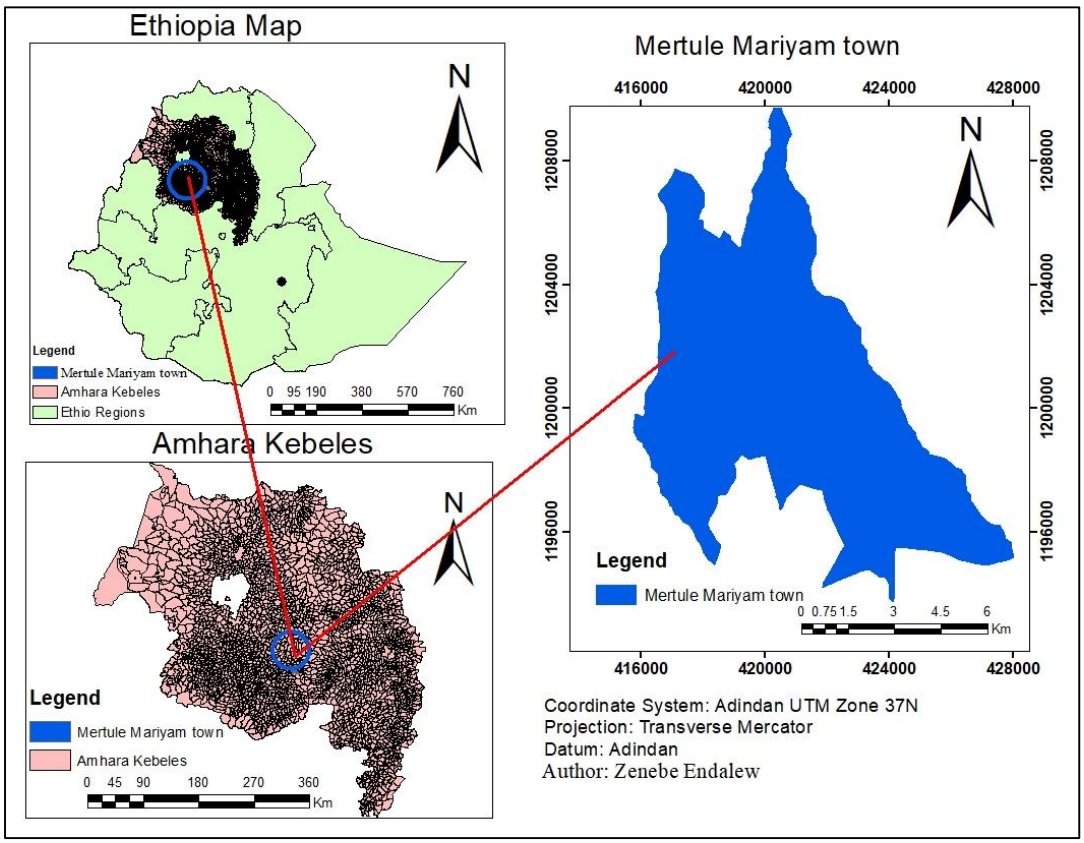

Figure 3.1: Study area map

3.1.2. Climate and Topography

According to the Woreda Agriculture Office Report (2021), Mertule Mariam town administration is found in Woyina-Dega climate condition. This climatic condition is characterized as a comfortable zone for living and carrying out different livelihood activities. In addition, the topography of the land in the Woreda comprises 20% plain (18,644.78 hectares), 45% moderate (36,018.325 hectares), 38% (27,119.68 hectares) mountainous, and 10% (2966.215 hectares) valley.

3.1.3. Rainfall

According to Ethiopian meteorology Agency report (2022), the town administration usually receives seasonal average rainfall pattern once a year. The rainy season is between June and September. However, there is also a chance of getting little rain from February to April. Its average rainfall is 153mm.

Table 3.1: Mertule Mariyam monthly Rainfall in mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2016	Na	Na	42.4	96.8	177.3	85.4	270	299	108.7	Na	0	na
2017	0	30.2	22.6	53.4	111.8	72.1	215.1	191.9	104.6	23.1	22.4	0.0
2018	0	21.6	6.8	21.4	25.4	161.1	312.7	254.7	46.5	96.6	51.6	1.7
2019	0	33.6	38.2	32.4	na	121.7	194.2	224.8	92.7	22.2	49.3	0.0
2020	0	12.5	9.8	66.1	105.9	99.6	255.2	229.9	113.3	73.5	15.1	0.0
2021	0	10.2	2.0	108.4	124.7	23.4	322.5	Na	79.6	Na	Na	na

Source: Ethiopian meteorology Agency, 2022

3.1.4. Temperature

The minimum maximum temperature of the town is 18.9 ^{0}C and the maximum temperature is 27.1. Its averages maximum temperature was 23 ^{0}C. From January to May high temperature were recorded and from June up to December the temperature was minimum relatively.

Table 3.2: Monthly maximum temperature in ^{0}C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	Na	Na	27.1	26.3	24.1	25.4	20.6	19.8	20.7	na	22.2	na
2017	23.6	24.0	25.2	26.5	23.8	24.0	21.6	20.3	20.7	23.2	23.5	21.0
2018	21.2	21.5	22.1	22.5	23.6	21.2	20.3	19.9	21.5	21.9	20.8	21.7
2019	21.7	22.7	22.9	22.5	na	21.8	19.9	20.2	20.7	22.0	22.7	22.5
2020	23.1	23.7	24.9	24.6	24.9	23.1	19.8	20.2	21.7	21.6	22.7	19.8
2021	22.5	23.8	24.5	24.5	22.0	22.2	18.9	Na	21.2	na	Na	Na

Source: Ethiopian meteorology Agency, 2022

Table 3.3: Mertule Mariyam Monthly minimum temperature in ^{0}C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	Na	Na	13.0	13.2	11.7	11.2	10.8	10.5	11.2	na	9.3	Na
2017	8.5	11.4	11.2	11.8	11.9	11.4	11.1	10.6	10.6	12.5	10.9	9.4
2018	10.3	10.9	11.6	11.1	12.5	11.4	10.6	10.6	10.9	10.8	10.7	11.6
2019	10.5	12.0	11.7	11.9	na	11.7	9.9	10.4	11.1	10.5	10.2	9.7
2020	9.6	10.8	12.2	12.5	12.7	11.5	10.9	11.3	11.7	11.3	12.2	9.7
2021	10.4	11.8	12.6	12.2	11.5	12.2	10.6	Na	11.2	na	Na	Na

Source: Ethiopian meteorology Agency, 2022

The minimum of monthly minimum temperature in 0c were 8.5 and the maximum of monthly maximum temperature were 13.2. Its average temperature is 10.85 ^{0}c.

3.1.5. Soil Type

According to Woreda agricultural office report (2021), 60% of the soil types of the town administration red soil type, 35% black soil, and 5% brown color soils. According to FAO (1990) soil type classification, the study area has Vertisols, Cambisols, and Luvisols types.

3.2. Research Approach and Design

3.2.1. Research approach

Urban land-use suitability assessment for sustainable residential development requires both qualitative and quantitative data. Hence, the researcher used a mixed research approach. A mixed approach is a form of research approach in which the researcher collects and merges or converges both quantitative and qualitative data to provide a comprehensive analysis of the research problem (Robi *et al*, 2019).

3.2.2. Research design

A survey research design is applied for this study, which aims to identify the potential suitable site for housing development. A cross-sectional design entails a collection of data at a single point in time (Bezuayehu, 2016). This design is considered to be useful for saving resources such as; time, labor, and cost. Because data are collected once.

3.3. Source of Data

To achieve the objectives, both spatial and socio-economic primary and secondary data were used for this study. The spatial primary data including Sentinel 2A satellite image (10*10m spatial resolution), Digital Elevation Model (DEM) 30m*30m spatial resolution were downloaded from the United States of Geological Survey, Global Visualization Viewer Website (earthexplorer.usgs.gov). Also, field observation and survey were conducted by using hand-held GPS for a verification of suitable site and for checking the accuracy of land use/land cover classification. Secondary data are reviewed from journals, reports, conferences, research papers, and government institution manuals.

Table 3.4: Source of spatial and non-spatial data

No	Criteria	Data Type	Source of data
1	LULC	Raster	USGS
2	Slope	Raster	USGS/STRM DEM
3	River distance	Vector	Orthophoto/digitized
4	Road distance	Vector	Orthophoto/digitized
5	Religious area	Vector	Orthophoto/digitized
6	Social service	Vector	Orthophoto/ digitized
7	Soil Type	Raster	Amhara National regional state agricultural office
8	Population density	Number	CSA, 2014
9	Questionnaires, interview and FGD	Primary data	Researcher

3.4. Population, Sample Size, and Sampling technique

According to the CSA (2014) report, the total population of the town is 50,159. The town administration has been geographically demarcated into four urban and three rural administrative kebele's. The total number of housholds in the town administration are 1317.

3.4.1. Sample Size and Sampling Techniques

Sample size determination is the technique of selecting the number of observations to include in a sample. The sample size in this study was determined by using (Yamane 1967) formula.

Yamane 1967 provides a simplified formula to calculate sample sizes;

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the household size, and e is the level of precision. The determined sample size is based on 95% confidence level and 5% level of precision that is 0.05. The total number of housholds in the town administration is 1317. When this formula was applied for this study the sample size is;

$$n = \frac{1317}{1+1317\ (0.05)^2}$$

=307

Therefore, the sample size of the study was 307 respondents.

Regarding method, both a simple random and purposive sampling technique were applied for selecting the target respondents. A simple random sampling technique was used to select sample household respondents whereas; a purposive sampling technique was used to select municipality and other land use experts.

3.5. Variables

Different criteria were used for evaluating the existing residential urban land use and selecting potential suitable site selection for housing development. The parameters or variables used in this research are the terrain slope, soil type, land use/land cover, distance to road, distance to river, distance to religious area, distance to social service area and population density. For each parameter, the weight was assigned for each criterion using IDRISI 32 software and the weighted linear combination method was computed for locating and evaluating potentially suitable site for housing development.

3.6. Method of Data Collection

Primary data were collected using questionnaires, Focus Group Discussion (FGD) and interviews.

1) Questionnaires

In this study, the researcher used both open-ended and close-ended questions, from households and municipality experts, for the purpose of identifying potentially suitable site for sustainable residential housing development. To conduct the primary data collection of the area, 307 households' respondents was selected and collected the primary data.

2) Focus Group Discussion

For this study, the researcher collected data in small groups of six to ten people. They are normally based around a shortlist of guiding questions, designed to investigate for in-depth information. The Discussions are carried out between one and two hours. It is an important way to gather detail information about selecting potential suitable site selection for housing development. There was a chance of interaction between one or more experts and more than

one individual to get depth information about the town administration. The researcher selected 8 groups for focus group discussion of whom 3 groups was females and 5 groups were males. All members of the household and different experts participated with voluntarily. The focus group discussion participants are 5 groups are legal housing association teams from 2014-2020 and two groups were female Idir in the town and one groups was taken at the time of kebele meeting.

3) Interview

In this study, both structured and semi structured interview questions used, between the researcher and the interviewee for the purpose of selecting suitable site for sustainable housing development by using GIS based computing approach and Multi Criteria Decision Making method to households and experts. The interviewer was produced the needed information on the research topic from the respondents. The 40 interviewees also selected from housing association team leaders, kebele administrators, land administration experts and Woreda housing construction and development office purposely.

3.7. Method of Data Analysis and Interpretation

The data collected from the field survey were analyzed using descriptive statistics. Spatial data such as sentinel image, and STRM Digital Elevation Model and non-spatial data was analyzed using spatial software like ArcGIS, SPSS and IDIRSI 32 software. Qualitative data were analyzed in a content-wise. Finally, the result was presented in tables, figures, and maps to evaluate the existing urban land use allocation and to select a potentially suitable site for residential development in the study area.

Image classification

As indicated in Figure 3.5, the satellite imageries were analyzed and computed using ArcGIS software through the prior knowledge and field observation of the training area. Then, the classification was computed using supervised image classification techniques by creating spectral signature, evaluating spectral signature and classified the image through maximum likelihood classification. The accuracy image classification was checked using accuracy assessment. When the accuracy assessment of the classified image was above 80%, it is acceptable and it can be prepared the LULC map of Mertule Mariyam town (Gao, 2009).

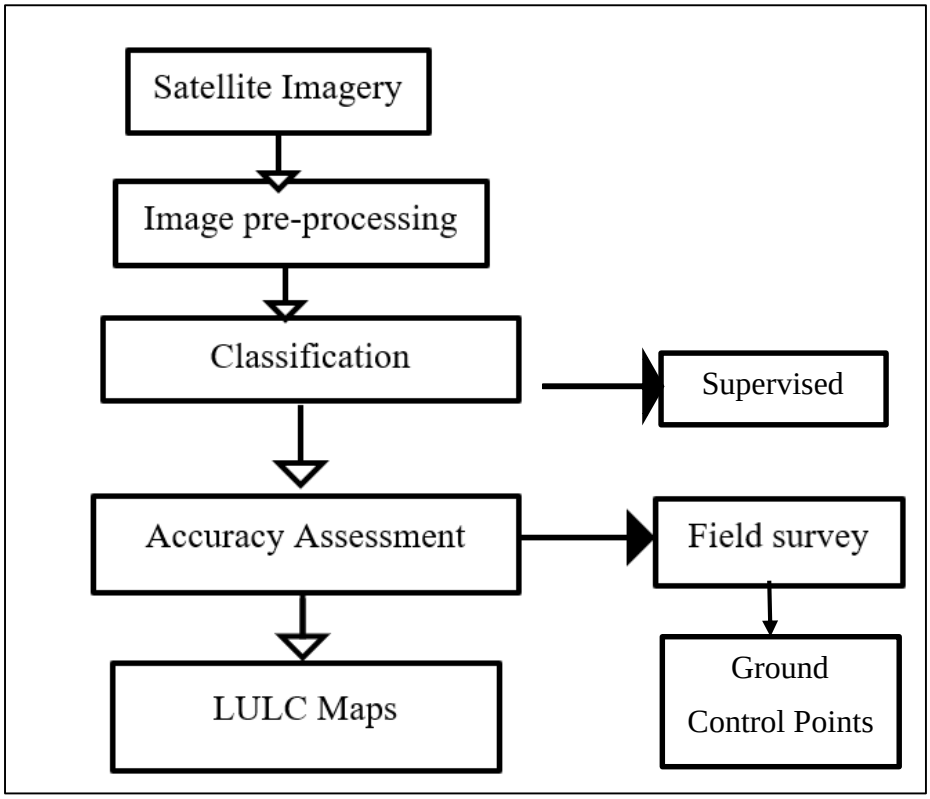

Figure 3.2: Supervised image classification workflow for LULC

3.8. Validity and reliability

This data is validated by cross-checking the land use/land cover change image of the study area that was done either by using supervised classification technique through the collection of ground control points using hand-held GPS. The researcher also cross-checks the validity of the data by using a different secondary source of data like journals, and research papers, that are conducted related to residential suitability analysis. The validity of the data is cross-checked by considering different parameters and standards to conduct the study area through the comparison of different sources of data for the increment of validity of the research.

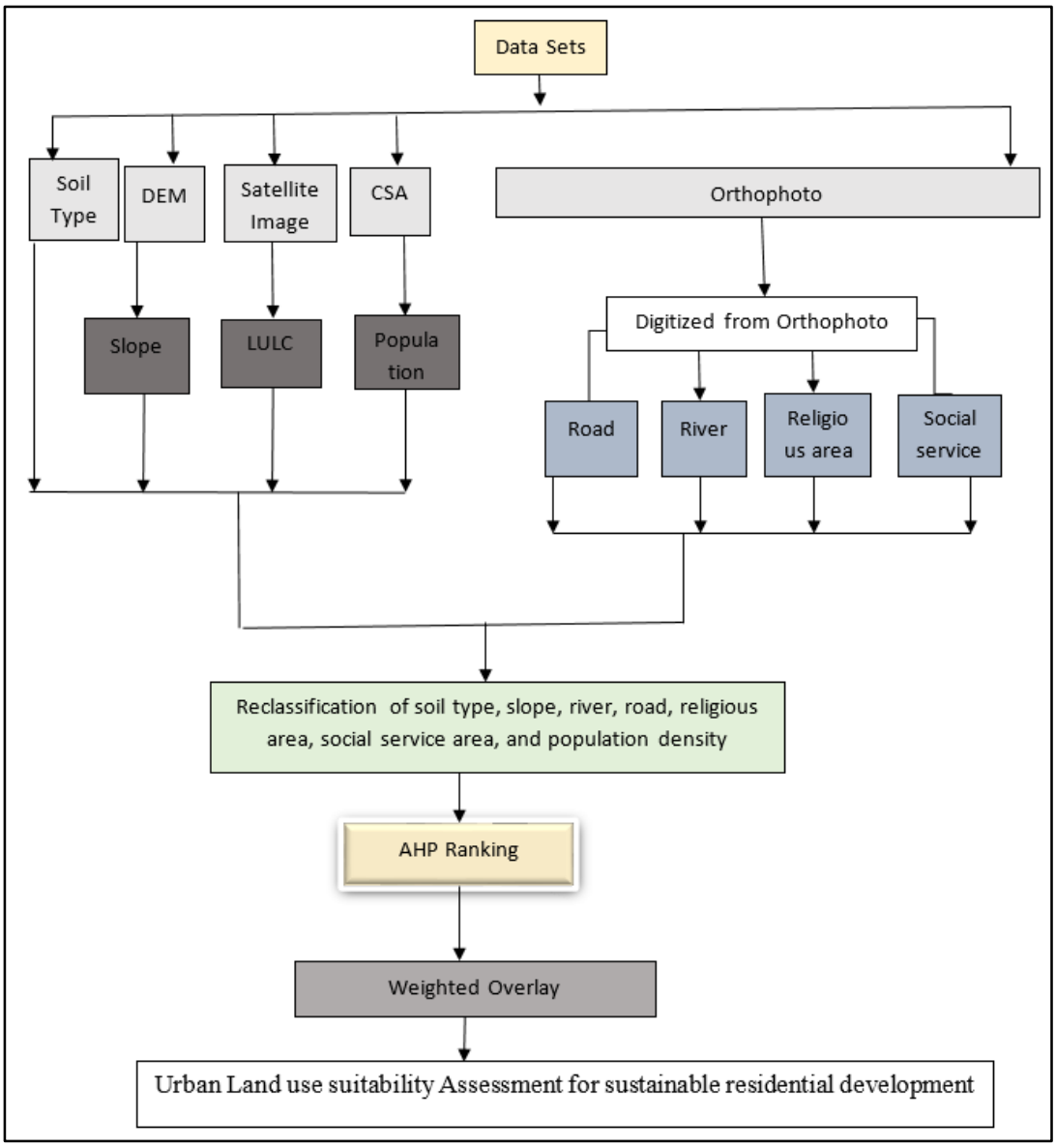

Figure 3.3: Methodological Framework

Chapter Four

4. Results and Discussions

This chapter presents the findings and discussions of the study. It constitutes five main sections which presents in a content wise in line with the data collection techniques. The first section presents the general characteristics of sample respondents. The second section deals about the current urban land use allocation and housing development strategies/frameworks. The third section presents the land use/land cover analysis of the study area. The fourth section presents the evaluation of different variables for sustainable housing development. The last section deals about the weighted land use suitability map for housing development.

4.1 General Characteristics of the respondents

Table 4.1: General characteristics of the respondents

Sex of the respondent			Age of the respondent			Educational-status			Marital-status			Economic activity		
Sex	Fr	%	Rang	Fr.	%	Stat	Fr	%	Stat	Fr	%	Activi	Fr	%
M	199	67.7	18-25	17	5.8	Illite	22	7.5	Mar	238	81	Gov't	73	24.8
F	95	32.3	26-40	110	37.4	P. Sch	94	32	Div	35	11.9	Trade	183	62.2
			41-60	141	48	S.sc	82	27.9	Sin	15	5.1	Agri.	38	12.9
			>60	26	8.8	Dip	53	18	Wid	6	2			
						Deg	37	12.6						
						MSc & >	6	2						
Tot	294	100		294	100		294	100		294	100		294	100

Fr stands for Frequency, stat=status, Rang=Range, Activi=Activity, M=Male, F=Female, Illite=Illiterate, P. Sch=Primary school, S.sc= Secondary school, Dip=Diploma, Dig=Degree, MSc= Master of Science, Mar=Married, Div=Divorced, Sin=single, Agri=Agriculture and Wid=Widowed.

Table 4.2: General characteristics of expert respondents

Sex of the respondent			Age of the respondent			Educational-status			Marital-status			Economic activity		
Sex	Fr	%	Rang	Fr.	%	Stat	Fr	%	Stat	Fr	%	Activi	Fr	%
M	10	76.9	18-25	1	7.7	Illite	--	--	Mar	12	92.3	Gov't	13	100
F	3	23.1	26-40	9	69.2	P. Sch	--	--	Div	--	--	Trade	--	--
			41-60	3	23.1	S. scho	--	--	Sin	1	7.7	Agri.	--	--
			>60	--	--	Dip	4	30.8	Wid	--	--			
						Deg	9	69.2						
						MSc & >	--	--						
Tot	13	100		13	100		13	100		13	100		13	100

4.2. Current urban land use allocation and housing development strategies /frameworks.

Empirical data were obtained from the sample household respondent using questionnaire survey to assess whether there is clear urban land use allocation and housing development strategies/frameworks or not. In this regard, only (22.8%) of the household respondents are indicated the existence of clear urban land use allocation and housing development strategies/frameworks. Conversely, the majority (77.2%) of the respondents are reported the absence of a clear urban land use allocation and housing development frameworks. Likewise, 76.9% of the sample expert respondents are reported the absence of clear urban land use allocation and housing development strategies/frameworks.

More likely, 23.1% municipal expert respondent indicated the existence of a clear urban land use allocation and housing development strategies/frameworks. In contrast, 76.9% expert respondents are reported the lack/absence of a clear urban land use allocation and housing development strategies/frameworks. Similarly, FGD participants and key informants are forwarded different views regarding the availability of clear urban land use allocation and housing development frameworks. Among the discussants, the majority FGD discussants

outline the absence of presence of clear urban land use allocation and housing development frameworks. Some discussants claim the existence of fragmented frameworks, but they outline the lack of comprehensive. This implies that there are still different perceptions on the existence of a clear framework enacted for urban land use allocation and housing development.

The finding of the study supports the arguments of Weldemariyam and Iguala (2016) and Mohammed et al., (2006). In this regard, Weldemariyam and Iguala (2016), indicated the lack of well-prepared land use planning framework/strategies for housing development in Dire Dewa city. Mohammed et al., (2006) also argued that the urban land use allocation and housing development strategies are inefficient in many towns. Both the previous study and this study consider socio economic and environmental factors. A crucial result of this leads to expansion of informal settlement/built-ups, and conflict over land.

Based on the household respondents 96.3% are replied on the occurrence of high conflict due to lack of proper land use allocation for housing development for the existing conditions. In contrast to this, 3.7% household respondents reported as there were no any conflict occurrence due to the lack of proper land use allocation for the existing residential land use conditions. Similarly, FGD participants also argued that there is a high conflict occurred due to lack of the existing land use allocation frameworks. As the interviewed participants give a response due to lack of proper land use allocation the community goes to boundary conflict, land grabbling, and illegal residential house building to bare lands/public lands. This implies that there are different ideologies forwarded to the respondents concerning on lack of proper land use allocation frameworks on the existing conditions.

This study partially supports Eskedar (2012), and Samson and Alok (2012) findings. Based on this, Eskedar (2012) showed that there are conflicts occurred due to lack of proper land use allocation and housing development. The previous studies only focused on addressing the shelter need of urban poor and women. The study used qualitative descriptive case study to understand the issue from the participants. However, this study conducted to address the need of housing for urban residents based on considering suitability of the land. It considers both qualitative and quantitative research approach. Correspondingly, Samson and Alok (2012) address these and the related urban development challenges, the government of Ethiopia has developed and implemented policies and strategies. However, this study mostly focused on the policies and strategies of urban development, it does not give attention to the affordability of

housing based on suitability of the land. Hence, the existing strategies and policies provide a framework for sustainable development.

A crucial result of this leads to boundary conflict, the problems of preparing the residential house certificate map within the appropriate time towards the municipality experts, the problems of unlicensed urban land possession, and closing water drainages. The social problems were lack of road accessibility, electricity, far from religious areas, far from market areas, and water supply areas. Environmental problems were highly disturbed by dry and wet wastage removal methods, and runoff water around the river. The economic problems were high cost for residential housing rent, for transportation and it results in reduced productivity. The political problems also address the problem on boundary conflict, lack of good governance, lack of responsibility and accountability, corruption, the cases were not solving at a time being, and there is no agreement between the community and the leaders of the government.

The Focus Group Discussion and interviewee participants identified the strength of the current housing provision such as; giving to anyone who have live in the town more than two years, and got a chance to be organized by a housing association. The weakness is also do not provide housing for people organized by housing association by a time and the opportunities to get housing land are only housing associations.

According to the town municipality office report (2021), there are 3517 legal housing units and 625 illegal housing units before 2022 and the town administration rural kebele's are 3134 residential units. It also has 241 legal housing associations, that includes 4578 individuals are the owner of urban residential house. Based on the above information the researcher has collected the real ground data and assessed the suitability condition for residential development. Accordingly, some residential units in the area are built ups around the river. This minimum distance from the residential house is unsuitable to live, because there is a high noise disturbance especially at the summer season and the house may be depleted by runoff water through a time. In some area the three rural kebele's are far from the accessibility of main road, social service and religious areas.

4.3. Land use/ land cover Analysis

The land use/land cover map of the study area was computed from sentinel 2A satellite image. The main land use/land cover types are built-ups, vegetation, agricultural land, and bare land, which cover 6.48%, 15.01%, 71.73%, and 6.69% respectively. As shown in figure 4.1

agricultural land covers the highest areas (71.73%). This is because rural kebele's are included to the town administration in 2019 (Mertule Mariyam municipality office report, 2019).

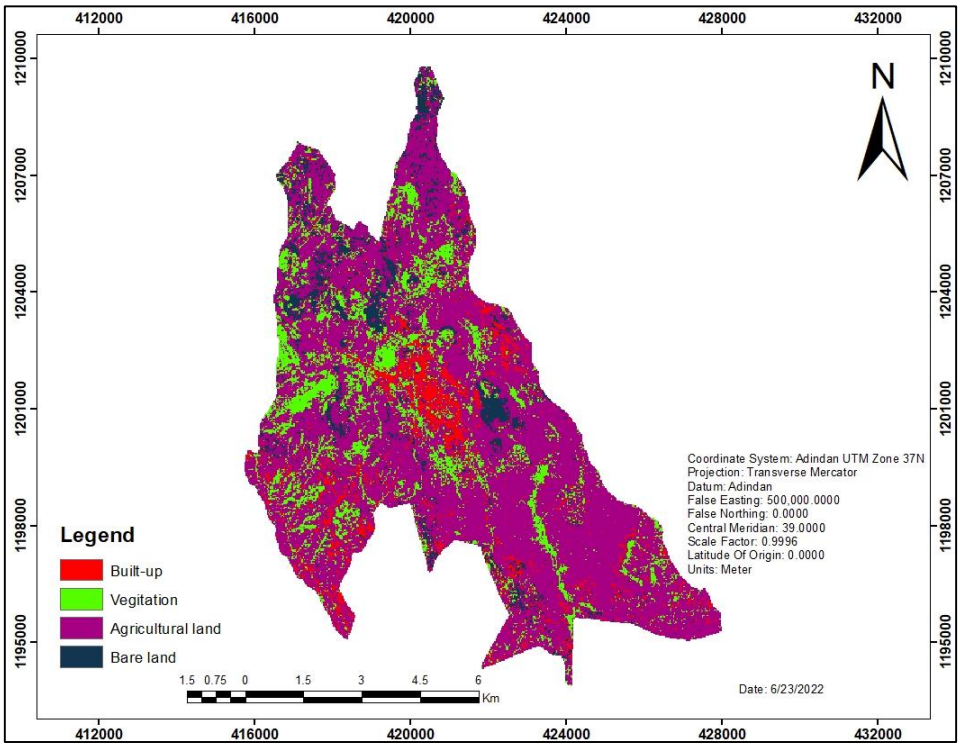

Figure 4.1: Land use/Land cover map of Mertule Mariam town in 2022

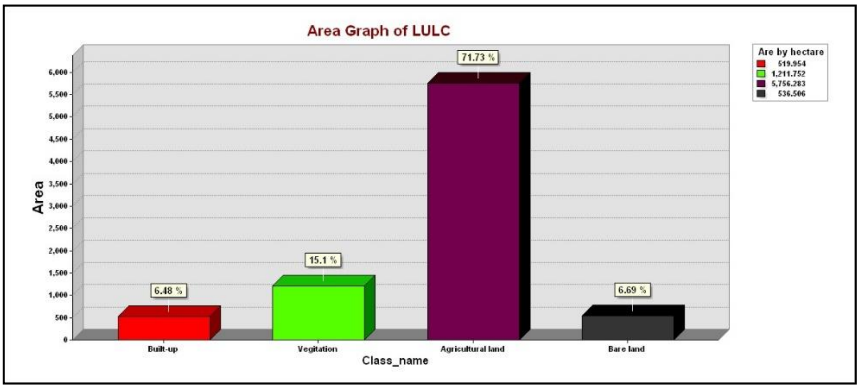

Figure 4.2: Area graph of land use/Land cover

The spatial data were computed by using ArcGIS software, to analyze the land use/land cover of the area. The socio economic survey analysis results also indicated the existence of high land use/land cover. From the household respondents 88.8% reported that there is existence of high land use/land cover in the area. Similarly, the sample expert respondents argued that there are high land use/land cover change observed overtime in the town. Conversely, 11.9% household respondents, reported as there were no any land use/land cover change in the town.

Likewise, FGD and interviewed participants argued that there is a land use/land cover change in the town. The majority discussants reflected as there are a high Land use/Land Cover change in the town and the most LULC change was due to illegal house building. In contrast to this, some discussants argued that there is no any land use land cover change in Mertule Mariyam town except the problems of the implementation of land use framework allocation. This implies that there are different insights on the land use/land cover change. A crucial result of this leads to illegal house building, demolish the beauty of the town, legal housing provision from the government and other related land use change activities.

The main reason for the change in land use/land cover change in the town administration is that the town has been bordered off recently in 2019 from Woreda town to town administration, there is no permanent and sustainable land use planning, the residential areas were built without the plans of the town administration (illegal housing), and high increment of the population from time to time. The consequence of land use/land cover change in the town are; the believes of the community towards the government were demolished, it also gives a chance for social, political, environmental and economic problems, retards the development of the town and it disappears the beauty of the town.

Accuracy Assessment

The accuracy assessment was done by using confusion or error matrix method. The confusion matrix includes the predicted value from the satellite imagery and the real ground control point of the training area. Based on this, the researcher determines if a map looks correct through the comparison of the satellite imagery to with what the researcher has seen on the real ground control points. The overall accuracy was the total number of corrected samples divided by the total number of samples multiplied by one hundred. The user accuracy is also number of correctly classified pixels in each category divided by the total number of reference pixels in that category (the row total) multiplied by 100. Producer accuracy also can be computed number of correctly classified pixels in each category divided by the total number of reference pixels in that category (the column total) multiplied by 100 and kappa coefficient is measured the agreement between the classification map and the reference map.

Table 4.3: Error matrix of the land use land cover analysis

	Built-up	Vegetation	Agricultural land	Bare land	Total (user)
Built-up	10	0	2	1	13
Vegetation	0	22	3	0	25
Agricultural land	0	4	44	1	49
Bare land	0	0	2	11	13
Total (producer)	10	26	51	13	100

Overall accuracy= $\frac{\text{Total number of correctly classified pixels (diagonal)}}{\text{Total number of reference pixels}} * 100\%$

$= \frac{(10+22+44+11)}{100} *100\% = 87\%$

User accuracy

User accuracy = $\frac{\text{Number of correctly classified pixels in each category}}{\text{Total number of reference pixels in that category (The row total)}} *100\%$

Built-up = 10/13*100% = 76.9%

Vegetation = 22/25*100% = 88%

Agricultural land = 44/49*100% = 89.8%

Bare land = 11/13*100% = 84.6%

Producer accuracy

Producer accuracy = $\frac{\text{Number of correctly classified pixels in each category}}{\text{Total number of reference pixels in that category (The column total)}} *100\%$

Built-up = 10/10*100% = 100%

Vegetation = 22/26*100% = 84.6%

Agricultural land = 44/51*100% = 86.3%

Bare land = 11/13*100% = 84.6%

Kappa Coefficient (Khat) = $\frac{(TS*TCS) - \sum (\text{Column total} * \text{row total}) *100\%}{TS^2 - \sum (\text{Column total} *\text{row total})}$

Where TS= Total Sample

TCS=Total corrected sample

$= \frac{(100) *(87) – ((10*13) + (26*25) + (51*49) + (13*13)) *100\%}{100*100 – ((10*13) + (26*25) + (51*49) + (13*13))}$

$= \frac{8,700-3,448}{10,000-3,448}$

= 0.802

The value of kappa coefficient 0.802 indicates that there is a strong agreement between the reference map and the classified map. In accuracy assessment Khat >0.80 represent strong agreement and good accuracy. 0.40-0.80 is middle, <0.40 is poor (Gao, 2009).

4.4. Sustainability of the Land for Housing Development from the Specific Variable Perspectives

4.4.1. Suitability of the Land from Distance to Road Perspective

As suggested by Mathias (2016) and Madurika and Hemakumara (2017) the residential development site is preferable when it is located at a suitable distance from roads in order to access transportation easily without suffering high traveling cost. Hence, the residential development site is highly suitable if distance from road is less than 0.5km. The distance from road between 0.5 to 1km is considered as suitable. The distance from road between 1km to 2km is considered as moderately suitable. The distance from road between 2km to 3km is considered as marginally suitable. If the road distance is greater than 3km, it is considered as unsuitable for residential development. According to the above criteria, 30.73% of the study area is found to be highly suitable; 27.91 % is suitable, 22.11% moderately suitable, 12.22 marginally suitable, and 7.03 % unsuitable for residential suitability development.

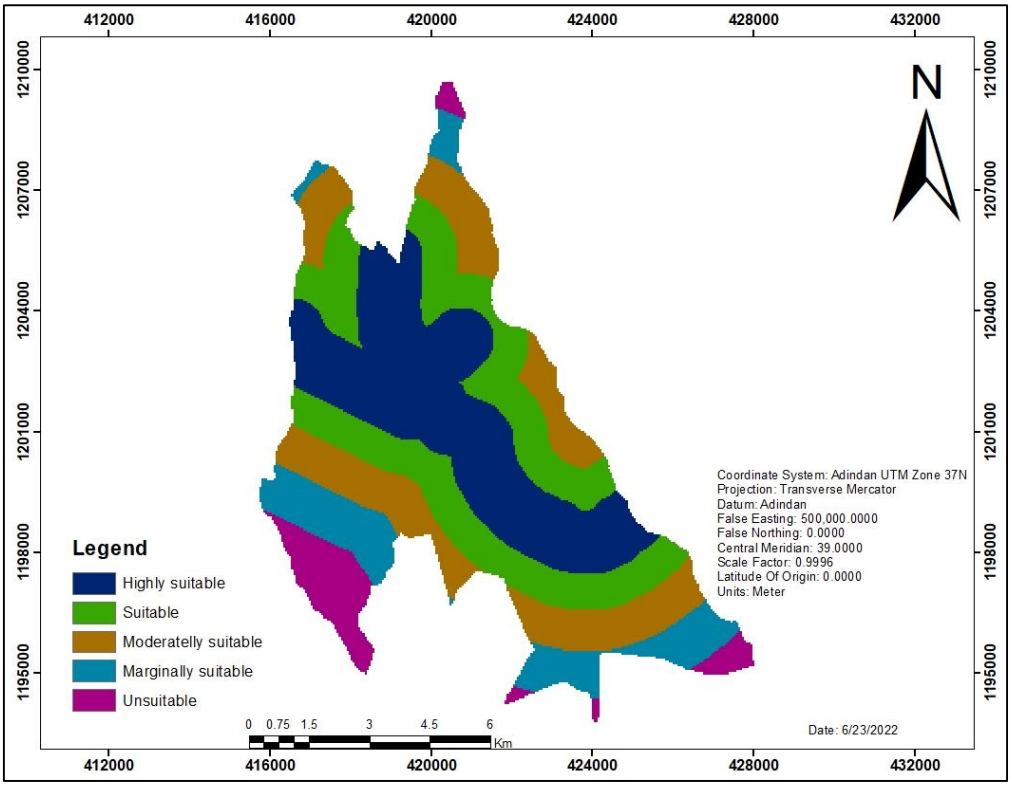

Figure 4.3: Reclassified Road distance map

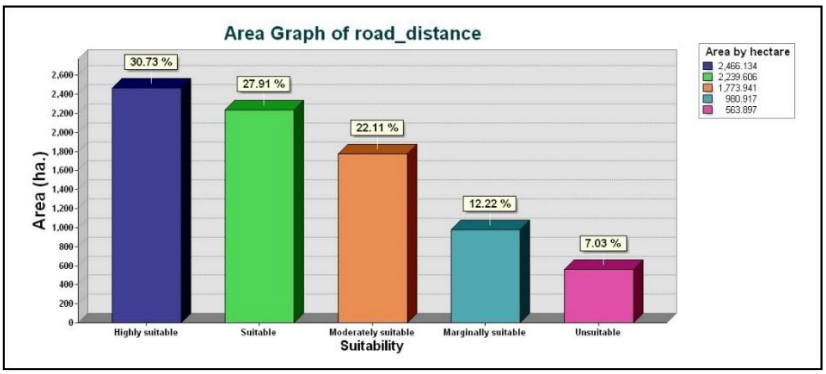

Figure 4.4: Rank of suitability based on road parameter

Similarly, FGD and key informant participants mentioned that the closer distance from the road is highly suitable for housing. This implies that the majority area is highly suitable for residential development.

This study is mostly similar with the findings of Mathias (2016) and Madurika and Hemakumara (2017). All the studies are based on GIS based computing and Multi Criteria Decision Making Approach and applied both qualitative and quantitative research approach. As conducted by Madurika and Hemakumara (2017) the residential area suitability was determined by using GIS based model builder tool in ArcGIS. However, this study conducted by using weighted overlay analysis method. Both the previous study and this study apply

Analytical Hierarchy process for selecting sustainable residential development. However, the findings of Madurka and Hemakumara (2017), was based on five criterias such as Elevation, population density, land use, land use zoning and facility.

4.4.2. Suitability of the Land from Distance to River Perspective

The closer river distance to the residential development is not suitable and the farther distance from the river is highly suitable (Abebaw, 2021). According to this argument to the experts less than 0.1km river distance unsuitable, between 0.1km-0.2km it is marginally suitable, between 0.2km-0.3km it is moderately suitable, between 0.3km-0.4km it is suitable and greater than 0.4km it is highly suitable. Accordingly, in the study area 32.17% covers unsuitable, 27.51% covers marginally suitable, 18.81% covers moderately suitable, 13.6% covers suitable, and 7.9% covers highly suitable (Figure 4.5).

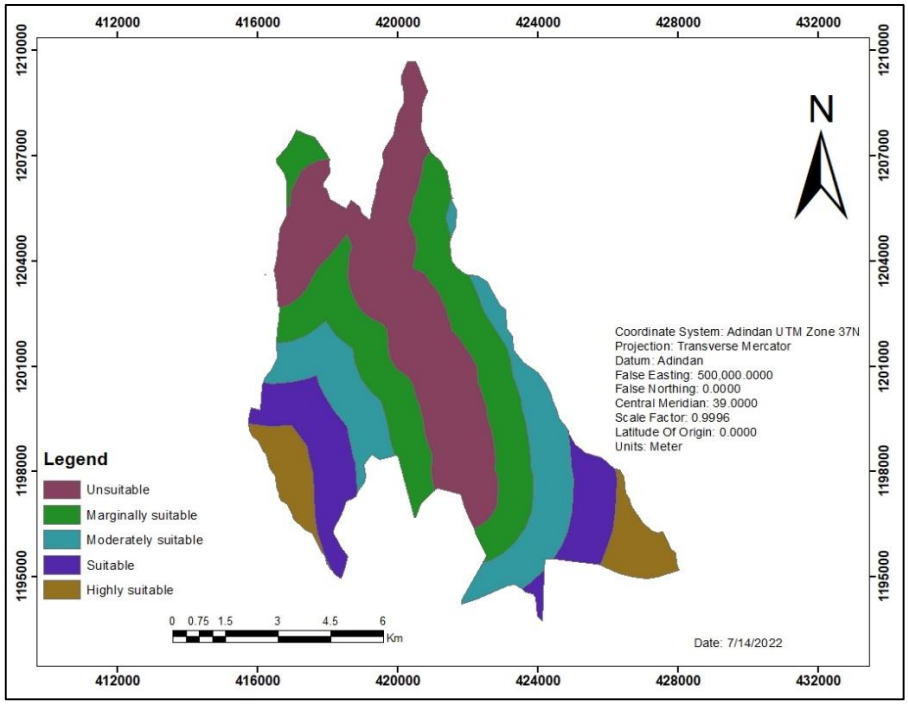

Figure 4.5: Reclassified River Distance map

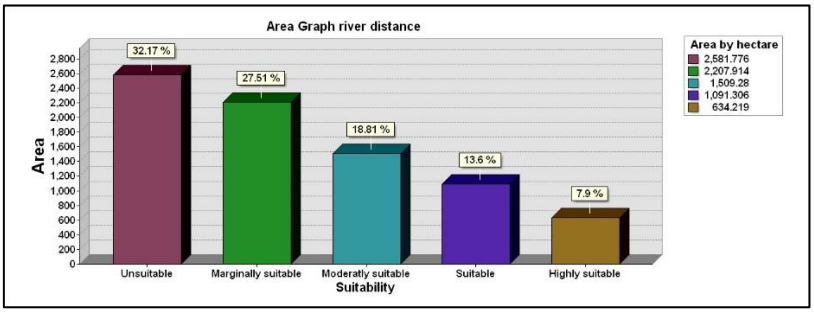

Figure 4.6: Rank of suitability based on river parameter

This study support the findings of Sayid (2007). Sayid (2007) indicated that the longer the distances from this water bodies (rivers) the safer the sites will be and the shorter distance to the river is not safe. This study not only consider suitability analysis of housing development, it also consider the urban expansion of the town. However, this study assesses the present land use condition and suitability analysis for housing development from different land use suitability variable perspectives.

4.4.3. Suitability of Land from Slope Perspective

Slope is a significant factor and it has an economic implication during the establishment of any urban infrastructure usually a flat and gentler grounds is preferable than to the steeper slope surface (Haymanot, 2009). In this study, based on FAO (2006) classification, used the following slope standards such as; 0-3% highly suitable, 3-8% suitable, 8-15% moderately suitable, 15-30% marginally suitable, and greater than 30% are unsuitable for residential development. The majority of the area are covered by flat surface, which covers 43.17% and the steep slope which covers 2.18%.

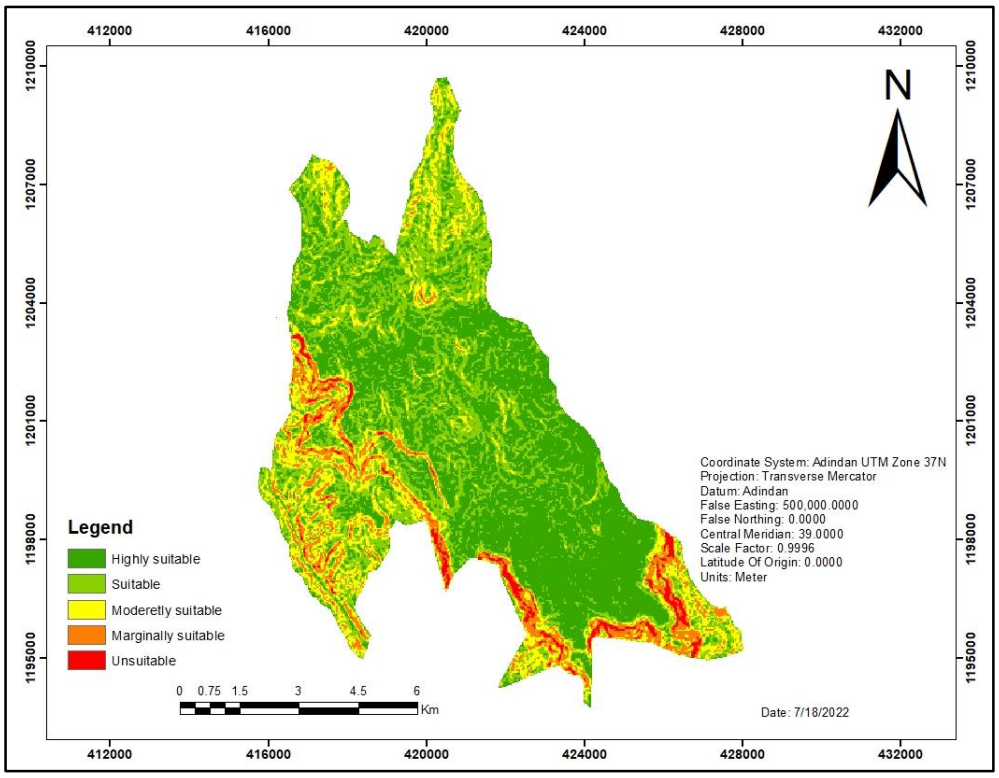

Figure 4.7: Reclassified Slope map

According to the above standards, 43.17% of the total area are flat, 31.14% of the area are gentle slope, 15.27% are sloping, 8.24% are steep slope and 2.18% are very steep slope are highly suitable, suitable, moderately suitable, marginally suitable and unsuitable for housing development respectively (Figure 4.8).

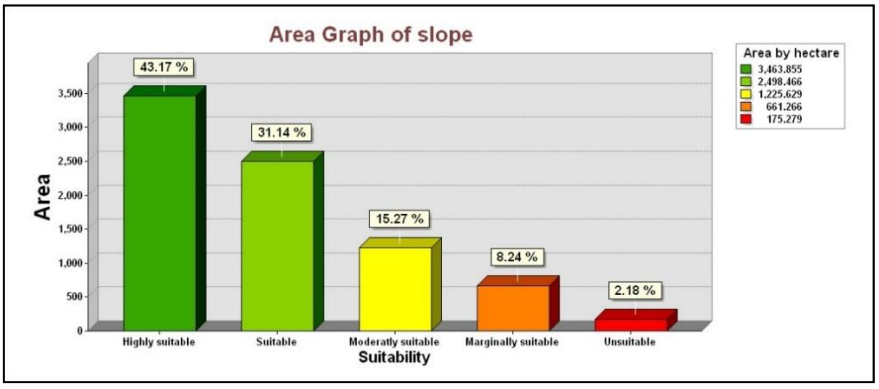

Figure 4.8: Rank of suitability based on road parameter

The main results of this study supports Morka (2020) and Mathias (2016) findings. In this regard, Morka (2020) and Mathias (2016) argued that 3-8% average steepness is acceptable for residential development. To conduct this study also, the major areas of slope is suitable and it is between 3-8%. A crucial result of this leads to due to high steepness of the area, it incure high cost, labour, time. etc. to build residential housing. Hence, selecting less steepness area for residential suitability was done by the investigator analyzed by ArcGIS software.

4.4.4. Suitability of the Land from Land use/Land cover Perspective

Unlike the other criterias, these criteria is classified according to the nature of land use. So, the researcher identify which class is highly suitable, suitable, moderately suitable, marginally suitable and unsuitable. The rank was given based on its nature of land use. Accordingly, bare land was highly suitable (6.69%), agricultural land was suitable (71.73%), vegetation was moderately suitable (15.1%) and built-up areas are marginally suitable (6.48%) for residential development. The land use/land covers of Mertule Mariyam town were dominated by agricultural land (71.73%), and the least area coverage of land use/land cover are built up area, which covers only 6.69%. The Land use/Land cover gives information about the truth of ground coverage, based on this the researcher determined the suitability of land for residential development to Mertule Mariyam town.

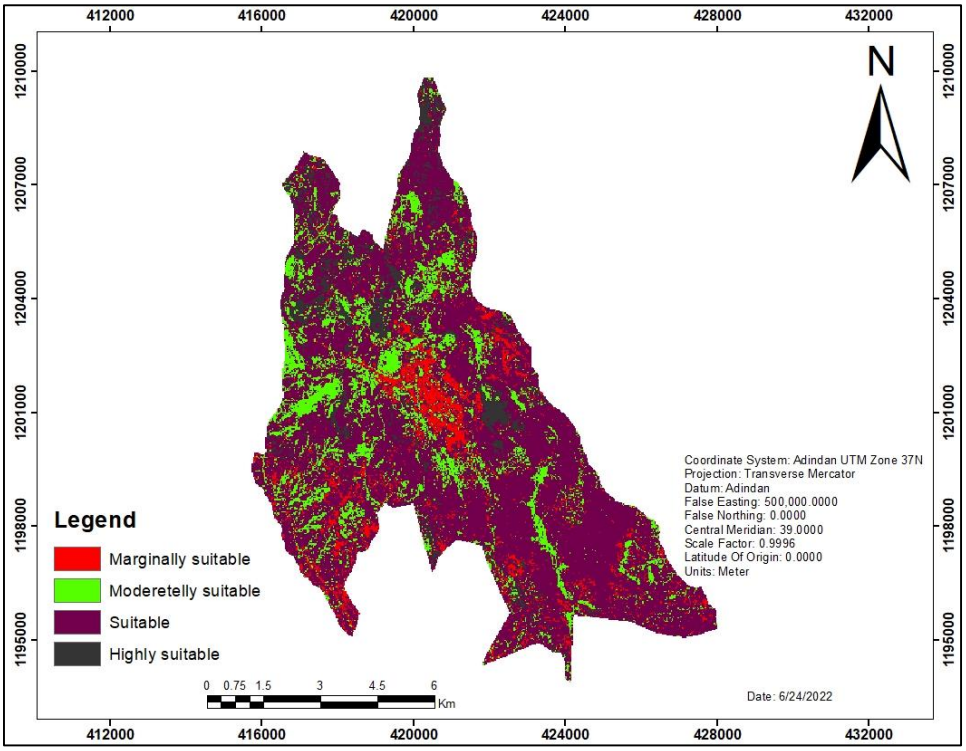

Figure 4.9: Reclassified land use/land cover map

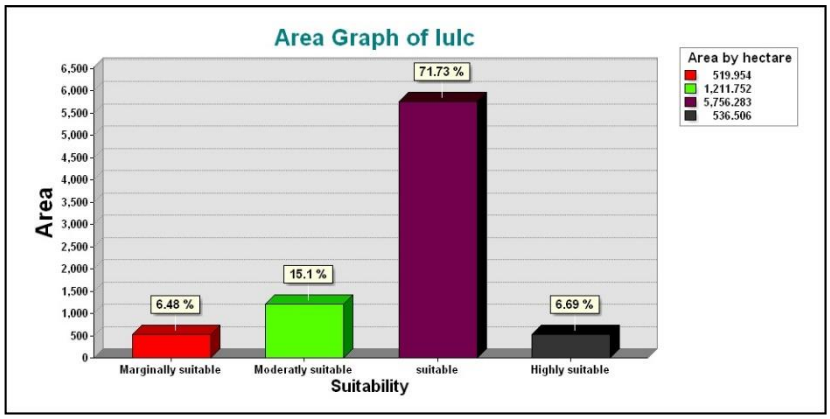

Figure 4.10: Rank of suitability based on LULC parameter

4.4.5. Suitability of the Land from Distance to Social Service Area Perspective

The nearest distance from the social service area (School, health center etc.) to the residential house are suitable, otherwise it is unsuitable. Based on the discussion of the expert and the researcher the suitability criteria were determined for the town administration. Accordingly, the distance less than 2km, between 2km-3km, between 3km-4km, between 4km-5km, and greater than 5km are highly suitable, suitable, moderately suitable, Marginally suitable and unsuitable for housing development respectively.

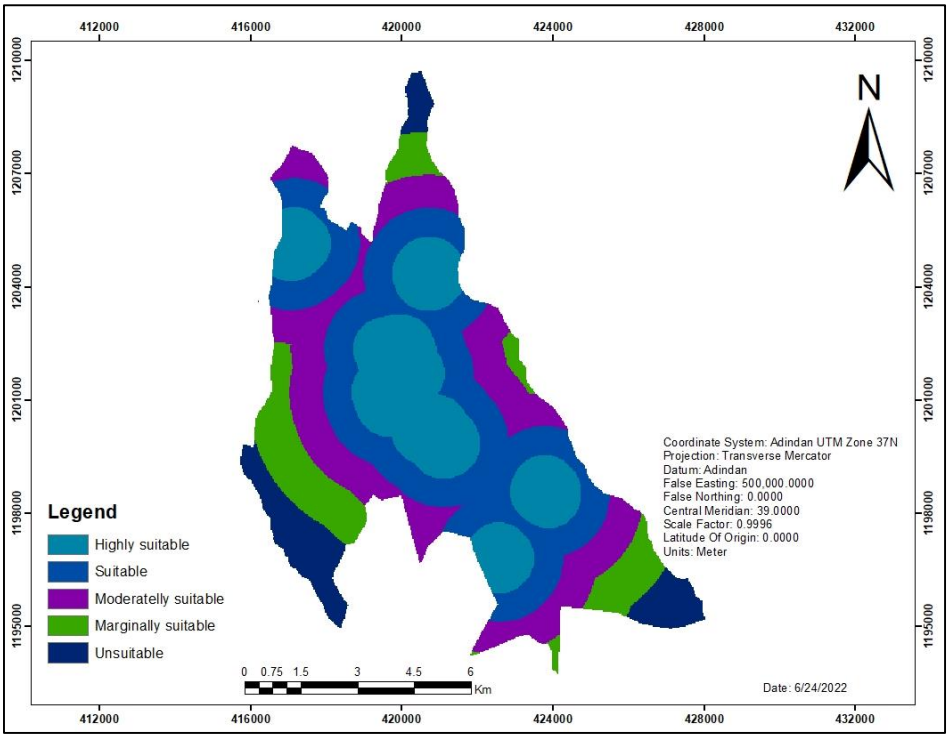

Figure 4.11: Reclassified map from distance to social service area

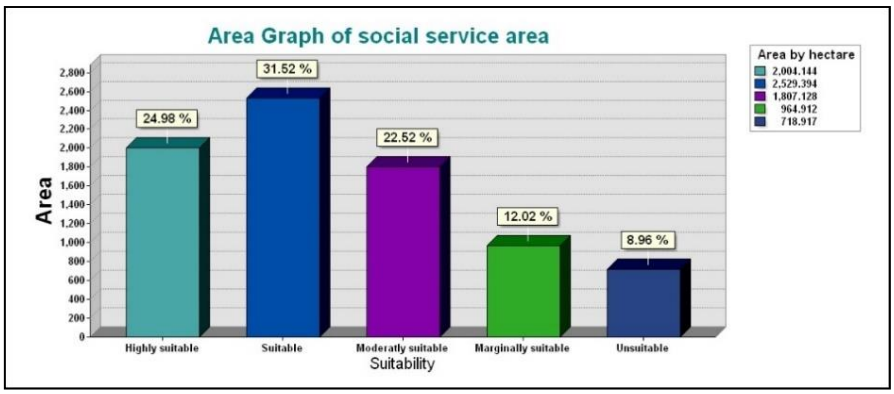

Figure 4.12: Rank of suitability based on social service area parameter

Similarly, the FGD participants discussed that the social service area is farther from the residential area it is unsuitable and the distance is nearest to the residential development it is highly suitable. This implies that there are similar thoughts on the distance from social service area suitability. The similar thoughts indicated that all the group participants argued that the less distance is more suitable than the farthest one.

The findings of this study is consistent with the result of Mathias (2016) and Morka (2020). They considered environmental and socio economic factors. However, this study considered environmental, social, economic and physical factors. The previous and this study used Multi Criteria Decision Making process for housing development. In this regard, Mathias (2016) and Morka (2020) argued that the residential area which is closer to historical place is more suitable

than the further residential area. In contrast to this, the distance from social service area was farther to the residential development it was unsuitable. A crucial result of this leads to pay high transportation cost, waste time and labour. So, distance from social service area nearest to the residential area is preferable than the farthest one to the community.

4.4.6. Suitability of the Land from Distance to Religious Area Perspective

Based on the argument of the expert and the researcher, the religious area distance from the residential house criteria was determined. Accordingly, the distance less than 1km were highly suitable, between 1-2km were suitable, between 2-3km were moderately suitable, 3-4km were marginally suitable and greater than 4km it was unsuitable. The suitability level of 26.63%, 31.72%, 21.84%, 12.76%, 7.04% are highly suitable, suitable, moderately suitable, marginally suitable, and unsuitable.

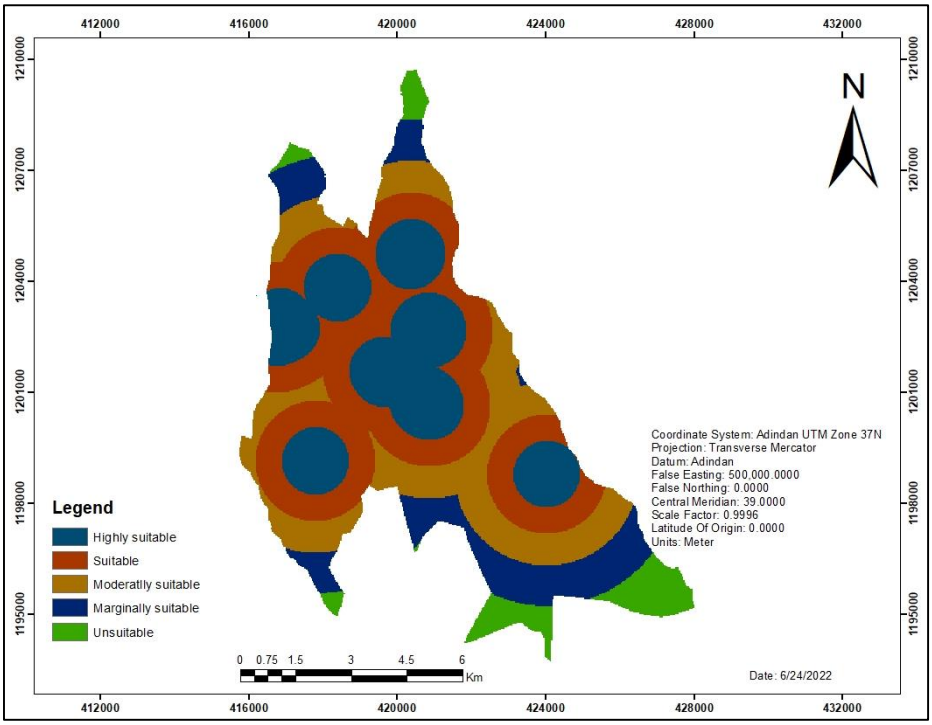

Figure 4.13: Reclassified map from distance to religious area

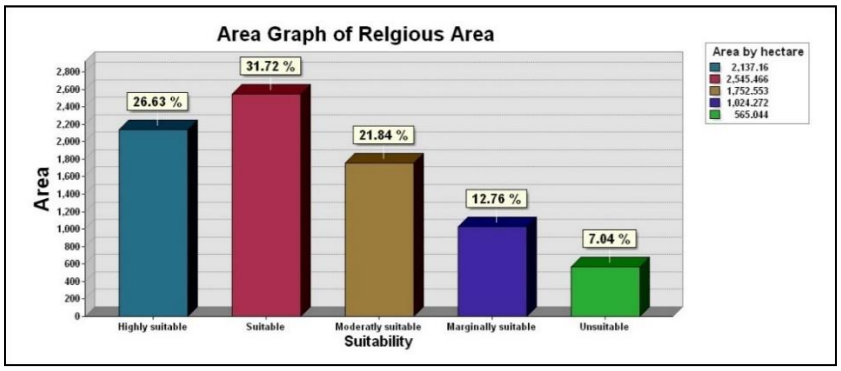

Figure 4.14: Rank of suitability based on religious area parameter

Likewise, the FGD participants also argued that the shortest distance from religious area is highly suitable and the longest distance is unsuitable for residential development. As Mathias (2016) argued that the land which is closer to the religious area it is suitable for residential development. The findings of the study also support the idea of the above sentence.

4.4.7. Suitability of the Land from Soil Type Perspective

According to FAO (1990) soil type classification, there are seven categories of soil type in Ethiopia namely chromic Luvisols, Pellic vertisols, Eutric Cambisols, Orthic solonchaks, calcic xerosols, Eutric Luvisols and Lithosols are covered more than 80% of the country and are the most important soils. However, Mertule Mariyam town administration is resting into the following five categories of soil types such as; Eutric Cambisols, Lithosols, Chromic

Luvisols, Pellic Vertisols and Rocky soil type. From those soil types the most dominant in the area is Pellic Vertisols and it covers 50.56% of the total area. The second-high coverage soil type of the town is Lithosols, which covers 20.07%. The third level of soil type coverage is Chromic Luvisols, which covers 19.09% of the area. The fourth level of soil type coverage is Rock surface (5.96%), and the least coverage soil type of the area is Eutric Cambisols, which covers 4.32%.

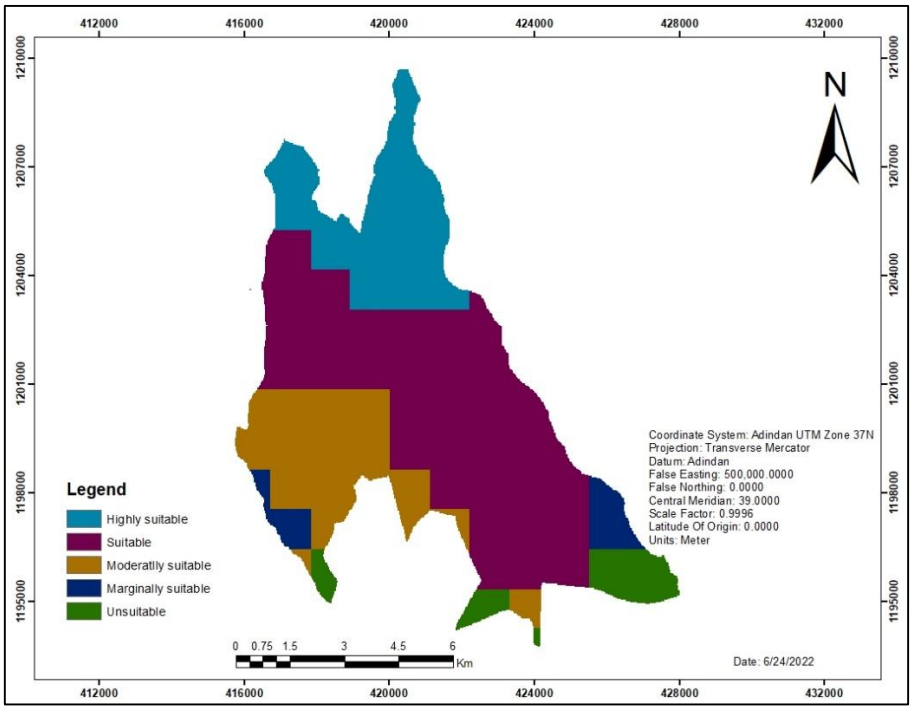

Figure 4.15: Reclassified Soil Type Map

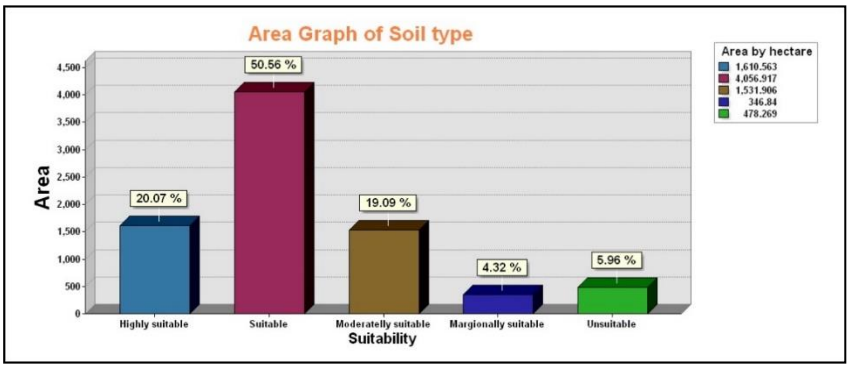

Figure 4.16: Rank of suitability based on soil type parameter

As indicated in Figure 4.16, Pellic Vertisols are Highly suitable, Lithosols are suitable, Eutric Cambisols are moderately suitable, Chromic Luvisols is marginally suitable and Rock soil type is Unsuitable for residential development. Based on color, vertisols have two groups: Chroma and Pellic vertisols. Chroma vertisols have high amount of clay relative to Pellic vertisols (Mathias, 2016).

4.4.8. Suitability of Land from Population Density Perspective

Population density is one of the major criteria for selecting suitable future residential development. Based on 2014 Central Statistics Agency data, the population density was used to compute population per hectare. Accordingly, the lower population per hectare was more suitable for residential development than the higher population density to develop a new residential site. However, based on the discussion on the experts and the researcher, the criteria for population density in the town was greater than 30 Unsuitable, between 20-30 Marginally suitable, between 15-20 moderately suitable, between 10-15 Suitable, and less than 10 Highly suitable for residential development suitability.

$$\text{Population density} = \frac{\text{Total population}}{\text{Area by hectare}}$$

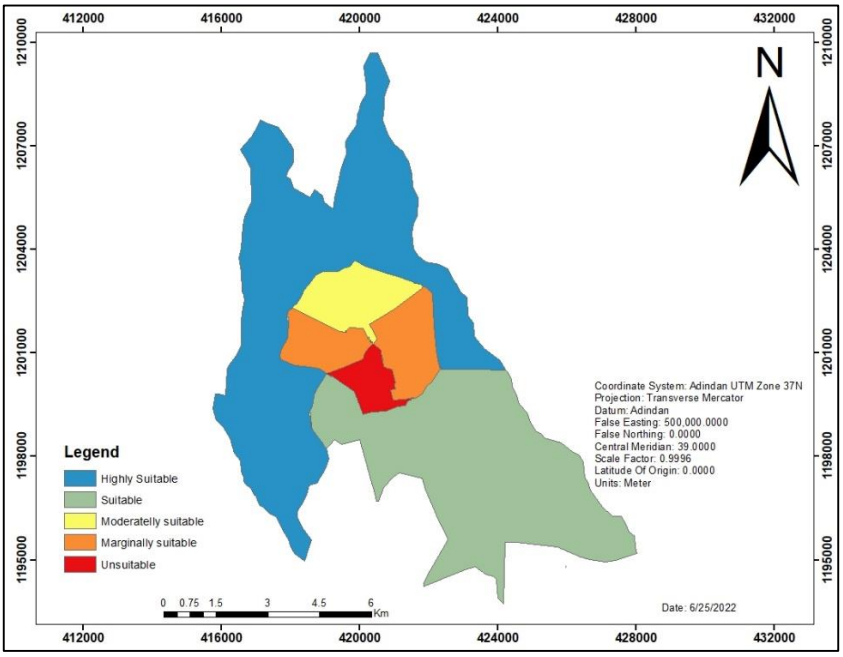

Figure 4.17: Reclassified Population density suitability map

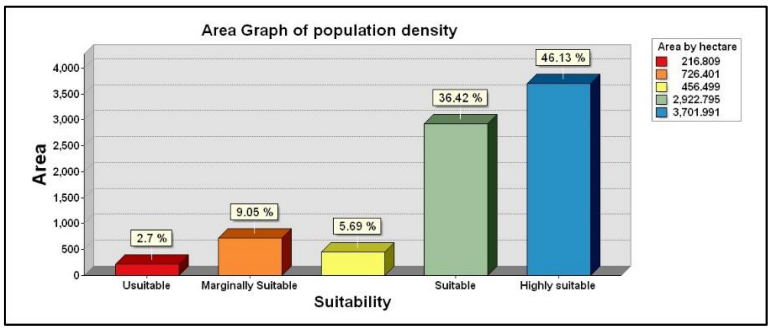

Figure 4.18: Rank of suitability based on population density parameter

Correspondingly, the FGD participants also argued that when the population per hectare was minimum it is suitable and population per hectare was maximum it is unsuitable for residential development.

The findings of this study support the idea of Wubalem and Abaynew (2017), Sayid (2007) and Madurika and Hemakumara (2017). Hence, Madurika and Hemakumara (2017) and Sayid (2007) directed that the adopted population density standard is better used in every town. It also stated that the minimum population density per hectare was advisable/suitable and the maximum population density was not suitable for residential development. This study also conducted based on the adoption of population density standards.

Table 4.4: Reclassified map for each criteria

No	Criteria (distance from residential area)	Standards used and its rank	Suitability
1	LULC	1. Built-up area 2. Vegetation area 3. Agricultural land 4. Bare land	Marginally suitable Moderately suitable Suitable Highly suitable
2	Road distance	1. <0.5km 2. 0.5-1km 3. 1km-2km 4. 2km-3km 5. >3km	Highly suitable Suitable Moderately suitable Marginally suitable Unsuitable
3	River distance	1.<0.1km 2.0.1km-0.2km 3. 0.2km-0.3km 4. 0.3km-0.4km 5. >0.4km	Unsuitable Marginally suitable Moderately suitable Suitable Highly suitable
4	Slope	1. 0-3% 2. 3-8% 3. 8-15% 4. 15-30% 5. >30%	Highly suitable Suitable Moderately suitable Marginally suitable Unsuitable
5	Religious area	1. <1km 2. 1km-2km 3. 2km-3km 4. 3km-4km 5. >4km	Highly suitable Suitable Moderately suitable Marginally suitable Unsuitable
6	Social Service area	1. <2km	Highly suitable

		2. 2km-3km 3. 3km-4km 4. 4km-5km 5. >5km	Suitable Moderately suitable Marginally suitable Unsuitable
7	Soil type	1. Pellic vertisols 2. Lithosols 3. Chromic Luvisols 4. Eutric Cambisols 5. Rocky soil	Highly suitable Suitable Moderately suitable Marginally suitable Unsuitable
8	Population density	1. <10 2. 10-15 3. 15-20 4. 20-30 5. >30	Highly suitable Suitable Moderately suitable Marginally suitable Unsuitable

4.5. Weighted Land Suitability for Housing Development

AHP principle was adopted to determine the weight of each factor. It is a method of assigning all criteria weights due consideration of different multi criteria decision making systems. One of the most significant methods that was developed by Saaty 1980, is pair wise comparison method to determine the relative importance of each criteria. Its hierarchy for pairwise comparison matrix including its objective and criteria. Three necessary steps were followed to get adequate result for sustainable residential development. Those are; completion of pair wise comparison matrix based on the relative of importance values from 1-9, calculated the weighting of each criteria, and assessment of the consistency matrix.

A pairwise comparison matrix was developed, where each factor was compared with the other factors relative to its importance based on a scale of 1 to 9, where 1 indicates equal preference between two factors, and 9 shows a particular factor which is extremely preferred over the other (1= equal, 3= slightly favors, 5= strongly favors, 7= very strongly favors, 9= extremely favors; 2, 4, 6 & 8 are intermediate values), (Sayed and Hakan, 2020). Based on this AHP is an important method to simplify the decision-making process.

As indicated in Table 4.5, the comparison was done based on Saaty nine-point continuous scale and the value for each criteria was assigned by the researcher to prepared a pairwise comparison matrix. The pairwise comparison matrix comparison was entered by using IDRISI selivea 32 software.

Table 4.5 Assigned value for AHP hierarchy

	Slope	Road	River	Religious Area	Social service area	Pop. density	Soil Type	LULC
Slope	1							
Road	½	1						
River	1/3	2	1					
Religious Area	1/3	1/3	1/3	1				
Social service area	1/4	1/2	1/3	2	1			
Population density	1/3	1/3	1/2	2	1/3	1		
Soil type	1/5	1/5	1/3	½	½	1/3	1	
LULC	1/7	1/3		1/3	½	1/2	1/3	1

4.5.1. Assigning Weights for each Criteria

The method for weighting the criteria is the pairwise comparison. It stems from the Analytic Hierarchy Process (AHP), a famous decision-making framework developed by the American Professor of mathematics (Saaty, 1980). A weight can be defined as a value assigned to an evaluation criterion indicative of its importance relative to other criteria under consideration (Morka, 2020).

From the figure 4.20 below, the eigenvector of each criteria calculated using IDRISI 32 software and each value multiplied by one hundred which gives the weight of each value by percent. Accordingly, the percentage value for each criteria approximately slope (30%), road distance (17%), river distance (19%), religious area distance (7%), social service area distance (10%), population density (8%), soil type (6%), and LULC (3%). The summation of all criteria weights must be 1. That is 0.297+0.167+0.189+0.068+0.103+0.085+0.057+0.034=1 or it becomes 100%.

4.5.2. Assessment of Consistency Ratio

The acceptable consistency ratio was defined as below 0.1 as Saaty (1980). However, in this study the consistency ratio was 0.07, that is below the standard and it was acceptable.

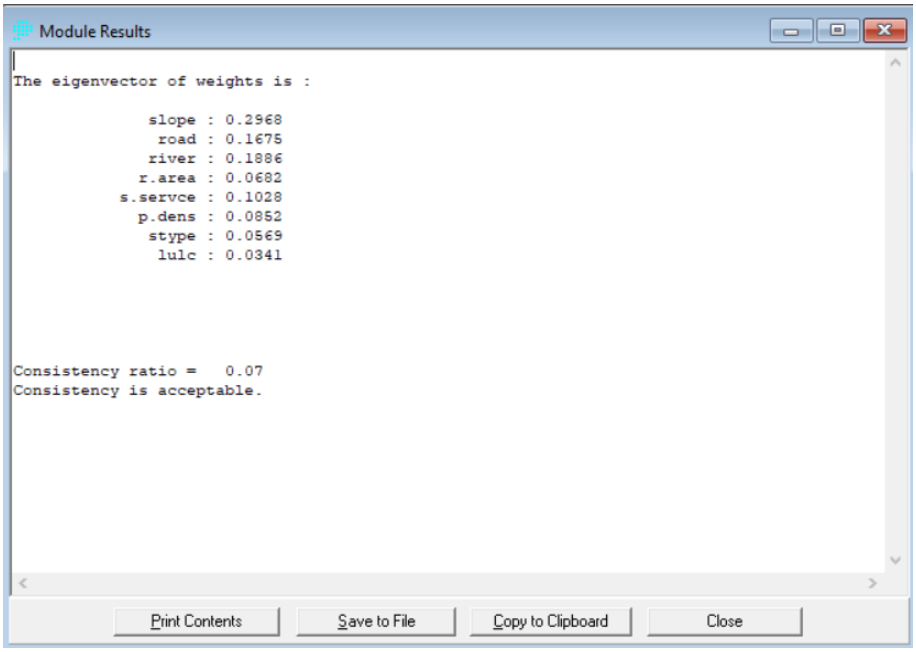

Figure 4.19: The value of consistency ratio

Table 4.6: Criteria influence for weighted overlay

No	Criteria	AHP Weight Influence (%)
1	Slope	30
2	River distance	19
3	Road distance	17
4	Social service area	10
5	Population density	8
6	Religious area distance	7
7	Soil type	6
8	LULC	3
Total		100

Suitability evaluation is the actual process of applying multi-criteria evaluation to different criteria or factors in order to arrive at certain decision (Zeyin, 2020). For residential suitability, eight factors were produced and reclassified each criteria map according to its importance for

residential development. The criteria used for residential suitability analysis using overlay method were slope map, river distance map, road distance map, religious area distance map, social service area distance map, population density map, and soil type map. According to the final weighted factor map result, 8.44%, 52.95%, 24.84%, 13% and 0.77% of the areas are highly suitable, suitable, moderately suitable, marginally suitable and unsuitable for sustainable residential development respectively (Figure 4.21). This implies the majority of the area 52.95% of the town administration are suitable for residential development. In contrast to this, 0.77% are unsuitable and 24.84% are moderately suitable for residential development.

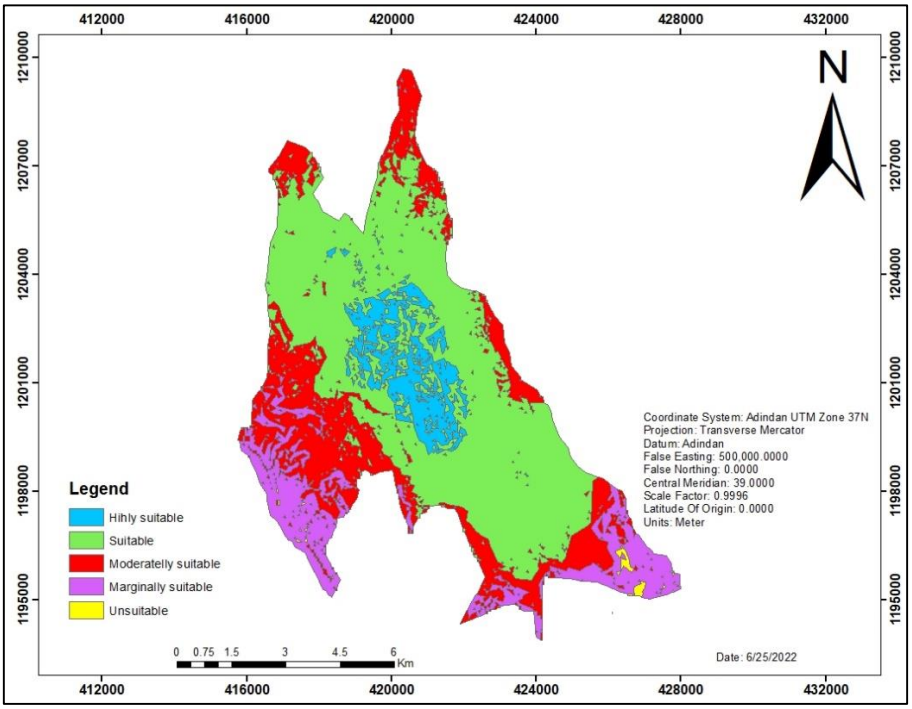

Figure 4.20: Final suitability map

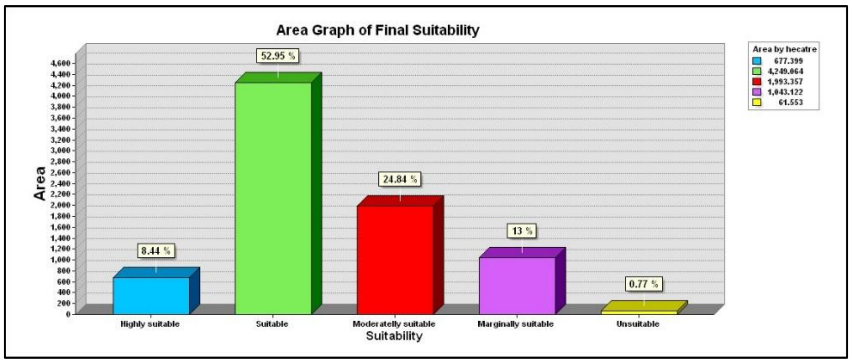

Figure 4.21: Area coverage suitability for housing development

Chapter Five

5. Conclusions and Recommendations

5.1. Conclusions

Now a day, many towns and cities in Ethiopia are inefficient land use allocation and lack of affordable housing. Among those Mertule Mariyam town is highly affected. The main purpose of this study was to assess and evaluate land use suitability with the focus for sustainable residential development by using GIS based computing approach. The study was vital to overcome the problems of fixed supply of land against high increment of population from year to year. To achieve the stated objectives eight factors/criterias are used to assess the suitability of land for residential housing development. These are LULC, terrain slope, distance to road from residential areas, distance to river from residential areas, distance to religious area, social distance to social service area, soil type and population density. Land suitability analysis is an essential element to determined areas suitable for specific purpose such as residential development.

Weighted overlay using AHP technique are used to produce the final suitability map for sustainable residential development. AHP is used as a weighted method in this study. The weighted suitability analysis result map portrayed that the majority (52.95%) of the area is suitable for residential housing development. The remaining 8.44%, 24.84%, 13% and 0.77% of the area are highly suitable, moderately suitable, marginally suitable and unsuitable respectively. The study also identifies the main challenges for affordable housing in the town including high compensation payment, lack of urban land planning system, corruption, lack of responsibility and accountability. All these hamper the affordability of housing and the sustainability of land use. Taking into account the results, this research recommends the use of land use suitability map for sustainable housing development in the town.

5.2. Recommendations

Based on the finding of the study, the following recommendations are forwarded;

- The population of the town and the need for land for housing are increasing from time to time. Hence, the municipality office should invite the real estate developers to build a residential house in the town by considering the proposed urban land use suitability map.
- The municipality experts should consider the proposed land use suitability criteria and standards to allocate land for residential development and other land use purpose.
- To reduce conflicts over land, the town administration should work to stop illegal construction of the house by creating awareness to the communities.
- The municipality office should encourage and support legal housing development by fulfilling and expand basic infrastructures for the communities who have legally building residential housing.
- The government should encourage legal housing associations for promoting sustainable residential housing.
- The present study considers the major physical, economic, social and environmental factors. However, other criterias such as aspect, proximity to urban center, and flood sheets aspect influence potential residential site selection, and should be included as evaluation criteria.

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Appendix I

BAHIR DAR UNIVERSITY

INSTITUTE OF LAND ADMINISTRATION

Department of Land Administration and Surveying

Survey Questionnaire

This survey questionnaire is prepared for academic purposes for the fulfillment of MSc Degree in Geomatics. The general objective of the study is to assess urban land-use suitability for sustainable housing development using a GIS-based computing and Multiple Criteria Decision-Making approach. The data will be used only for academic purposes; hence your genuine responses are vital for the success of the study. Hence, I would kindly request you to answer the following questions.

Thank You in Advance!

I: Background Information

1. Sex of respondent 1. Male ☐ 2. Female ☐
2. Age: 15-25 ☐ 29-40 ☐ 40-60 ☐ > 60 ☐
3. Education status of the respondent: 1. Illiterate ☐ 2. Primary (1-8 grade) ☐
   3. Secondary (9-12 grade) ☐ 4. Diploma ☐ 5. BSc ☐ 6. MSc and above ☐
4. Religion of individuals: 1. Orthodox ☐ Muslim ☐ 3. protestant ☐
   Other_____
5. Marital status: 1. Married ☐ 2. Divorced ☐ 3. Single ☐ 4. widowed ☐
6. Major economic activity: 1. Governmental ☐ 2. NGOs ☐ 3. Trade ☐ 4. Agriculture ☐ Other____

II. **Main Research Questions to HH Respondents**

I. Questions for evaluating the existing urban land use allocation and housing development strategies/frameworks.

1. Is there a clear urban land use allocation and housing development strategies/frameworks?
   Yes ☐ No ☐
2. If your answer for Q Nº 1 is "Yes' what are the positive impact of the existing land use allocation for housing development?

   _____

   _____

   _____.

3. If your answer for Q Nº 1 is "Yes' what are the negative impact of the existing land use allocation for housing development?

   _____

   _____

   _____.

4. If your answer is 'No' for Q Nº 1, why?

   _____

   _____

   _____.

5. What are the social problems about the existing land use allocation/frameworks for sustainable housing development?

   _____

   _____

   _____.

6. What are the environmental problems about the existing land use allocation/frameworks for sustainable housing development?

   _____

   _____

   _____.

7. What are the economic problems about the existing land use allocation/frameworks for sustainable housing development?

_____

_____

_____.

8. What are the political problems about the existing land use allocation/frameworks for sustainable housing development?

_____

_____

_____.

9. Are there any kinds of conflicts occurred due to lack of proper land use allocation frameworks for the existing conditions?

Yes ☐ No ☐

10. If your answer is Yes for Q. Nº 9 what kinds of conflicts occurred due to lack of proper land use allocation frameworks for the existing conditions?

_____

_____

_____.

11. What kind of urban land use allocation and housing development strategies /frameworks could you propose for sustainable housing development?

_____

_____

_____.

12. What do you recommend to the government, real estate developers, and financial institutions and to the community in general?

i. To the government:

_____

_____

_____.

ii. To real estate developers

_____

_____

_____.

iii. To financial institutions

_____

_____

_____.

iv. To the community

_____

_____

_____.

II. Questions for evaluating the land use/ land cover map of the study area.

1. Do you think that there are a land use/land cover change in the town administration?

   Yes ☐ No ☐

2. If your answer is Yes for Q Nº 1, What are the major causes of land use land cover change?

   _____

   _____

   _____.

3. What are the consequences of land use land cover change of the town administration?

   _____

   _____

   _____.

4. If your answer is No for Q Nº 1, please justify by reason?

   _____

   _____

   _____.

III. Questions for proposing suitable site for sustainable housing development.

1. Do you have a residential house? Yes ☐ No ☐
2. If your answer is "Yes' for Q Nº 1, how do you rank the suitability of your house? 1) Highly suitable, 2) Suitable, 3) Moderately Suitable, 4) marginally Suitable, 5) Unsuitable

3. If your answer is “Suitable’ for Q Nº 2, what are the indicator?

_____

_____

_____.

4. If your answer is “Unsuitable’ for Q Nº 2, Why and what are the indicator?

_____

_____

_____.

5. If your answer is “No’ for Q Nº 1, why and what the main social impacts because of the absence of housing?

_____

_____

_____

_____.

6. If your answer is “No’ for Q Nº 1, why and what the main environmental impacts because of the absence of housing?

_____

_____

_____.

7. If your answer is “No’ for Q Nº 1, why and what the main economic impacts because of the absence of housing?

_____

_____

_____.

8. If your answer is “No’ for Q Nº 1, why and what the main political impacts because of the absence of housing?

_____

_____

_____.

9. What are the challenges to access affordable housing in the town administration?

_____

_____

_____.

10. What are barriers to affordable housing?

_____

_____

_____.

11. What is the best solution to support the access of challenging housing affordability?

_____

_____

_____.

12. What are the strengths, weakness, opportunities and threats of the current residential housing provision/development framework?

Strength

_____

_____

_____.

Opportunities

_____

_____

_____.

Weakness

_____

_____

_____.

Threat

_____

_____

_____.

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Survey Questionnaire prepared for Municipality experts

This survey questionnaire is prepared for academic purposes for the fulfillment of MSc Degree in Geomatics. The general objective of the study is to assess urban land-use suitability for sustainable housing development using a GIS-based computing and Multiple Criteria Decision-Making approach. The data will be used only for academic purposes; hence your genuine responses are vital for the success of the study. Hence, I would kindly request you to answer the following questions.

Thank You in Advance!

I: Background Information

1. Sex of respondent 1. Male ☐ 2. Female ☐
2. Age: 18-25 ☐ 29-40 ☐ 40-60 ☐ > 60 ☐
3. Education status of the respondent: 1. Illiterate ☐ 2. Primary (1-8 grade) ☐
   3. Secondary (9-12 grade) ☐ 4. Diploma ☐ 5. BSc ☐ 6. MSc and above ☐
4. Religion of individuals: 1. Orthodox ☐ 2. Muslim ☐ 3. protestant ☐ Other _____
5. Marital status: 1. Married ☐ 2. Divorced ☐ 3. Single ☐ 4. widowed ☐
6. Major economic activity: 1. Governmental ☐ 2. NGOs ☐ 3. Trade ☐ 4. Agriculture ☐ Other____

II. Main research Questions for Municipality experts

I. Questions for evaluating the impacts of the existing/current urban land use allocation and housing development strategies/frameworks.

1. Is there a clear urban land use allocation and housing development strategies/frameworks?

Yes ☐ No ☐

2. If your answer for Q Nº 1 is "Yes' what are the positive impact of the existing land use allocation for housing development?

_____

_____

_____.

3. If your answer for Q Nº 1 is "Yes' what are the negative impact of the existing land use allocation for housing development?

_____

_____

_____.

4. If your answer is 'No' for Q Nº 1, why?

_____

_____

_____.

5. What are the social problems about the existing land use allocation/frameworks for sustainable housing development?

_____

_____

_____.

6. What are the environmental problems about the existing land use allocation/frameworks for sustainable housing development?

_____

_____

_____.

7. What are the economic problems about the existing land use allocation/frameworks for sustainable housing development?

_____

_____

_____.

8. What are the political problems about the existing land use allocation/frameworks for sustainable housing development?

_____

_____

_____.

9. Are there any kinds of conflicts occurred due to lack of proper land use allocation frameworks for the existing conditions?

Yes ☐ No ☐

10. If your answer is Yes for Q. Nº 9 what kinds of conflicts occurred due to lack of proper land use allocation frameworks for the existing conditions?

_____

_____

_____.

11. What kind of urban land use allocation and housing development strategies/frameworks could you propose for sustainable housing development?

_____

_____

_____.

12. Do you think that the provision of housing for individuals is based on its suitability standards (Slope, Distance from the road, distance from the river, soil type etc.)?

Yes ☐ No ☐

13. If your answer is "Yes" for Q Nº 1, which criterias are suitable based on its standard?

A) Slope B) Distance from road C) Distance from river D) Soil type

14. If Not why?

_____

_____

_____.

16. What are the obstacles/challenges to giving housing based on its standards?

_____

_____

_____.

17. What are the strengths, weakness, opportunities and threats of the current residential housing provision/development framework?

Strength

_____

_____

_____.

Opportunities

_____

_____

_____.

Weakness

_____

_____

_____.

Threat

_____

_____

_____.

II. To identify the dominant factors or criteria for sustainable housing development in the town administration.

1. Which criteria is the main factor that affect the economy of the residents?
   A) Soil type B) Population density C) Slope D) Road distance E) Distance from social service F) River distance
2. From the following criteria which one is the problems to live in safe environment in the town administration?
   A) River proximity B) Road proximity C) Soil type D) Population density E) Slope F) Distance from social service area

III. To identify/propose a potentially suitable site for sustainable housing development of the town.

1. What are the predictions you have put for future housing development?

_____

_____

_____.

2. Is that the high increment of population affecting the housing process?

Yes ☐ No ☐

3. What if an increase in population is affecting the housing process?

_____

_____

_____.

4. What are the challenges of affordable housing in Mertule Mariyam town administration?

_____

_____

_____.

5. What do you recommend to the government, real estate developers, and financial institutions and to the community in general?

ii. To the government:

_____

_____.

iii. To real estate developers

_____

_____.

iv. To financial institutions

_____

_____.

v. To the community

_____

_____

_____.

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Interview

This interview is prepared for academic purposes for the fulfillment of MSc Degree in Geomatics. The general objective of the study is to assess urban land-use suitability for sustainable housing development using a GIS-based computing and Multiple Criteria Decision-Making approach. The data will be used only for academic purposes; hence your genuine responses are vital for the success of the study. Hence, I would kindly request you to answer the following questions.

Thank You in Advance!

I: Background Information

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2. Age: 18-25 ☐ 29-40 ☐ 40-60 ☐ > 60 ☐
3. Education status of the respondent: 1. Illiterate ☐ 2. Primary (1-8 grade) ☐
4. Secondary (9-12 grade) ☐ 4. Diplom☐ 5. BSc ☐ 6. MSc and above☐
5. Religion of individuals: 1. Orthodox ☐ 2. Muslim☐ 3. protestant ☐Other _____
6. Marital status: 1. Married ☐2. Divorced ☐ 3. Single☐4. widowed ☐
7. Major economic activity: 1. Governmental ☐ 2. NGOs ☐ 3. Trade ☐ 4. Agriculture ☐ Other____

Interview Questions

1. What is the impact of the existing land use allocation for housing development?
2. How do you evaluate the housing development of the town administration?
3. What are the conditions for housing development (like from road proximity, river proximity etc.)?
4. What are the main criteria to select suitable site for housing development?
5. What does mean potentially suitable site selection for housing development?
6. If you understand the meaning of potentially suitable site selection, are you seen the residential areas are built based on its suitability?
7. Who are the major responsible bodies to develop potentially suitable site for housing development?
8. From your opinion, where the residential areas are suitable in the town?
9. How far the municipality support the housing development in the town administration?
10. What are your suggestion and recommendation for selecting suitable site for housing development?

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Focus Group Discussion

This Focus Group Discussion is prepared for academic purposes for the fulfillment of MSc Degree in Geomatics. The general objective of the study is to assess urban land-use suitability for sustainable housing development using a GIS-based computing and Multiple Criteria Decision-Making approach. The data will be used only for academic purposes; hence your genuine responses are vital for the success of the study. Hence, I would kindly request you to answer the following questions.

Focus Group Discussion Questions

1. What are the strength and weakness of the current residential housing provision/development framework?
2. How do you see the change of land use/land cover of the town administration?
3. What are the dominant factors or criteria for sustainable housing development of the town administration?
4. What do you know already about residential house development?
5. How did you first hear about residential house site selection?
6. What are your problems or concerns when you are at home?
7. What trends do you see for residential house site selection?
8. What features do you think are better for proposing residential house development of the town administration?
9. What is your general feeling about residential house development?