SITE SUITABILITY ANALYSIS FOR CONDOMINIUM HOUSING DEVELOPMENT USING GEOSPATIAL TECHNOLOGY: A CASE OF BISHOFTU CITY, ETHIOPIA

Tamirat Gemechu Alemu

A Thesis Submitted to
The Department of Geomatics Engineering
School of Civil Engineering and Architecture
Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Geo-informatics Engineering

Office of Graduate Studies
Adama Science and Technology University

September, 2022
Adama, Ethiopia

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DECLARATION

I, Tamirat Gemechu Alemu hereby declare that this Master Thesis entitled “Site Suitability Analysis for Condominium Housing development Using Geospatial Technology: A Case of Bishoftu City” is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Tamirat Gemechu Alemu	_______________	________________
Name of the student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled “Site Suitability Analysis for Condominium Housing Development Using Geospatial Technology :A Case of Bishoftu City” prepared under my guidance by Tamirat Gemechu Alemu submitted in partial fulfillment of the requirements for the degree of Mater’s of Science in Geo-informatics Engineering. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Roba Gemechu(PhD)	_______________	________________
Advisor	Signature	Date

APPROVAL SHEET

I, the advisor of the thesis entitled "Site Suitability Analysis for Condominium Housing development Using Geospatial Technology: A Case of Bishoftu City" and developed by Tamirat Gemechu Alemu, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Roba Gemechu(PhD) _______________ ________________

Advisor Signature Date

We, the undersigned, members of the Board of Examiners of the thesis by Tamirat Gemechu Alemu have read and evaluated the thesis entitled "Site Suitability Analysis for Condominium Housing Development Using Geospatial Technology: A Case of Bishoftu City" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geo-informatics Engineering.

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Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

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AHP	Analytic Hierarchy Process
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
CSA	Central Statistical Agency
DEM	Digital Elevation Model
ERDAS	Earth Resource Data Analysis System
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Global Positioning System
LULC	Land Use and Land Cover
MCA	Multi-criteria Analysis
MCDA	Multi Criteria Decision Analysis
MCDM	Multi-criteria Decision Making
MoUDC	Ministry of Urban Development and Construction
MoUDH	Ministry of Urban Development and Housing
WLC	Weighted Linear Combination
QoL	Quality Of Life
TIFF	Tagged Image File Format
KML	Keyhole Markup Language
SA	Sensitivity Analysis

ABSTRACT

Nowadays, condominium houses have been steadily increasing in popularity in densely populated cities since demand for residential houses in urban areas has become a major problem facing cities planners today. With the high increase in urbanization due to the increase in the population, residential houses are becoming more difficult to find and afford. Planners aim at developing new ideas like affordable condominium house development to combat the high increase in demand for residential buildings. In recent times, different methods of analysis have been introduced that will help planners select the best locations to erect condominium houses. In this study, geographical information system (GIS) based multi-criteria analysis (MCA) using the analytical hierarchy process (AHP) is the tool for identifying the potential areas. The main objective of this research is to analysis the availability of suitable condominium development sites in the Bishoftu urban council area. This research also identified criteria for residency and the extent to which its impact has influenced the creation of relevant condominium house development areas. Accordingly, this research also recognized GIS-AHP models as a cost-effective and time-efficient approach to spatial decision making. This research evaluated analytical methods by specifying the criteria in terms of slope, soil type, existing land use, and proximity analysis was also done to find out how (facilities, railway and highway, noisy and poisonous industry, high tension electric power line, and military camp and air force) are close to the study area. It could be concluded that in the Bishoftu urban council, 4.84% (982.85 hectares) of the total area of consideration (20578.9 hectares) is designated as a very high potential area for condominium house development, and 16.68% (3386.15 hectares), 37.01% (7513.15 hectares), and 41.27% (8376.97 hectares) is designated as a high, moderate and least potential area for condominium house development, respectively. Moreover, 0.2% (40.26 hectares) of the total area of consideration could be observed as unsuitable for condominium house development. Last but not least, it can be said that 21.52% of the total land area in the Bishoftu urban council is appropriate for condominium house development sites at different levels of suitability.

Keywords: Multi criteria analysis, Analytical Hierarchy Process, Site Selection, Geospatial Technology, and Suitability.

CHAPTER I. INTRODUCTION

1.1. Background of the study

Urbanization is one of the most dynamic processes of geographic phenomena in the history of humankind and is represented by two contradictory and conflict perspectives (Woldemariam et al, 2018).It also acts as an engine and indicator of transformation from traditional rural economy, both physically and functionally, is widely recognized for enormous socio-economic improvements of the resident. Urban dwellers have the opportunity to access better dwelling infrastructure and facilities, social-wellbeing, and improved living standards as compared to their rural counterparts (Weldu, 2020).However, urbanization in the case of developing countries is overshadowed due to the absence of proper planning domains that are accompanied by acute socioeconomic and ecological impacts (Belal & Moghanm, 2011).

Presently, more than half of the world population lives in urban areas and considerably half of the population in developing countries also live in urban areas. The urban population in developing countries was increasing at an alarming rate during the last 50 years as a result of push and pull factors influenced from third world urbanization. Due to high demand for residential use, population is unevenly scattered in the urban edge of the metropolitan areas(Ekanayaka & Weerakoon, 2019). This problem is more aggravated in the developing countries and mushroomed slums and squatter settlements is the result. These overcrowded residential areas have no access to affordable facilities for a better living. Therefore residential land development plays a major role in the urban development. Due to the scarcity of land, real estate developers are concern on vertical development rather than horizontal development. Most real estate developers try to maximize their profit margin and pay less attention for selecting best locations.

Similarly, the situation of developing countries like Ethiopia is more aggravated due to the lack of proper planning regulations and economic inefficiency (MadurikaH, 2017).Hence, ensuring land suitability for residential areas is one of the main purposes of land-use planning through spatial analysis of a particular location. Planning of residential area is one of the most components in the urban planning tools in any country including Ethiopia (Raghunath, 2006). As indicated in the urban planning and implementation manual of Ethiopia (MUDC, 2012) the location of the residential area should be in terms of certain predetermined factors such as physical, economic, and environmental conditions which influence the suitability of the site. A residential area is a place classified under land use categories in which housing predominates as opposed to industrial and commercial areas. However, due to lack of proper planning and limitation of the effectiveness of plan regulation and implementation, urban development in Ethiopia urban centers rarely meets the standards. According to Dejene (2015), the urbanization rate is growing annually and generating high demand for residential land. Hence, planners and policymakers need to prepare proper guidelines for a suitable location for residential development.

Suitable site selection has become more complex with an increasing desire to integrate goals related to sustainable development. Hence the modern site selection process has evolved into a path of conflicting and contradicting interests among spatial, environmental, economic, and social issues (Wandimu, 2011). Planners are facing new challenges in assessing land suitability to identify the optimal site for a particular project as they attempt to plan and design projects which maintain safe and quality places, ecological system sustainability, and contribute to economic development. Access to safe and healthy shelter and basic services is essential to a person's physical, psychological, social, and economic well-being (Seid, 2007).

Accordingly , urban land suitability analysis for a part of a residential area, condominium house purposes is a complex process that involves considerations of multi-criteria evaluation, which considers not only physical conditions but also environmental, social, and economic factors in the multifunctional pattern of urban areas, and a scientific approach should be used for that (Ekanayaka, 2014). Geospatial technologies and techniques are powerful tools and methods that can be used to analyze spatial data and its sophisticated analysis functionalities with multi-criteria evaluation provide a better approach for suitability analysis. The process of land suitability analysis involved the evaluation and grouping of specific areas of land in terms of their suitability for a defined use (Ekanayaka, 2014).

Integrated geospatial techniques and the MCE process add some valuable insight to a strong analysis platform for finding suitable condominium site locations. The rapid progress made in geospatial sciences and technologies like GIS, remote sensing, and GPS augmented with multi-criteria evaluation and analytical hierarchy process nowadays have been put forward with a series of functional capabilities and applications to solve conflicts and complexities in any geospatial decision making. Hence this study aims at analyzing urban land suitability to identify possible suitable locations for future condominium houses development in Bishoftu city, Ethiopia using geospatial techniques with Multi-criteria Evaluation (MCE) and analytical hierarchy process.

The condominium developments required to focus on the affordability of the residents to live and work with accessibility, infrastructural facilities, environmental quality, financial ability etc. But most of the real estate developers mostly concern on financial affordability of the buyer and not the social and environmental factors. Then in the long term residents face many difficulties in day to day living in those particular locations. Therefore evaluation of location suitability of the condominium development is most important to a country to provide a better living for people. In the long term a country with a good living environment can earn good benefits from the society, and it maximizes the highest and best use of the land(Ekanayaka & Weerakoon, 2019). Geographical Information Systems (GIS) and Multi Criteria Evaluation (MCE) can be used as a tool to analyze location suitability of condominium development. Choosing an appropriate location for condominium use is obviously related to decision support and MCE. The problem can be generalized as a question of what must be done and where it should be realized.

1.2. Statement of the Problem

The city is expanding quickly and continuously, drawing residents from all across the country to its metropolitan areas as a result of its advantageous location and high job opportunity. One of the most important and rapidly expanding cities in the nation is Bishoftu. Due to the city's advantageous location and proximity to the capital city of the country, its rapid expansion has been attributed to its attractive potential (Cities Alliance, 2016). The city has been spurred by rapid population growth and industrialization, which have brought an unprecedented urbanization process over the past few decades.

As a result, there was a strong demand for residential houses, making it difficult for the city administration to house everyone. Aside from overcrowding, poor and insufficient social amenities, unfavorable environmental conditions, urban squalor, a lack of open space, the development of land that results in overcrowding of buildings, accessibility issues within residential areas, and scarcity and high costs of building materials, housing problems and needs also manifest themselves in these ways. The present problem of residential houses in the city is putting pressure on the unplanned growth of the city and the poor quality of life. Moreover, high population growth, municipal ineffectiveness, high cost of construction materials, low level of income and saving , shortage of infrastructure, and shortage of financial resources have contributed a lot to the current gap between demand and supply of residential houses (IDP,2016).

Consequently, the most challenging task facing Bishoftu city is to provide land with better infrastructure because of economic affordability brought on by the consistently rising cost of living and zoning regulations. In addition, the number of people in Bishoftu who spend 50% or more of their income on housing rent has increased over time due to the sharply rising cost of private house rent, which is contrary to the 30% rule of thumb for rent, which suggests spending no more than about one-third of your monthly income on a rent payment each month (Herbert et al., 2018). Therefore, it's crucial to find affordable housing, such as condominiums, that can house more than ten families and that are built on a single parcel of land in a suitable location close to urban areas, with at least four floors in each building. Hence, the current planning and it is observed that the present proposed land use plan cannot fulfill this requirement. As a result, the land suitability analysis for urban affordable condominium housing development is intended to identify and serve the best potential sites for residents to live (Weldu, 2020).

Numerous case studies have been done to evaluate the degree of urban land appropriateness for condominium dwelling development. (Heldana Shiferaw,2017,Adem Kedir,2010; Seid, 2017, Zereu Geremew, 2020). It was discovered through the literature reviews that there are no set standards for determining the suitability of a condominium housing site. According to their goals, subjective assessment, theoretical knowledge, and local expertise, researchers chose their criteria for condominium housing site appropriateness analysis. The fact that much of the research relied on a limited set of assessment criteria, however, makes it harder to include enough evaluation criteria to adequately represent the spectrum of human decision-making and reasoning.

The main weaknesses in these studies are the omission of some important criteria, such as the level of distance from a military camp, the level of distance from a railway and highway, the level of distance from industries with high noise and pollution, and the level of distance to a high-tension electric transmission line. Furthermore, because of environmental sensitivity, natural risks, and legislative restrictions on future development, they failed to take into account limits that should have been taken into account in the suitability study. Lastly, they did not evaluate the suitability of the proposed condominium housing land use to validate its suitability and status. In addition, it is uncommon to apply cutting-edge technologies in Ethiopian metropolitan centers to assess urban land appropriateness for a certain application, such as a condominium building site. Particularly, in Bishoftu city, despite preparing proposed land use plans at different time intervals, the level of suitability for future condominium housing sites has remained unclear. However, urban residential land use planning, by its nature, is not a one-time activity. It is an ongoing process that needs further study and should be updated regularly.

1.3. Objective of the study

1.3.1. General Objective

The main objective of this study is to analysis the optimal location for condominium housing development in Bishoftu city using Geospatial Technology.

1.3.2. Specific Objective

More specifically, the specific objectives of the study aspire to:

i. Identify the major criteria to be used in selecting a suitable site for condominium housing in Bishoftu city;

ii. Evaluate the existing site of condominium house in Bishoftu city;

iii. Identify optimal location for future condominium house development by using the analytical hierarchy process (AHP) based multi criteria analysis (MCA) methods.

1.4. Research question

1. What are the factor affecting suitable site selections for condominium house development?
2. What is the suitability level of existing condominium house site in Bishoftu?
3. Which sites are suitable for future condominium house development in the study area?

1.5. Significance of the study

This study investigates the perceived factors influencing the suitability of site for condominium housing projects in Bishoftu city. It is hoped that the study's findings will benefit and raise awareness among condominium housing project developers, the government, contractors, project managers, and other organizations concerned with the environmental, physical and economical suitability of integrated housing projects. It can also be a part of a case library study related to assessing suitable site for condominium housing as a reference material for similar studies in the future. For the public/reader, it can help create awareness about suitable condominium housing, shed some new insight on the benefits of selecting suitable sites for construction, renovation, and promote willingness to achieve suitable condominium housing. The thesis can assist responsible bodies to assess the appropriateness and weaknesses of candidate site for condominium housing construction process. And hopefully, it will inspire researchers to further study in the area.

1.6. Scope of the study

This study focused on analysis of urban land suitability for future condominium house development in Bishoftu city. Hence, Bishoftu City administration boundary of 2022 was considered as the spatial restriction of the study. Thematically, relevant related kinds of literature, reports, and urban land policies have been reviewed to acquire background information, strong theoretical basis, selection of appropriate methodology, identification of gaps in the literature, and comparison of the findings in the existing body of knowledge.

1.7. Limitations

This study is aimed at analyzing urban land suitability for condominium housing development areas. However, due to the existing limitations of data availability, time, and intended depth of analysis, land uses other than condominium housing are not considered in this study. Furthermore, the study was confronted with a range of challenges such as the scarcity of the relevant data in expected expertise offices, the occurrence of the virus, "COVID-19" situations followed by the unwillingness of important groups to allow the sack of the physical contact, and other constraints. However, this limitation did not affect the result of the study much.

1.8. Organization of the Paper

This thesis includes four chapters and a conclusion and recommendations section. The first chapter presents the introductory part, which describes the background of the study; the statement of the problem; the objectives of the research; the research question; the significance of the study; the scope of the study; the limitation of the study; and the organization of the paper. The second chapter discusses the literature related to the study and reviews related papers to find the scientific support and the theories behind the methodology. The third chapter includes a description of the study area, data sources, and data collection methods, software, and facilities used to analyze the data. The fourth chapter presents results and discussions that focus on developing spatial data analysis techniques using geospatial techniques with MCE and AHP methods. The determination of criteria (factors and constraints) and weight computation are key parts of the study. Finally, conclusions are drawn from the findings, and recommendations are provided to improve the analysis of urban land suitability for a condominium site in the future**.**

CHAPTER II: LITERATURE REVIEW

2.1. Definition and concepts of Terms

Affordable housing is defined a housing that is appropriate for the needs of a range of very low to moderate income households and priced so that these households are also able to meet other basic living costs such as food, clothing, transport, medical care and education. As a rule of thumb, housing is usually considered affordable if it costs less than 30% of gross household income.

Condominium housing is a large affordable housing constructed at some specific area, divided into single units for the purpose of sale, is a condominium. So it is different from a regular property. Much of the difference springs up due to the kind of ownership. For example, in the case of an apartment, a single family purchases not just the unit but they also have a right of ownership on the land on which the structure is built. In the case of a condo, the ownership is slightly different (webb & webber, 2017).A condominium is inside a residential building or community but the unit is privately managed by the individual or landlord of the property. This landlord has no say in the functioning of the larger building or even the plot of land in which his/her property is built upon. A home owners' association may, however, come together to help out with the property management. They may also be referred to as the condominium management, consisting of a group of owners that come together to oversee lawn maintenance, etc. For services such as these, condo owners will have to pay a certain amount. Condominium is much like apartments but differ in terms of the ownership (Selam, 2018).

Housing provision is a physical process of creating and transferring a dwelling to its occupiers, its subsequent use and physical reproduction and at the same time, a social process of dominated by the economic interests involved.Government intervention through good housing policies is needed to deliver the housing provision for the nation, either by private sector or public sector (hamizah yakob,2013).

2.1.1. Land use zoning regulation and control for condominium housing areas

Zoning regulation is part of the development guide to establish a compatible land use pattern that will help to secure optimum, economic, and environmental advantages. The decision for allocating different activities on different sites should at least be examined based on the area and location of the proposed sites concerning the different parts of the city, neighboring activities, alternative activities and sites for allocation, land value, and future development (IDP, 2016). On the other hand, land-use zoning regulation is an implementation tool for planning and plan implementation to control the nature of development in line with the neighboring activities and the natural environment (IDP, 2016).

Land use regulations are used to restrict the rights of private landholders while they use the land. Land use controls and regulations are also used to protect the public interest when they need to use private land. These regulations are also used to ensure the availability of land to all groups, and to ensure that the benefits of development go to the community as a whole. Land use controls and regulations are common urban land policies in almost all cities of the world (Kono & Joshi, 2018) mentioned common regulations. These are Zoning by which urban land uses are restricted zone by zone; lot size regulations that limit the size of each housing area; urban growth boundary control which separates urban development areas from urbanization control areas; and floor area ratio regulations which directly limit building sizes both in horizontal and vertical dimensions. However, the methods and implementations of these regulations may vary from country to country or city.

2.1.2. Compatibility of Land Uses

Compatible is defined as development, building and/or land use that is designed to be able to exist or occur without conflict with its surroundings in terms of its uses, scale, height, massing, and location on its site (Nosal, 2009).Land use compatibility is a recognized factor and principle of good land use planning, whereby land uses which are known or expected to cause environmental problems for one another when in proximity, are deemed incompatible and are protected from one another by separation and/or other means (Nosal, 2009).Land uses in a structured plan ought to be proposed taking into account compatibility of adjacent land uses or compatibility of different land uses which would be proposed close to each other.

Table 1: shows the compatibility matrix produced based on major land use

Land use	Residence	Commerce	large-scale Industries	Small-scale Industries	Social Service	Cultural Center	Administration
Mixed	√	√	X	√	√	√	√
Center	√	√	X	√	√	√	√
Manufacturing & Storage	X	√	√	√	X	X	X
Green Frame	X	√	X	X	X	√	X
Services	?	X	X	X	√	√	X
Transport Centers	X	√	X	√	X	X	?

N.B: '√' Denotes compatibility, 'X' denotes incompatibility of function, '?' Denotes partly Compatible but to be decided depending on the specific situation

2.2. Suitability of urban condominium housing site and influencing factors

2.2.1. Influencing factors for suitability of condominium housing site

According to (Abdula et al, 2015), suitability analysis and site selection require consideration

of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for defined land use. Multi-criteria evaluation is a technical procedure that typically multiplies conflicting and corresponding criteria that are essential to be assessed in decision-making (Stephen, 2013). In general, the basic advantage of using the MCE method is the possibility to evaluate complex and multiple factors at different scales and aggregated to produce a composite map that portrays suitable land for a particular project. (Murseli & Isufi, 2014)revealed that "During the planning process two steps are very important, the first step is to know and locate which area important resources to preserve or restrict for future development in an area and the second step is what is left from a preserve or restrict resources to plan than to develop for future development.

Defining the criteria is made based on the restrictions of spatial developments arising as part of the national legislation, planning documents, analyzing the most appropriate distance for land functions dedicated for housing, as well as documents and different practices" Therefore, "site suitability is the process of understanding existing site qualities and factors which will determine the location of particular activity" (Murseli & Isufi, 2014). So, it requires analysis of wide-ranging and consistent datasets to achieve the objective. Hence, to ensure the maximum society's benefits and sustainable environmental health, this study considered the real urban situations of the study area with factors such as economic, environmental, and physical conditions and support in the analysis of urban land sites for future condominium housing developing areas.

Therefore, based on different countries' experience, local expert's opinion, Ethiopia's Ministry of Urban Development and Construction manual on Revised Standards(Ministry of Urban Development and Construction, 2012)for Structure Plan Preparation and Implementation, and availability of data, different parameters for future residential areas can be considered in the context of the study area. Accordingly, the criteria identified from these literature reviews are: the settlement site should be on a slope range of 2–8%;the houses should be placed on vacant land (open area),for accessibility of transportation, the new condominium site should not be far from major roads. For safety reasons, the residential site should be away from the river (flooding during the summer season);there should be no condominium areas within 250m of the river, the presence of physical hazards reduces the suitability of a site for selecting safe housing sites and increases the risks For example, it should not be located in high-risk areas (susceptible to natural hazards). For safety and noise reasons, it should be away from the railway line side. Some protected areas, such as parks and industrial areas, should be masked.

According to the urban planning and implementation manual (MUDC, 2012), the activities should be considered during selecting condominium housing areas: they should be free from black cotton soil as much as possible, located in all corners of the town unless there is a constraint; It has a gentle slope, i.e., 2%–15% (a slope between 2% and 8% is highly recommendable). Due to its gentleness, it reduces the cost of construction, landslide risk, and floods and is free from exposure to natural disasters such as geological hazards (land and mudslides and rock fall), floods, and malaria-affected areas (unless both are protected (treated) properly). Avoid unplanned settlements on hazard-prone lands that contribute both to environmental degradation and vulnerability to catastrophic events; Take the necessary engineering precautions to alleviate the situation. Certain hazard-prone lands, such as wetland areas, are suitable for recreation as long as they are not impacted by human and animal interference, provide the necessary management controls to prevent incompatible land use and environmentally destructive activities, and provide a proper drainage network system to avoid floods and storm water, which in all cases aggravate environmental degradation, resulting in catastrophic events.

When land is zoned in a development plan designation, the development plan should identify where practicable the sequential and coordinated manner in which zoned lands will be developed, to avoid a haphazard and costly approach to the provision of social and physical infrastructure. The development plan specifies that zoning shall extend outwards from the Centre of an urban area, with undeveloped lands closest to the core and public transport routes being given preference, encouraging infill opportunities, and that areas to be zoned shall be contiguous to existing zoned development lands(Metternicht, 2017).The provision of utility investment programs by planning authorities must also be related to the sequencing of residential lands and must also be integrated with the provision of public transport, schools, community, and facilities, etc. This will involve keeping up the close contact with other agencies, which would have occurred during the plan-making period(Metternicht, 2017).As stated by the Minister for the Environment, Heritage and Local Government (Metternicht, 2017), for sustainable and affordable residential housing development, the range of relevant national policies was established to share a common goal to create high-quality places which

Prioritize walking, cycling, and public transport, and minimize the need to use cars, deliver quality of life which residents and visitors are entitled to expect, in terms of amenity, safety, and convenience; provide a good range of community and support facilities, where and when they are needed and that are easily accessible; present an attractive, well-maintained appearance, with a distinct sense of place and a quality public realm that is easily maintained and easy to access for all and to find one’s way around; promote the efficient use of land and energy, and minimize greenhouse gas emissions; provide a mix of land uses to minimize transport demand; promote social integration and provide accommodation for a diverse range of household types and age groups; enhance and protect the green infrastructure and biodiversity; and enhance and protect the built and natural heritage.

2.3. Quality of life and housing domain

Quality of Life and Housing Domain Quality of life (QoL) studies recognized that it is a function of quality of life domains, such as housing, built-up environment, financial and material well-being. (Gebrewold, 2015)argue that people living place, housing condition will influence their QoL. Another study by (Zebardast, 2009) found that housing provision improve individuals quality of life. Despite the fact that housing is a determinant of QoL, housing quality affect the states of QoL and the dwellers' satisfaction. To detect QoL with housing domain (Robert and Stimson, 2011) identified objective, subjective and behavioral indicators.Some of indicators in these categories were residential density as an objective indicator, housing and neighborhood satisfaction as a subjective indicators and residential mobility as behavioral indicators. (Mridha & Moore, 2011) study shows that satisfaction with neighborhood also affects residents' life satisfaction. Lee and Park (2010) finding revealed that housing satisfaction was a main determinate of quality of life among temporary resident in the USA.

2.4. Condominium Satisfaction and Perception

Housing satisfaction is one of popular researched topic in quality of life study. The purpose of this section is discussing factors that affecting condominium dwellers satisfaction within the context of body of knowledge and relevant research. It focus on major housing domains namely: site aesthetic, structure and space, affordability, utility and service, accessibility, sanitation, neighborhood attraction, noise and security effect on dwellers satisfaction and perception. The overall condominium dwellers' housing satisfaction was slightly higher than dissatisfaction. Housing satisfaction percentage result show that inner city condominium sites percentage was above average while urban periphery condominium below average. Previous finding by (G. Abebe & Hesselberg, 2014); (Keller & Mukudi-Omwami, 2017)confirmed that in Addis Ababa inner city condominium site dwellers were advantageous than urban periphery. On the other hand, the result show ground floor score was slightly higher than top floors and negative perception and low preference for top floors.

2.4.1. Site Aesthetic Domain

Pervious finding has shown that aesthetic value such as building density, streets, public space arrangement and connection have significant effect on resident's satisfaction (Yang, 2008; UN Habitat, 2003). When we evaluate the case study sites aesthetic visual impact with respect to site plan, blocks connection, external block paint evenness, street light and surface structure of roads; chalalaka site attractive and Genesis site less attractive. Although there was similarity in building floor level in the sites, aesthetic attributes seems less considered in Genesis. In addition, we observed that there was variation within the site. For instance, in Genesis and chalalaka distant from Main Street do not have streetlight or having electric pole without light. It an important attribute for feeling safe and secure and proliferation of quality of life (Kowaltowski et al., 2006).

This suggests that to increase housing satisfaction level in less attractive sites, project office should improve their overall conditions. The research found that structure and space domain affects dwellers psychological and socioeconomic aspects. Satisfaction with this domain was specifically related with suitability for home based business, suitability for children, elders, disabled, comfort, enough space to live and level of privacy. Sungur and Cagdas (2003) investigate that sufficient housing space increase level of privacy and by implied increase housing satisfaction. On the contrary, (Kahlmeier et al., 2001)found that housing quality satisfaction associated with dwellers wellbeing than suitability for children and social life.

2.4.2. Accessibility Domain

Inaccessibility affects the dwellers satisfaction in many ways. For example, families relocated in urban periphery site in the middle of academic year, their children travel long distance to previous school location or else forced to school dropout. Shopping centre inaccessibility also exposed dwellers to spent high cost to bought goods and travel long distnce for shopping. Unavailability of mode of transport increase travel cost (e.g. walking distance to access the mode of transport, transport waiting time, transportation cost) and service cost of individuals to access the service. These cost has direct implication on site and house un affordability, i.e. it increase direct housing cost plus high service cost due to housing location. Dwellers' housing dissatisfaction may aggravate if a site may have low or no employment access for low income or informal worker. This implies that inaccessible site location has increase the budgetary constraint and decreasing wealth accumulation by increasing expenses. Previous finding also suggested that accessible house improve quality of life (Yang, 2008; Olajuyigbe et al., 2013). (Zainal et al., 2012)also found that it increase person mobility and strengthen social network. The implication is fair and proper basic service intervention in order to improve the quality of life of urban periphery sites.

2.4.3. Noise and Security Domain

It is an important element not only housing satisfaction but also for the overall life satisfaction. Similarly, (Sirgy & Cornwell, 2002)found that satisfaction with neighbours and tie with community significantly contribute for life satisfaction. With this regard resident stress the importance of strength fence, gated locked and guardhouses manned service to control thieves and stranger frequent visit. Therefor the spatial separation is not the only solution for safety and security, instead strengthen societal network, promote social safety program, strength community police and ensure street lighting would have better result to alleviate driving factors of crime and social evils.

2.5. Condominium contribution for quality of life

In Bishoftu, much is unknown on the outcome of condominium contribution in addressing housing need of different income group and its impact on their quality of life. As indicated earlier, the condominium has contributed to improved quality of life or standard of living of dwellers. Numerous researchers examined housing as a domain of quality of life and its effect on other domains such as material wellbeing, health, financial capability and general wellbeing of individuals (Zebardast, 2008). It is for this reason that the following section summarizes only the major condominium contribution for quality of life. This study considered dwellers' housing satisfaction level as an indication of the quality of life. The research found that satisfaction and dissatisfaction determinants about condominium. The main finding of the study is that the dwellers of condominium are generally satisfied by having a dwelling for their family.

Satisfied dwellers acknowledged that condominium contribution for modern life style, positive influence on saving culture, homeownership, sanitation improvement, improvement over previous housing location, a relief from chronic house shortage, culture of tolerance and mutual understanding among neighbors, better housing space management, privacy, freedom of using facilities and utilities. These factors are important ingredients for quality of life improvements. Previous studies held on housing and quality of life support this finding (Dunny and Kyle, 2007; Ilesanmi, 2012; Zebardast, 2008). On the other side, dissatisfied dwellers depreciates condominium contribution for quality of life. The main causes are associated with housing cost burden, structural inconvenience for home-based business, absence of recreation and children playground, urban periphery site inaccessibility for basic social services.

Therefore, previous studies suggest that housing condition to improve quality of life of dwellers should be affordable (Agnew, 2014), structurally convenient for low income group (Samaratunga, 2013), accessible (Zainal et.al., 2012), recreation and public amenities (Richards et al., 2007). A better understanding of their impact on dwellers satisfaction and overall quality of life will helps decision maker to responds on the gap. Condominium project at macro level also has impact on overall quality of life. Ministry of Works and Urban Development (2010), Addis Ababa Housing Development Project Office (2005) reports and publication claimed that condominium project contribute for housing provision, thousands of job creation for micro and small-scale enterprise, strength of construction sectors and consultants, slum clearance, improvement in urban design, infrastructure development, alleviating social problem and poverty. Another study by UN Habitat (2011); Haregewoin (2007) also support this claim. Evaluating the project performance and overall contribution for project beneficiaries' quality of life and city development as a whole are not the concern of this study. However, from the perspective of urban planning, habitat agenda and millennium development goal support the condominium project contribution for quality of life improvement.

When we evaluate the housing condition of Bishoftu, specifically slum area, condominium site is better serviced in terms basic infrastructure, public amenities, land use effectiveness and have improved site plan. Literature advocate these determinants improve urban quality of life (Serag et al., 2019); Yang, 2008). According to UN Habitat (2009) of the list of habitat agenda indicators: durable house structure, affordable house, tenure security, housing finance, access to basic service, solid waste disposal, slum clearance and mode of transport; condominiums in general have improvement in Bishoftu housing conditions and general wellbeing of the city residents. However, these improve the urban quality of life and dwellers quality of life in sustainable way only the decision-makers will address the identified housing quality gaps.

2.6. Historical Perspective

With the increasing demand for land, land use planning and land evaluation have become more important as people strive to make better use of the limited land resources. Land evaluation is the process of assessing land performance for specified purposes(Paudel et al., 2016). As well as land suitability assessment, a typical analysis approach for land evaluation is the process of determining the fitness of a given tract of land for a defined use. It is an indispensable part of land evaluation in the process of land use decision-making. Accordingly, it can argued that land use planning is a technical process which deals with physical, economical, environmental as well as social factors of users of that area. Since 1950s, land suitability assessment has been used in land evaluation processes in many western countries(Paudel et al., 2016).In the beginning, there was no conformity in the standards and methods used in land suitability assessment.

Since land evaluation approaches differed from country to country, information exchange was rather difficult. It was not until 1976 that the fundamental document for land evaluation, proposed by the Food and Agriculture Organization of the United Nations (FAO), "A Framework for Land Evaluation", was published. The framework described the procedures of land evaluation and the classification of land suitability. A universally accepted and a systematic standard for land suitability assessment was the most important contribution of this framework. After "the Framework for Land Evaluation" was published, the FAO developed specific land evaluation frameworks for irrigation, grazing and rained agriculture. Since the 1990s, land evaluation has become a synthesis of the land capability and land suitability assessment in many countries (Turan et al., 2018).This kind of development in land suitability assessment generally helps to have highest and best use in any area and gradually it moves from agriculture to other areas such as residential, industrial as well as office locations. Land suitability assessment was introduced to China in the end of 1970s. In the past decades, land suitability assessment has been adopted as an important part of land use planning in rural areas, urban areas and the fringe of urban and rural areas of China.

In China, land suitability evaluation for a given crop is the most widely used aspect of land suitability assessment (Fang and Liu, 2004). Since China is one of the best agricultural countries in this part of the world, they used this technique to utilize their land usage in to the highest percentage. In comparison, land suitability assessment has played a very limited role in the process of urban development. Urban sprawl, urban edge development and unplanned development are some of the serious land use problems which should be given more attention in most of the countries in Asia as well as in Europe(Klinphan, S. (2009). Land suitability assessment can help planners to select appropriate areas for government activities, residential land use, and industrial land use and so on. By taking the results of land suitability assessment into development consideration, the planners and decision makers can plan the future land use planning properly and maximize benefits from the use of land resources. Along with the development of computer technologies, Geographic Information System (GIS) has been developed rapidly in the past twenty years. Since 1990s, GIS have been applied to land suitability assessment for managing spatial data and presenting visual results.

2.7. Overview Suitability Analysis

Suitability Analysis is the process and procedures used to establish the suitability of a system that is, the ability of a system to meet the needs of a stakeholder or other user. Before GIS (a computerized method that helps to determine suitability analysis) was widely used in the mid to late 20th century, city planners communicated their suitability analysis ideas by laying transparencies in increasing darkness over maps of the present conditions. This technique's descendant is used in a GIS application called multi criteria decision analysis (Malczewski, 2004) . In the 1960s, a mechanism called the ecological inventory process was developed to document existing surrounding land conditions to help inform the analysis for the land in question. These mechanisms were computerized upon the advent of computers due to inefficiencies in the methods, such as the inability to overlay a large number of transparencies (Ekanayaka & Weerakoon, 2019).In order to feed a growing population that is pushing on the ability to extensively farm, suitability analysis is becoming more necessary to utilize the most productive land to its fullest potential, matching the needs of the plants more carefully to the existing assets in the environment. This technique is known as precision farming (Krishnaveni & Anilkumar, 2020).Suitability analysis can also be used to track and label potential hazards, like earthquakes, contamination, or even crime. It can also be used to locate advantageous locations for commercial centres (Weerakoon, 2014).

2.8. Land Suitability Analysis

Land suitability analysis is one of the most useful applications of GIS for planning and management (Ekanayaka & Weerakoon, 2019). Land-use suitability analysis aims to identify the most appropriate spatial pattern for future land uses according to specified requirements, preferences or predictors of some activity (Collins et al., 2001). In order to determine the most desirable direction for future development, the suitability for various land uses should be carefully studied with the aim of directing growth to the most appropriate sites. Shalabi (2006) stated that, establishing appropriate suitability factors is the base for construction of suitability analysis.

2.9. Suitability Analysis Techniques

Initially, suitability analysis was developed as a method for planners to connect spatially independent factors within the environment and consequently to provide a more unitary view of their interactions. Further, (Abdula et al., 2015) Stated that, Suitability analysis techniques integrate three factors:

a. An area- location
b. Development activities
c. Environmental processes.

These techniques can make planners, landscape architects and local decision-makers to analyze factors interacting in various ways. Moreover, such suitability analysis enables elected officials and land managers to make decisions and establish policies in terms of the specific land uses.

2.9.1. GIS Based Site Suitability Analysis

GIS is an innovative integrated technology base on many disciplines such as Computer science, Geography, Cartography, Statistics, Remote sensing, Land surveying and Navigation. With a period of nearly 50 years of development, together with the popularization of the Internet, GIS has been widely immersed in the people's daily life like Global Positioning System (GPS) navigation. In the Land Management domain, GIS has been applied efficiently to deal with the geo-spatial data for screening and evaluation, facilitating the optimal site selection. A number of tools are available to determine the optimum site (Witlox, 2005) Traditional methods of GIS site selection are based on the transformation of effective layers into a classified map, such as using a Boolean model (Abdollahi et al., 2019)or Index Overlay operations (Nikolakaki, 2004); (Alesheikh et al., 2008); (Kallali et al., 2007).Nowadays, the GIS approaches used in the site selection usually are network analysis, spatial analysis, proximity analysis, with AHP. 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. The basic premise of GIS suitability analysis is that each aspect of the landscape has intrinsic characteristics that are to some degree either suitable or unsuitable for the activities being planned. Suitability is determined through systematic, multi-factor analysis of the different aspect of the terrain. Model inputs include a variety of physical, cultural, and economic factors. The results are often displayed on a map that is used to highlight areas from high to low suitability (Islam et al., 2021).

A GIS suitability model typically answers the question, "Where is the best location, whether it involves finding the best location for a new road or pipeline, a new housing development, or a retail store. For instance, a commercial developer building a new retail store may take into consideration distance to major highways and any competitors' stores, then combine the results with land_use, population density, and consumer spending data to decide on the best location for that store (Veronesi et al., 2017).Site selection or suitability analysis is a type of analysis used in GIS to determine the best place or site for something. Potential sites used in suitability analysis can include the location of a new hospital, store or school among many others. When performing site selection analysis users must set various criteria from which the GIS software can rate the best or ideal sites. Site selection analysis can be performed with vector or raster data but one of the most widely used types of site selection, weighted site selection, uses raster data (Richard et al., 2016).

2.9.2. Multi-Criteria Evaluation (MCE)

Multi-criteria Evaluation is primarily concerned with how to combine the information from several criteria to form a single index of evaluation. MCE techniques are numerical algorithms that define the suitability of a particular solution on the basis of the input criteria and a weight together with some mathematical or logical means of determining trade- offs when conflicts arise (Weerakoon, 2014)A spatial multi-criteria decision problem involves a set of geographically defined alternatives from which a choice of one or more alternatives is made with respect to a given set of evaluation criteria (Weerakoon, 2014). The data are processed using GIS and MCE techniques to obtain information for making the decision. The process of spatial multi-criteria evaluation combines and transformed geographical data (input) into a result decision (output).

The MCE procedures define a relationship between the input maps and output maps which involves evaluation of geographical events based on the criterion values and the decision maker's preferences with respect to a set of evaluation criterion. "The procedures involve the utilization of geographic data, decision maker's preferences and manipulation of the data and preferences according to spatial decision rules and they aggregate multi-dimensional geographical data and information into un-dimensional values of alternative decisions" (Meng et al., 2011).The common procedure of GIS-based MCE is to determine decision alternatives and decision criteria, establish the performance of alternatives in those criteria and aggregate the performance values to a single evaluation score for each alternative in order to create a preference ranking.

There are different stages of the spatial multi-criteria analysis involved and in both stages GIS and MCE methodologies are used. In the earlier stages GIS techniques played the major role, while in the later stages, MCE techniques are of major importance. Hence with this combination GIS provide the capabilities until analysis of the data to obtain information for making decisions (GIS has limited capability to analyze the value structure). The MCE techniques provide the tools for aggregating the geographical data and the decision maker's preferences into un dimensional value or utility of alternative decisions(Meng et al., 2011). Within this process determination of criterion weights are important and Analytic Hierarchy Process (AHP) is one of the best methodologies to be applied.

2.9.3. The Analytical Hierarchy Process

The Analytic Hierarchy Process (AHP) is a powerful and flexible decision making process which helps people to set priorities and make the best decision when both qualitative and quantitative aspects of decisions need to be considered. AHP was developed in 1970's by Thomas Saaty, as a decision-making theory. (Smith & Tighe, 2006)stated that the AHP is a decision making tool that incorporates both qualitative and quantitative factors. By reducing complex decisions to a series of one-on-one comparisons, then synthesizing the results, AHP not only helps decision makers to arrive at the best decision, but also provides a clear rationale that it is the best. The main framework of AHP is a hierarchical model. It comprises goal, criteria, perhaps sub-criteria and alternatives to each problem or decision. Pair wise comparison matrix is most important procedure of AHP.

The criterion pair-wise comparison matrix takes the pair wise comparisons as an input and produces the relative weights as output and the AHP provides a mathematical method of translating this matrix into a vector of relative weights for the criteria (Meng et al., 2011).A decision rule is a method of weighting or scoring criteria to assess their importance .It is the procedure by which criteria are combined to arrive at a particular evaluation and by which evaluations are compared and acted upon (Malczewski, 2004). In the pair wise comparison matrix, two elements are compared at a time using a scale that ranges from “extreme important” to “equally important”, and their inverses (down to 1:9). Based on the criterion weights derived from the pair-wise comparison matrix, scores for group attributes in the hierarchy are calculated as a weighted average of elements in the group.

2.10. Research and Knowledge Gaps

Recently, a number of research using geospatial technologies have been carried out all over the world on land use suitability analysis, settlement site selection, and locational appropriateness analysis for residential housing development. Some of them have been well-reviewed to help direct and mold this. On the other hand, Zereu Geremew and Seid, 2017 conducted a study entitled “GIS Based Multi-criteria Approaches to apartment Housing Site Suitability Assessment in Bishoftu city” The key flaws in these studies include the exclusion of some important criteria, such the distance from a military camp, the distance from a railway and a highway, the distance from industries with significant levels of noise and pollution, and the distance to a high-tension electric transmission line. Furthermore, because of environmental sensitivity, natural risks, and legislative restrictions against future development, they neglected to take into account limits that must be taken into account in suitability analysis in order to allow land to be used for its intended purposes. Last but not least, they did not assess the planned housing land use's eligibility to confirm its status. Analyzing urban land suitability for housing areas should be considered in a broad context, encompassing specific physical, environmental and economic factors of the study area. The reviews of the literature revealed that there are no set standards for determining the suitability of a condominium house development site. According to their goals, judgments, and theoretical knowledge as well as their local expertise, the researchers chose their own criteria for the investigation of condominium house development site suitability. A large number of the research, however, relied on a limited number of assessment criteria, making it more difficult to include enough evaluation criteria to adequately portray the breadth of human decision-making and reasoning.

The majority of earlier studies did not consider constraints when determining criteria for condominium housing site suitability. But constraints should have to be considered in suitability analysis as they are a restriction set up by legal framework. hence this study uses the multi-criteria methods integrated a larger amount of evaluation criteria (ten factors and constraints) than in previous studies to determine the suitability index of urban land for future condominium house development. Almost all of the previous studies did not validate the suitability index of their analysis by comparing with proposed land use plan of their study areas which would have prepared by authorized body for city's spatial development and regulation. From principles of land use suitability analysis, the final results of suitability analysis for land use should be validated. This research tried to fill this gap of knowledge by confirming the final suitability map with existing land use to validate its suitability. This is not experienced well before in suitability analysis of urban land uses for some particular.

CHAPTER III: MATERIALS AND METHODOLOGY

3.1. Description of the Study area

3.1.1. Historical Background

The late nineteenth and early twentieth century's were a period in which Ethiopia entered an important new phase of urban development due to the establishment of military forts and the introduction of motor vehicles (Akalou, 1973). In addition, the Ehtio-DjiBouti rail line was built, resulting in the formation of a number of towns along the route. Among them, Bishoftu is the one that was established in 1917 along with the railway and served as the main railway post.The development of Bishoftu continued as a railway station and military fort until it became a municipality entity in 1943 (BCA, 2011; OUPI, 2009). The city's foundation was the railway station.

The name Bishoftu is derived from the watery features of the area. It was also known by the name Debre-Zeit, which was given in 1955 by Emperor Haile Sellasie, and the name served until 1994. Then after, it started to be called by its previous name, Bishoftu. Following the administrative restructuring, Bishoftu was put under the Shewa governorate as a center of Adea district and its municipality services were extended. The new town reform of 2003, known as local government administration, was practiced all over the country's large city like Bishoftu. Bishoftu is the fourth largest urban center in Oromia Region in terms of population size, next to Adama, Jimma, and Shashemene (Adem, 2010).

3.1.2. Geographic location

Bishoftu city, which is located in the East Shewa zone, is 47 kilometers south of the capital city of the country, Addis Ababa, on the main road to Adama. Bishoftu is located at 8° 45′ N latitude and 38° 59′ E longitude. The city is topographically located in the tepid to cool sub-moist midland at an elevation of about 1920 meters above sea level, with moderate weather conditions. Bishoftu is truly a resort city, known for five crater lakes: Lake Bishoftu, Lake Hora, Lake Bishoftu-Guda, Lake Koriftu, and the seasonal Lake Chalaklaka.

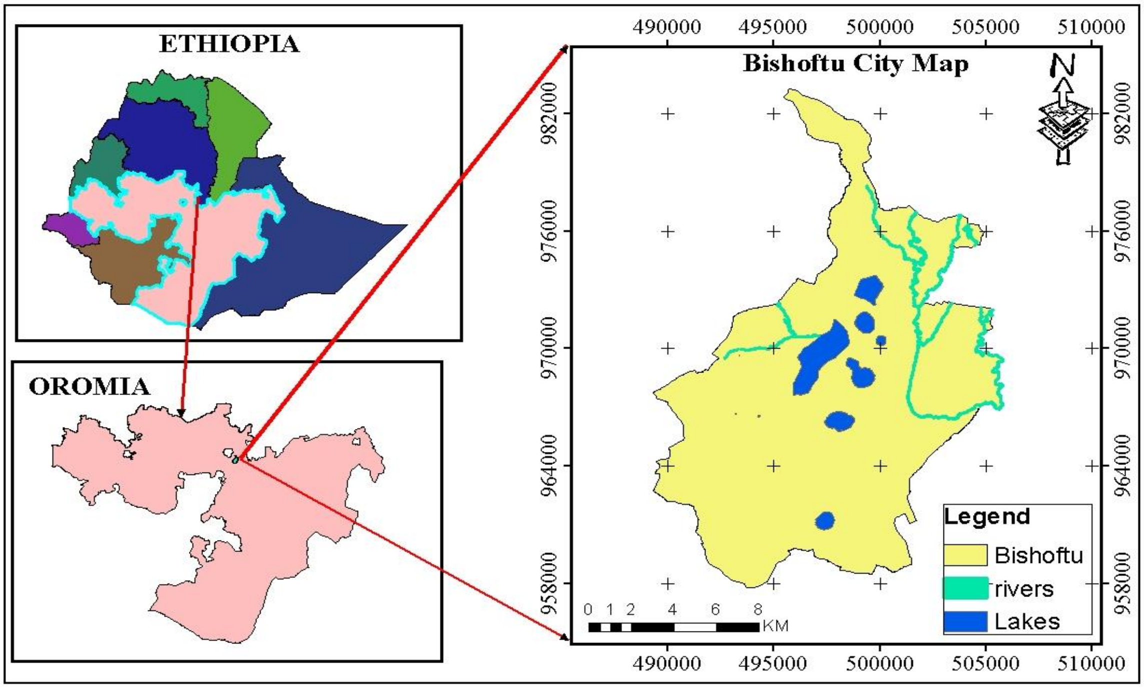


Figure 1: Location Map of the Study Area

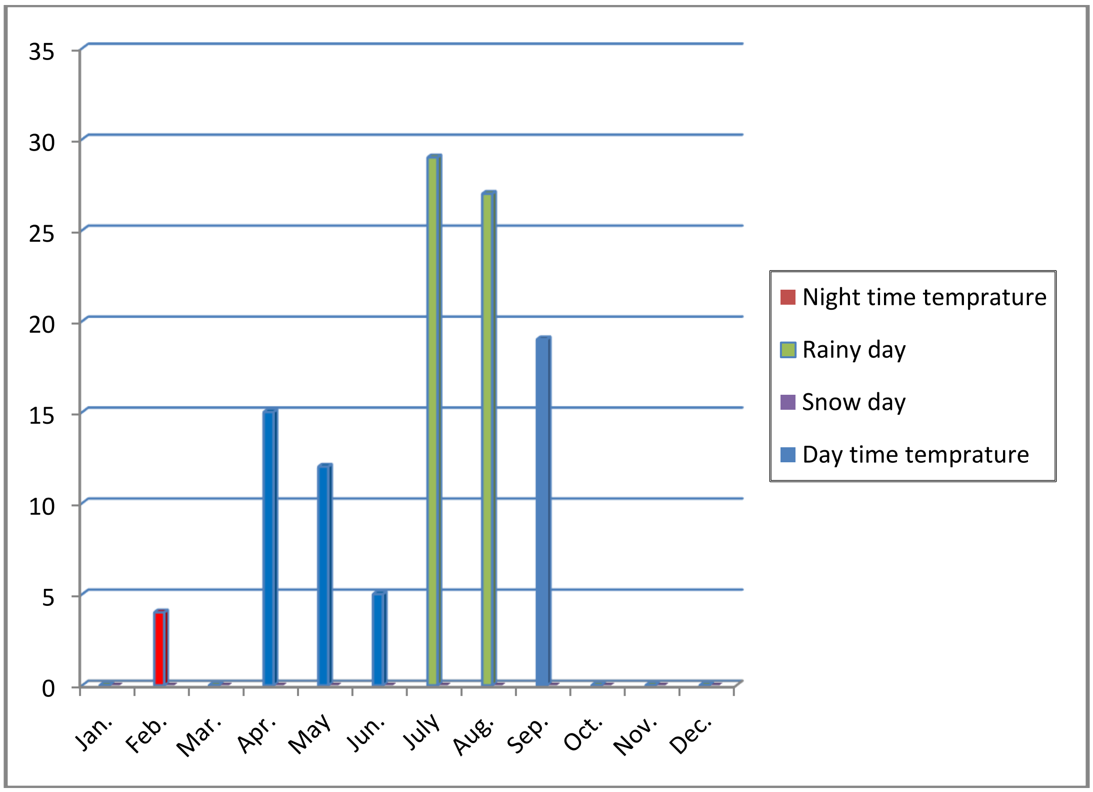
3.1.3. Climate

The city enjoys favorable climatic conditions due to its geographical locations surrounded by plateaus that experiences moderate temperature and rainfall which is favorable for life. Rainfall mostly occurs in the summer season. It receives abundant and heavy rainfall every year during this season. The table below reveals the trends of rainfall and temperature during the consecutive past five years. As can be observed from table 2 during the past five consecutive years the maximum average and minimum average annual temperature was 29.4 c℃ and 15.8 ℃ in the year 2015/16 and 2021/22 respectively. Similarly, the maximum annual total and minimum annual total rainfall was 934.8 mm and 736.5 mm in the year 2016/17 and 2020/21 correspondingly (Socio-economic profile of Bishoftu 2022).

Table 2: Rain fall and temperature data of Bishoftu (2015-2022 G.C)

	Jan	**Feb.**	**Ma.**	**Ap.**	**May**	**Jun**	**July**	**Aug.**	**Sep**	**Nov.**	**Oct.**	**Dec**
Day-time	27℃	28℃	29℃	27℃	27℃	28℃	22℃	22℃	23℃	26℃	27℃	26℃
Night-time	4℃	6℃	9℃	11℃	10℃	8℃	10℃	10℃	9℃	7℃	5℃	3℃
Rainy days	0	4	0	15	12	5	29	27	19	0	0	0
Snow days	0	0	0	0	0	0	0	0	0	0	0	0

Source:-hikerbay.com/climate/Ethiopia/Bishoftu



Source: developed from Rain fall and temperature data of Bishoftu (2015-2022 G.C)

Figure 2: Monthly Temperature and Precipitation of Bishoftu (2015-2022 E.C)

3.1.4. Population

According to the last three consecutive censuses conducted in the country, Bishoftu city showed a large increase in population. In the first Ethiopian population and housing census, which was held in May 1984, Bishoftu had a population of 37,568. The second population and housing census conducted in 1994 reported that Bishoftu had a total population of 52,650 of whom 26,250 were males and 26,400 were females. According to Bishoftu city administration office, the number of registered population of the city as of 2022 is 245,544 which was 100, 114 as of 2007 reported by the population and housing census of 2007. The city administrative area currently encompasses 9 urban Kebeles and 6 sub-urban Kebeles.

Table 3: Population of Bishoftu city from 1984 to 2022(CSA, 2021/22 projected)

Year	Population	Male	Female
1986	40,040	19,938	20,102
1994	52,650	26,250	26.400
2000	63,187	31,504	31,682
2008	79,113	39,458	39,654
2015	96,210	48,096	48,114
2022	245,544	125,673	119,871

3.1.5. Wind

This section discusses the wide-area hourly average wind vector (speed and direction) at 10 meters above the ground. The wind experienced at any given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages. The average hourly wind speed in Bishoftu experiences significant seasonal variation over the course of the year. The windier part of the year lasts for 7.7 months, from October 1 to May 25, with average wind speeds of more than 6.3 miles per hour. The windiest month of the year in Bishoftu is November, with an average hourly wind speed of 8.1 miles per hour. The calmer time of year lasts for 4.3 months, from May 25 to October 1. The calmest month of the year in Bishoftu is September, with an average hourly wind speed of 5.0 miles per hour.

3.1.6. Geology

The Bishoftu volcanic field, also known as Debre-Zeit, consists of an area of fissure-fed Holocene lava flows, cinder cones, tuff rings, and maars. Several of the maars are filled by lakes, which are popular recreational destinations from the nearby capital city of Addis Ababa. Most of the craters and cones are aligned NE-SW, parallel to the direction of the Ethiopian Rift Valley. The 750 x 1000m wide Haro Maja tuff ring and its neighbor, lake-filled Kilole, are offset to the east. The cones and maars of the Bishoftu volcanic field were erupted through rhyolitic welded tuffs.

3.2. Data Collection and Data Source

Trustworthy data is necessary to realize the designed objectives and hence the study is based on both primary and secondary data. In this study the primary and secondary Data sources included both spatial and non-spatial data from fieldwork and secondary data. The following table describes data required, data source, years of production, types of data used in the study, formats and where the data were gathered from.

Table 4: data type used for study

No.	**Data required**	**Data type**	**Data source**	**Purpose of data**	**Year (GC)**	**Format**	**Resolution**
1	Land use map	Secondary data	Extracted from Sentinel-2A image	For identifying existing LU	2022	Geo-Tiff	10M
2	Bishoftu Proposed Structural Plan	Secondary data	Bishoftu city Land Administration	for Roads and Rivers analysis	2016	Shape file (.shp)	-
3	ASTER Digital Elevation Model (DEM)	Secondary data	Geospatial information institute (GII)	For slope analysis	-	Raster(.tiff)	-
4	Administrative boundaries	Secondary data	Bishoftu city Land Administration	For masking boundary	2022	Shape file (.shp)	-
5	Demographic details (Pop.)	Secondary data	Central Statistical Authority (CSA)	For identifying need of house statics	2022	Csv	-
6	Health facility School	Primary data	GPS field survey	Proximity analysis	2022	(.shp)	-
7	Soil type	Secondary data	FAO	Site suitability analysis	-	Raster	-

3.3. Software Used

Various sorts of software were utilized to accomplish the study's goal. Software refers to programs that are used to gather, organize, analyze, interpret, and present data. The types of software utilized in the study, their versions, and their uses are listed in the table below.

Table 5: software used for study

No.	Software Name	Version	Purpose
1	Microsoft Word and Excel	2016	Integrating attribute data and compositing final thesis
2	ARCGIS SOFTWARE	10.8.1	For data analysis and site suitability mapping
3	IDRISI	32	Time series analysis, multi criteria and multi-objective decision support, compare and predict for the future
4	GOOGLE EARTH	Pro	Provides access to high resolution satellite imagery
5	ERDAS SOFTWARE	2014	Existing Land Use classification

3.4. Data preparation methods

The following stage was to prepare the data for further analysis after they had been collected from their different sources. Geo-referencing, clipping, digitization, image classification, and accuracy assessment are some of the data preparation techniques used in this study.

3.4.1. Geo-referencing

Assigning positions to geographic objects inside a geographic frame of reference is known as Geo-referencing. It is fundamental to geographic information systems (GIS) in particular and geospatial technology in general. The basic goal of Geo-referencing is to connect the internal coordinate system of a digital map, aerial shot, satellite image, and scanned map to a physical set of geographic coordinates. In order to connect each data layer to the physical world and make the spatial analysis easier, all the data utilized in this study were geo-referenced in Arc Map 10.8.1 using Ground Control Points (GCP) and the projected coordinate system used for the study area is Adindan_UTM_Zone_37N (Zurmotai, 2016).

3.4.2. Clipping

Clipping involves cutting specific elements from an image, a scanned map, a digital map, or any other GIS layer that are relevant to the area of interest. To clip features in the study area, overlay the boundary of the study area over the features that need to be clipped and run the GIS procedure(Qashqo, 2018). By using the Bishoftu city boundaries, the majority of the data that were acquired for this study were clipped in Arc Map 10.8.1. The DEM, soil map, road network, river network, and satellite image used in this study were all clipped as a result.

3.4.3. Digitization

The process of transforming analog data into digital data is known as digitization(S et al., 2018). The existing condominium site that was used in this study was digitally created in Arc Map 10.8.1 in shape files format. Like roads, rivers were also digitized from Google Earth in kml format and transformed to shape files in Arc Map 10.8.1 for use in this study.

3.4.4. Image Pre-Processing

After the data were collected, the study undergoes the processes of manipulating, sorting, and preprocessing collected data to analyze the existing LULC of the study area. The satellite image of 2022 was processed using Erdas Imagine 2014. The coordinate system, layer stacking and layer extraction took place. Then a Landsat image was corrected for the atmospheric, sensor and an illumination variance through radiometric calibration procedures.

3.4.5. Image classification

Different feature types on the earth’s surface have a different spectral reflectance property. Their recognition is carried out through the classification process. Image classification is defined as the extraction of differentiated classes or themes of land use and land cover categories, from raw remotely sensed digital satellite data(Kindu et al., 2013) .It is a technique to identify different features such as urban area, vegetation types and farm land from the satellite images. Satellite images were classified and analyzed using the basic photogrammetric elements (color, tone, texture, size, shape, structure, association, and shadow); the prior knowledge of the study area and field observation. The land use and land cover maps for 2022 were produced by supervised classification using the maximum likelihood classifier of ERDAS IMAGINE 2014 software. LULC classes were mapped from digital remotely sensed data through a supervised classification method (a training process) based on the field knowledge to perform the classification. In ERDAS IMAGINE software, drive signatures were then classified using the supervised classification type and the maximum-likelihood classification algorithm. Supervised classification is based on the quality and quantity of training samples to produce good quality classification results. Accordingly, the images were classified into five major land-use/land-cover classes, such as built up, shrubs and bushes, farm land, bare land, and water bodies.

3.4.6. Accuracy Assessment

The term accuracy is typically used to express the degree of correctness of a map or classification in thematic mapping from remotely sensed data. The increased usage of remote sensing data and techniques has made geospatial analysis faster and more powerful; however, the increased complexity also creates increased possibilities for errors (Turan et al., 2018a). Therefore, the assessment of the accuracy of mapping generated from remote sensing data is a critical and essential step in the classification process (Turan et al., 2018a). The error matrix is the most common tool in terms of determining the accuracy of the classification results (Fan et al., 2007). User accuracy, producer accuracy, overall accuracy and Kappa statistics were then derived from the error matrices for LULC classes. According to (Krishnaveni & Anilkumar, 2020),Kappa analysis is a discrete multivariate technique used in accuracy assessments. In other words, Kappa analysis is a standard component of accuracy assessment and is considered as a required component of most image analyses (Dagistanli et al., 2018).

3.5. Data Analysis Methods

In this section, we describe the main methods used for this project. After the data is collected from various sources, data integration and analysis GIS and MCDM techniques have been used in solving site selection problems in different areas. Therefore, combining GIS and MCDM is a powerful approach to land suitability assessment. Integration of these tools is needed so that each tool is used to address certain aspects of the problem. In this paper, Arc GIS 10.8.1 will be used to manage the spatial data and to perform the required spatial analysis operations, where GIS allows for the computation of the criteria and MCDM can be used to group them into a suitability index while taking into account the decision(s) made by the decision maker(s).The final results may differ for different individuals as it considers subjective judgments. Under this section, emphasis is given to the roles of the input datasets that are affecting the suitability values more. And then the performances of the existing sites with respect to these factors were evaluated.

3.5.1. Buffering

Buffering is a spatial analysis, also called proximity analysis. It is used to generate areas of a given distance around the specified criteria that have been used for condominium development site selection. In this study, buffer zones were created around roads, rivers, schools, and health care centers, military camp, and railway and highway line based on the specified distance for each parameter.

3.5.2. Rasterization

Rasterization can be defined as the process of converting information in vector format to raster format. As mentioned under the data preparation section, most of the data used in this study was digitized from secondary sources. Vector data (road, river, soil, existing built-up, school, and health care center) were converted to raster format in ArcMap 10.8.1 for further analysis.

3.5.3. Reclassification

It is the process of classifying something (a map) again and again. In this regard, the parameters considered in this study were slope, soil, river, existing built-up area, LULC, road, school and health care center, military camp, railway and highway and high poisoning industry. Finally, based on FAO (1976) classification, all those parameters were internally classified into five classes (Very highly suitable, highly suitable, moderately suitable, less suitable, and unsuitable) with values ranging from 5 to 1, where 5 denotes the very highly suitable and 1 denotes the unsuitable for all factors and constraints considered.

3.6. Site Selection Tools

Geographic information systems (GIS) based multi-criteria analysis (MCA) techniques have been used in solving site selection problems. The site selection process for condominium housing developments involves various environmental, technological, social, and economic aspects. GIS based MCA is a process that transforms and combines geographical data and value judgments (the decision maker's preferences) to obtain information for decision making (Malczewski, 2006). According to Abu Taha and Daim (2013), GIS based MCA provides a flexible tool that is able to handle and bring together a wide range of variables assessed in different ways and thus offers useful assistance to the decision maker in pointing at appropriate locations. In this thesis, MCA has incorporated ArcGIS as a method to select suitable locations for condominium housing development. Therefore, this study used the application of GIS-based multi-criteria suitability analysis using the analytical hierarchy process (AHP) to support the decision-making process on selecting an appropriate site for condominium housing development.

3.7. Methods of Multi-Criteria Analysis (MCA)

In this study, to select a suitable site for condominium housing development using GIS-based multi-criteria analysis, the following six main steps were used (Rikalovic et al., 2014).

1. Set the goal/ define the problem
2. Determine the criterion (factors/constraints)
3. Standardize the factors/criterion scores
4. Determine the weight of each factor
5. Aggregate the criteria
6. Validate/verify the result

1. Set the goal/ define the problem

In this study, the main aim of GIS based Multi-Criteria Analysis (MCA) was to produce a map showing suitable sites for condominium housing development in Bishoftu city.

2. Determine the criterion (factors/constraints)

There were no universally agreed criteria or factors for condominium housing development (Jabir and Arun, 2014). Different literature suggests a variety of factors that may influence condominium housing development. According to the researchers (Pantalone, 2010; Ahmed et al., 2011; Heshmat et al., 2013; Elahe et al., 2014; Yousef et al., 2014; Abebe and Megento, 2017; Li et al., 2020), air quality, climate, historic and cultural sites, distance from the park, distance from roads, LULC, soil type, slope, distance to noisy influence, distance from facility locations, and distance to the stream were often used for condominium housing site suitability assessments.

Based on the existing situation and availability of data for Bishoftu city, land suitability analysis for the selection of a suitable site for condominium housing development was carried out based on the following factors: distance from roads, LULC, soil type, slope, and distance from poisonous and noise influence, distance from facility locations, distance from military camp, distance from railway and highway, distance from high tension electric power, and distance from stream. Though air quality, climate, distance from the park, historic and cultural sites are the other factors influencing land suitability as well, they were not included in this analysis, because there is not much variety in the study area in terms of climate; and regarding air quality, Also, parks, historic and cultural sites are not found in the study area.

3. Standardize the factors/criterion scores

It's essential to standardize the data in GIS-based multi-criteria decision-making analysis, in order to integrate the data measured in different units and mapped in scale of measurement such as ordinal, interval, nominal and ratio scales (Pereira & Duckstein, 1993). Even though there are different methods that can be used to standardize criterion, linear scale transformation is the most frequently used technique (Malczewski, 2003). In this study for factors standardization, all the vector maps of the factors were converted to raster data formats. Then using the Spatial Analyst tool in ArcMap, the raster maps were reclassified. According to (FAO, 1981), land suitability classification, the datasets were reclassified from very highly suitable (5) to unsuitable (1); where 5, 4, 3, 2 and 1 represents the very highly suitable, high suitable, moderately suitable, less suitable and not suitable conditions for condominium housing development respectively. This method enables all measurements to have an equivalent value before any weights are applied.

4. Defining weights/ Determine the weight of each factor

Assigning criteria weights for each factor is an important component of GIS-Based multi-

criteria decision-making analysis. The purpose of weighing is to express the importance or preference of each factor relative to one another factor effect on condominium housing development. There are Several methods available to determine the weight like Analytical Hierarchy Process (AHP), rating and ranking(Kordi & Brandt, 2012). For this study the Analytical Hierarchy Process (AHP) method using pair-wise comparison matrices was adopted to assign weight for each factor.

3.8. Analytical Hierarchy Process (AHP)

AHP is first developed by Saaty (1980) who combines qualitative and quantitative analysis of complex problems of land management with the best alternatives (Kordi & Brandt, 2012).Analytical hierarchy process (AHP) methodology has been widely used for multi-criteria decision-making regarding land suitability analysis of different land uses. The AHP method determines the weight of importance of different factors influencing land suitability based on pair-wise comparisons of the factors considering their relative significance (Kordi & Brandt, 2012). Weighting is an important component of land suitability analysis as it affects the output and is complicated as the considered factors interact with each other.

In this study, to select a suitable site for condominium housing development the AHP was carried out in the following three steps:

A. Pair-wise comparison of criteria
B. Calculating criterion weights
C. Calculating consistency ratio (CR)

A. Pair-wise comparison of criteria

Pair-wise comparison of criteria was performed first and results were put into a comparison matrix. A Pair-wise comparison matrix was constructed, where each criterion was compared with the other criteria, relative to its importance, on a scale from 1 to 9 which is suggested by Saaty (1980) (Table 6).

Table 6: AHP Scale of Relative Importance

Intensity of relative importance	Definition	Explanation
1	Equal Importance	Two activities combine equally to the objective.
3	Moderate importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another.
7	Demonstrated importance	An Activity is strongly favored and its dominance is demonstrated in practice.
9	Extreme Importance	The evidence favoring one activity over another is of the highest possible order of affirmation.
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed.
1/3,1/5,1/7,1/9	Reciprocal values of the previous appreciation	

Source: Saaty (1985)

According to Saaty (1980), the values in the matrix need to be consistent, which means that if x is compared to y, it receives a score of 9 (extreme significance), y to x should score 1/9 (less significance) and something compared to itself gets the score of 1 (equal significance). In this study the pair wise comparison matrices were developed by taking into account the information provided by various literatures (M. T. Abebe & Megento, 2016; Turan et al., 2018).

B. calculating criterion weights

The weights of all factors are calculated by normalizing the eigenvector associated with the maximum eigen value of the (reciprocal) ratio matrix. Manually the computation of the criterion weights involves the following operations: (a) summing the values in each column of the pair-wise comparison matrix; (b) dividing each element in the matrix by its column total (the resulting matrix is referred to as the normalized pair-wise comparison matrix and (c) computing the average of the elements in each row of the normalized matrix that is, dividing the sum of normalized scores for each row by the number of criteria. In this study the computation of the criterion weights was calculated by using IDRISI Selva software.

C. Calculating consistency ratio (CR)

After the pair-wise comparison was filled and the weight of the factors was determined, a consistency ratio (CR) was calculated to identify inconsistencies and develop the best-fit weights in the complete pair-wise comparison matrix. Consistency ratio of 0.1 or less is acceptable to continue the AHP analysis (Saaty, 2008). But if a consistency ratio is greater than 0.1, then there are inconsistencies in the evaluation process and the AHP method may not yield a meaningful result (Saaty, 2008). A consistency ratio was calculated for the matrix to verify the degree of credibility of the relative weights, by using the following formula:

$$\mathrm{CR}=\frac{\mathrm{CI}}{\mathrm{RI}} \qquad \text{Equation (1)}$$

where CR=Consistency ratio, CI = referred to as consistency index, RI = is the random consistency index whose value depends on the number (n) of factors being compared; as illustrated in table 7 (Saaty, 1980). The consistency index (CI) was calculated by the following formula:

$$\mathrm{CI}=\frac{\lambda\mathrm{max}-\mathrm{n}}{\mathrm{n}-1} \qquad \text{Equation (2)}$$

Where λ max is the principal Eigen value; n is the number of factors. λmax = Σ of the products between each element of the priority vector and column totals.

Table 7: Random Consistency Index (RI)

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1980)

5. Aggregate the criteria

Step five was to aggregate the criteria using weighted linear combination (WLC) and apply it in the Arc GIS raster calculator.

3.9. Weighted overlay analysis

After the criteria maps and weights have been developed and established, a decision rule of multi-criteria analysis was used. There are three common decision rules in multi-criteria analysis namely weighted linear overlay, boolean overlay and ordered averaging (Jiang and Eastman, 2000; Malczewski, 2003). In this study the weighted linear combination (WLC) technique was applied to aggregate the standardized layers. In this technique, factors or parameters (Xi) are multiplied by weight of the parameters (Wi) to get composited weights and then summed. WLC technique is a straightforward linear method calculating composite weights. WLC multiplies and sums up the layers to produce suitability maps for condominium housing development site. This can be done by using the following formula to derive the intended map (i.e., condominium housing development site suitability map for Bishoftu City).

$$S = \sum^{n}_{i=1} (WiXi) \quad \text{..Equation (3)}$$

Where S = Suitability, Wi = relative importance or weight of factors / parameters i, Xi = parameters i, and n = total number of parameters related to the study.

6. Validate/verify the result

Validating or verifying the result was the final step and it helps to assess the reliability of the output and usually assessed by ground truth verification. According to Abebe and Megento (2017), sensitivity analysis was performed by changing the weight of criteria and field surveys were conducted for ground truth verification.

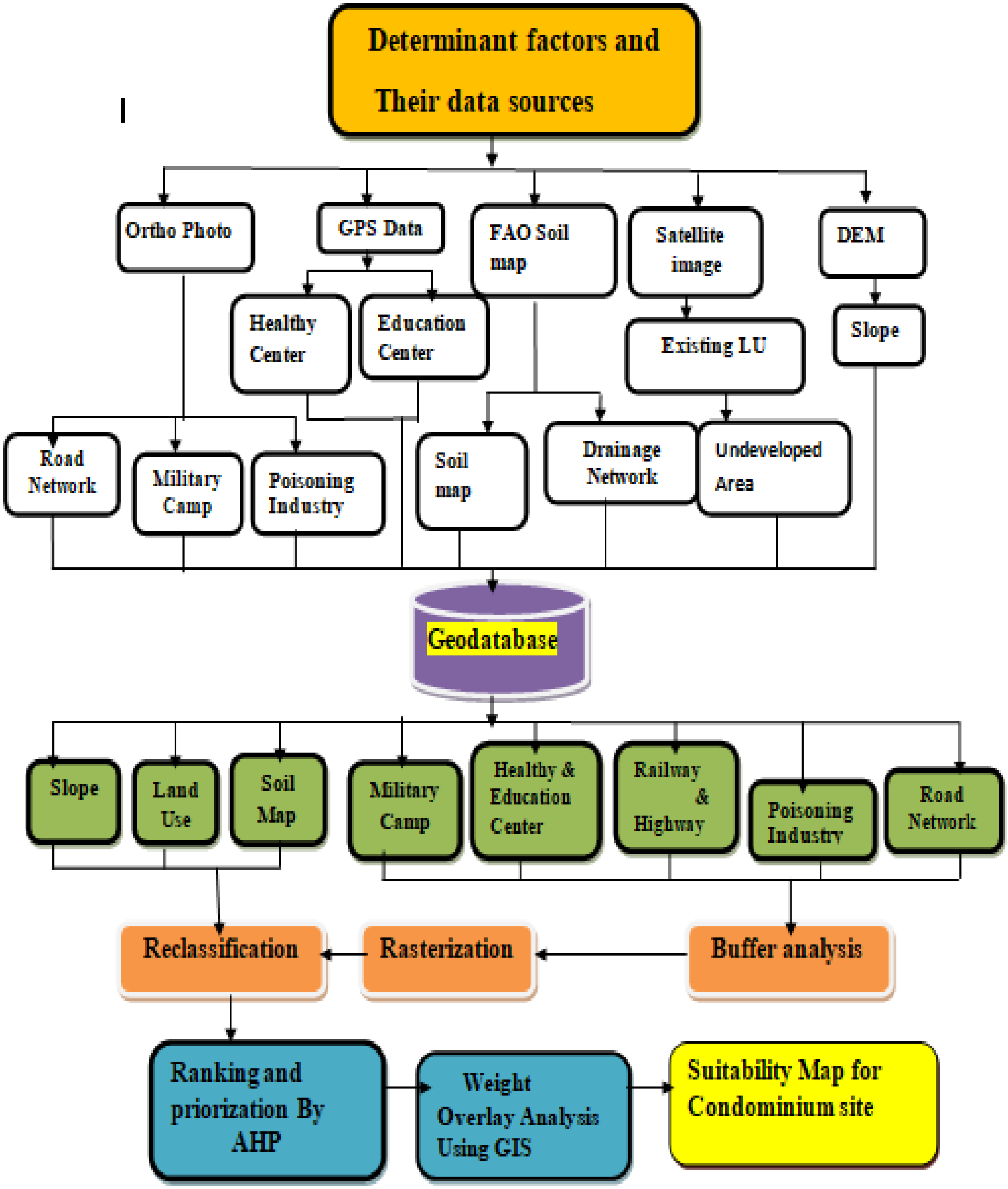


Figure 3: General work flow

CHAPTER FOUR: RESULTS AND DISCUSSIONS

In this study, suitable condominium housing construction sites were determined for Bishoftu city and surrounding area by using the GIS tool and weighting product of AHP method. A condominium housing development site should be kept close to urban center, road, school and health care center to get service of existing infrastructure. On other hand urban development site should kept far away as possible from river, restricted area such as military camp, railway, highway, high tension electric power and highest slope to reducing impact that may happen on socio-economic and health of city peoples. The GIS tool and weighting output of the AHP approach were used in this study to locate potential condominium housing construction sites for Bishoftu City and the neighboring areas. A condominium housing site should be located near a road, a school, and a medical facility in order to benefit from the existing infrastructure. As opposed to this, condominium housing development sites should be kept as far away as possible from rivers, restricted areas like military bases, railways, and highways, from high-tension electric power, and from the steepest slope in order to minimize any potential effects on the socioeconomic status and health of the local populace.

4.1. Selection and Preparation of Criteria Maps for locating condominium site

This chapter discusses different data sets that were used to determine suitable Condominium Housing development site. In this study, suitable site of condominium house development of Bishoftu city by using the GIS environment and weighting product of AHP method was discussed in detail. Significant criteria are commonly used in designing the framework of AHP to identify the best locations for Condominium Housing (Chakma, 2014); Kumar & Shaikh, 2013). However, selecting the criteria used may depend on other causes that are related to data availability. Most significant data that has been used in AHP studies to identify the appropriate sites for Condominium Housing are accessibility factors such as distance from main roads, highways, railways, school and health care center and physical factors such as slope and environmental criteria such as distance from rivers and water surface, soil categories, existing land cover (Chakma, 2014; Kumar & Shaikh, 2013).For this study based on the presence of influencing factors and availability of data, ten parameters were identified (distance from noisy and poisoning, proximity to main road, distance from river, distance from highways and railways, distance from Military camp or air force, land use land cover, proximity to school and health care center, slope, soil, and to determine the suitability of site for Condominium Housing in Bishoftu city and surrounding area. Those parameters were selected based on the relevant literatures, multi-criteria evaluation procedure, standards of Ethiopian Ministry of Urban Development and Construction, in addition to international practices.

After all necessary data were collected from their respective sources and prepared in GIS environment, buffer zones were created by using standard distance to (river, highways and railways, Military camp or air force ,major road, school and health center), next all parameters in vector format were converted to raster format in Arc Map 10.8.1 and reclassified in to five suitability classes (unsuitable, less suitable, , moderate suitable and highly suitable, very high suitable) based on their suitability order. Finally, Maps were created for each suitability criterion and the final composite map was produced by weighted overlaying of the individual parameters map. The map of each parameter and final composite were discussed below in detail.

4.1.1. Proximity to Major Road

Road is one of the criteria that should be considered in site suitability analysis for Condominium Housing development. It plays an important role in urban planning and development as it connects different settlements and also important for conveying goods and services. The road networks used in this study were digitized from the Google earth pro in kml format and converted to shape file in Arc Map 10.8.1. As more settlement develops near the road because of the transportation facilities and very easy access to the nearby places and city centers (mesfin Girma, 2019; Santosh et al., 2018),discussed in their study Buffer zone falling under 500m distances are highly suitable for Condominium Housing development. The suitability decreases as the area far away from the road and area > 2000m away from major road is considered as unsuitable for Condominium Housing development. Finally, the buffered zone was converted to raster and the map was reclassified in to five classes and scored based on their suitability order.

Table 8: Reclassified distance from major road and area coverage of suitability levels

s/no	Buffer(m)	Score	Suitability degree	Area(hectare)	Area covers in (%)
1	<500	5	Very high suitability	8858.34	43.04
2	500-1000	4	High suitability	4973.32	24.17
3	1000-1500	3	Moderate suitability	2431.74	11.82
4	1500-2000	2	Low suitability	1070.81	5.20
5	>2000	1	Unsuitability	3246.11	15.77

As shown in table 8 above out of 20578.9 hectare, 43.04% of the area is very highly suitable, 24.17% of the area is High suitability, 11.82% moderately suitable, 5.20% of the area is less suitable, 15.77% of the area is unsuitable for future condominium housing development (Figure 4).

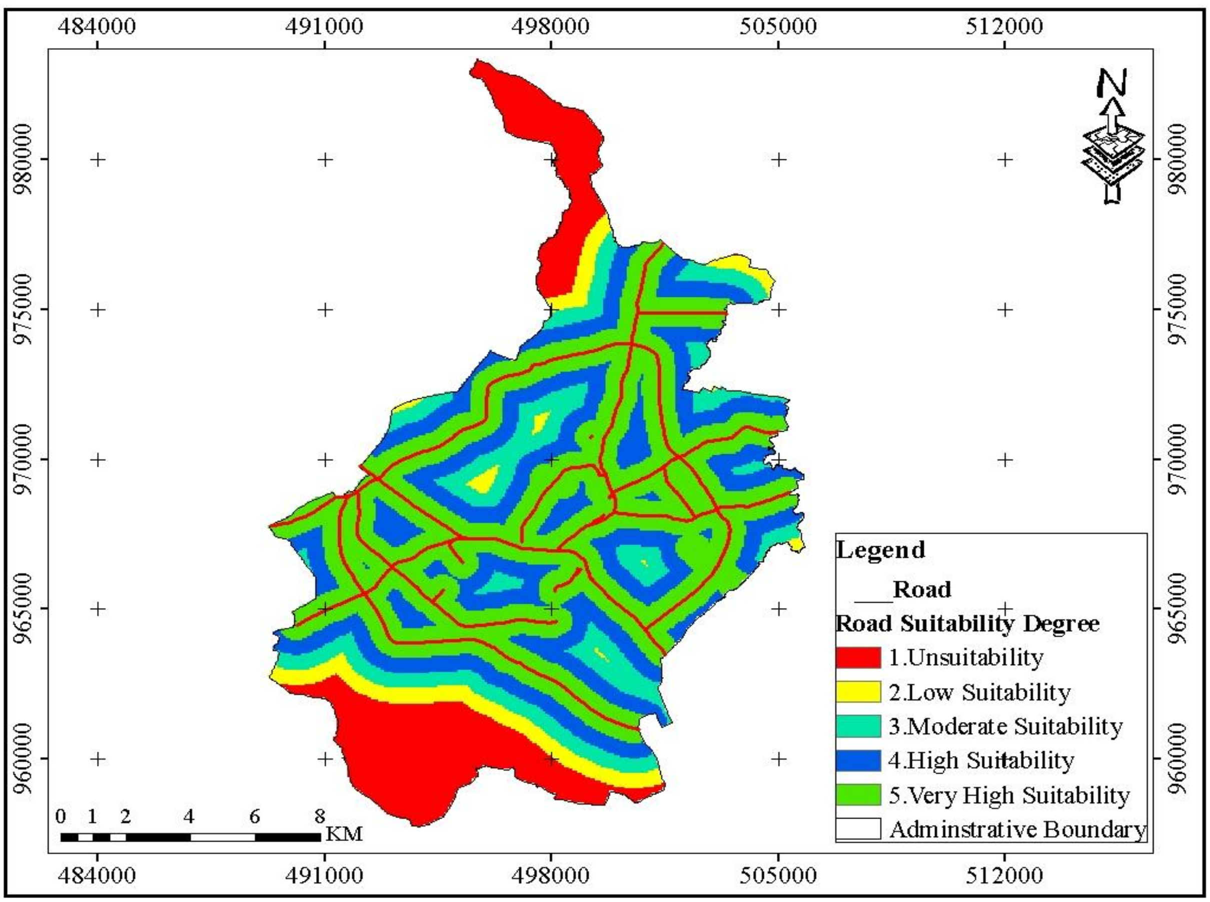


Figure 4: Road Suitability map

4.1.2. Distance from Rivers (streams)

The river (stream) network used in this study were clipped from propose land use. As kamal jain & Y. Venkata subbaiay (2007) and Ishaq & Hakan (2019), mention in their research the area near the river is vulnerable to flood. To avoid flood hazards and related problem caused by river and stream buffer zones were created using stream map of the study area and after the vector stream map were converted to raster, the map was reclassified in to five classes and scored based on their suitability order. Areas < 250m away from streams was considered as vulnerable to flood and ranked as unsuitable. The ranking score was increased with the increase of distances from river, where the highest score was given to the areas > 750m away from river.

Table 9: Reclassified distance from river and area coverage of suitability levels

s/no	Buffer(m)	Score	Suitability degree	Area(hectare)	Area (%)
1	<250	1	Unsuitability	3501.6994	17.02
2	250-500	2	Low suitability	2616.8644	12.71
3	500-750	3	Moderate suitability	2400.2905	11.66
4	750-1000	4	High suitability	1085.1167	5.27
5	>1000	5	Very high suitability	10975.0439	53.33

As shown in table 9 above out of 20578.9 hectare , 53.33 % of the area is very highly suitable, 5.27% of the area is High suitable , 11.66% moderately suitable, 12.71 of the area is less suitable, and 17.02% of the area is unsuitable for future condominium housing development. The ranking score was increased with the increase of distances from river, where the highest score was given to the areas > 750m away from river (Table9; Figure 5).

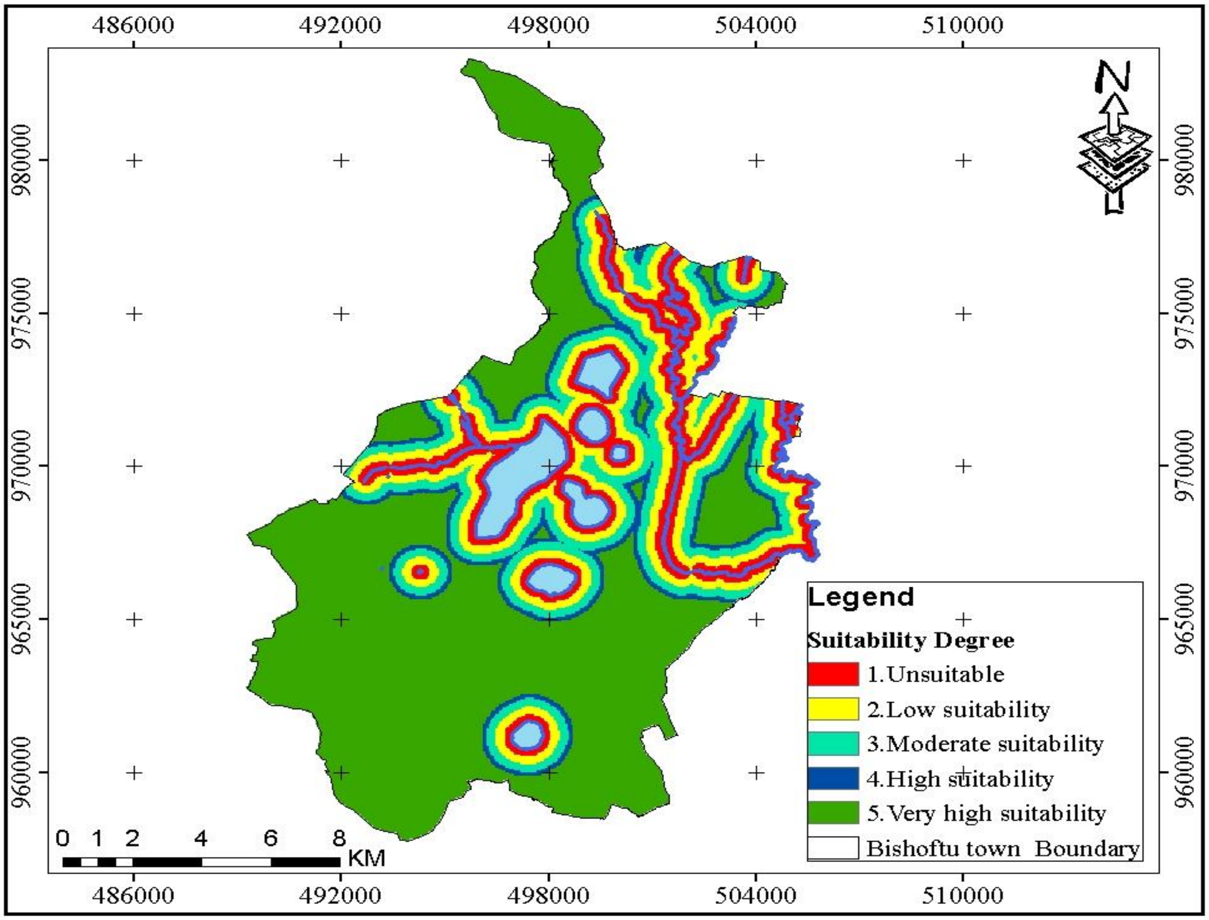


Figure 5: Reclassified distance from stream map

4.1.3. Suitability of Slope

Slope is one of the basic factors to be considered in site suitability analysis for condominium housing development. Urban areas should be located on relatively flat land because areas with steep and high slopes are prone to landslides (Culshaw and Price, 2011; Akbulut et al., 2018; Mesfin Girma, 2019). Due to issues such as flooding, erosion, runoff, and floor limits, as well as the cost of construction, steep slopes should be avoided. The slope of the study area was generated from DEM obtained from the Ethiopian Geospatial information institute with the help of Arc GIS 10.8.1. The slope of the study area ranges from 0-60.0856 degrees, and it was classified into five classes based on suitability ranges obtained from different literature and standards. Gentle slopes are highly suitable for condominium housing developments where steeper slopes are not suitable. According to Maher M. et al. (2016), the type of slope highly suitable for urban development should be a gentle slope.

Table 10: Reclassified slope and area coverage of suitability levels

s/no	Slope (%)	Score	Suitability degree	Area(hectare)	Area (%)
1	<4	5	Very high suitability	8772.33	43.16
2	4-7	4	High suitability	5050.23	24.84
3	7-10	3	Moderate suitability	1864.75	9.17
4	10-15	2	Low suitability	1346.15	6.62
5	>15	1	Unsuitability	3290.9	16.19

As shown in table 10 above, out of 20578.9 hectares, 43.16% of the area is very highly suitable, 24.84% of the area is highly suitable, 9.17% moderately suitable, 6.62% of the area is less suitable, and 16.19% of the area is unsuitable for future condominium housing development (Figure 6).

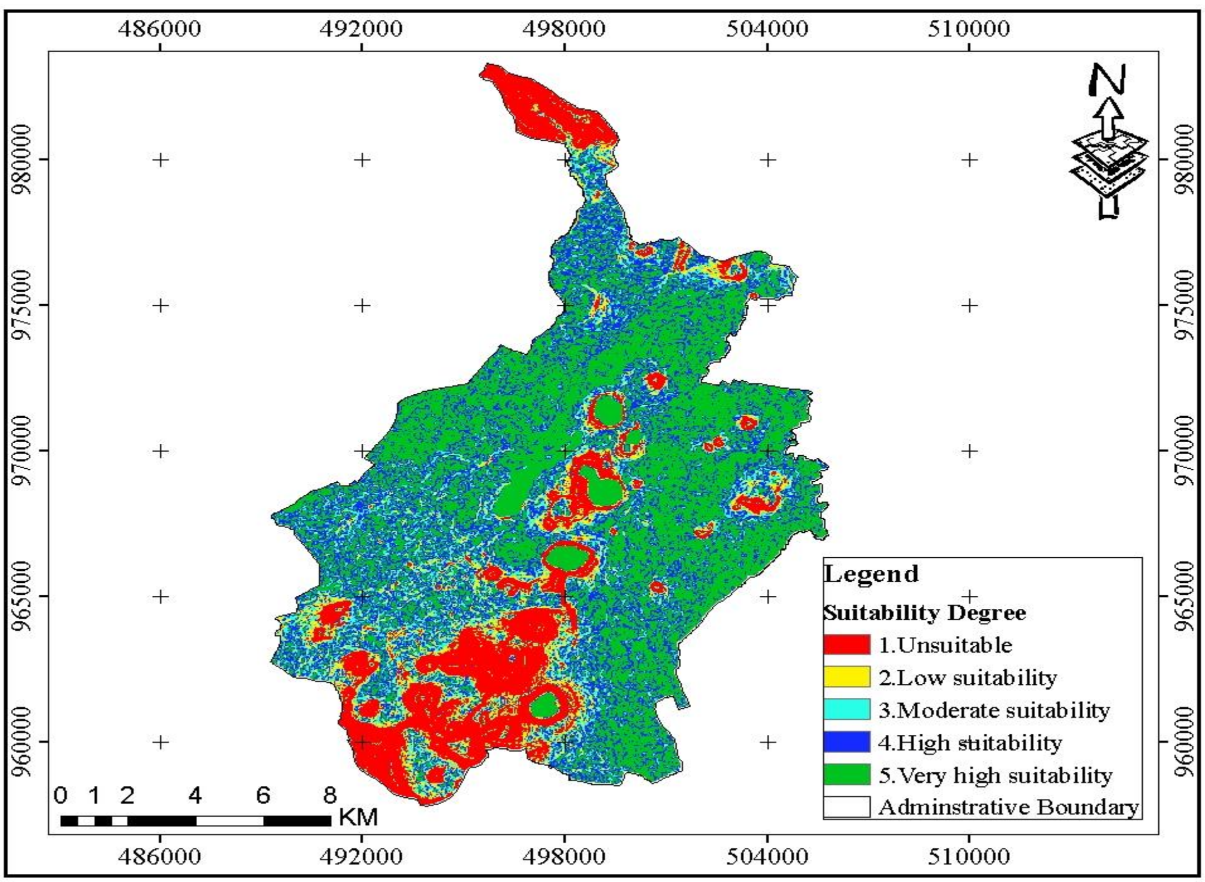


Figure 6: Reclassified slope map

4.1.4. Land-uses land-cover suitability

To accomplish this objective, LULC of the study area was first classified from sentinel-2A images of 2022. The images was interpreted or classified into five LULC classes, namely built up, shrub and bushes, farm land, bare land and water body. The LULC maps generated after running a maximum likelihood supervised classification in ERDAS IMAGINE software. Accuracy assessment in this study revealed the overall accuracies of 99.29%, with the Kappa statistics of 0.982 was calculated. A total of 1000 reference sample points were taken to assess the accuracy of all the classification results. Each reference sample was checked by an aerial photograph, visual interpretation, and Google Earth map. This indicates that all classifications are in acceptable range because an overall accuracy calculated was greater than 85% and kappa coefficient greater than 0.80 represents strong agreement (Landis and Koch, 1977) is an indicator for a strong accuracy.

Table 11: Error matrix of classification for 2022

				Reference Map				
	Classified Data	Bare-land	Water body	Shrubs and bushes	Built-up	Urban agriculture	**Row Total**	**User Accuracy (100%)**
Classified Map	Bare-land	9	0	0	0	0	**9**	**100**
	Water body	0	20	0	0	0	**20**	**100**
	Shrups and bushes	0	1	140	0	0	**141**	**99.3**
	Built up	0	0	2	496	2	**500**	**99.2**
	Urban agriculture	0	0	0	1	175	**176**	**99.4**
	Column Total	**9**	**21**	**142**	**497**	**177**		
	Producer Accuracy (100%)	**100**	**95.2**	**98.59**	**99.79**	**98.87**		
				Overall Accuracy = 99.29(%)				
				Kappa Statistics K ^= 0.982				

Therefore, According to national urban planning institute experiences, vacant (bare) lands are more preferable for future urban development, bare lands are ranked as very high suitable followed by shrub lands for condominium housing development whereas built-up lands are already developed; thus, it was ranked as unsuitable for condominium housing development.

Table 12: Reclassified LULC and area coverage of suitability levels

s/no	Category	Score	Suitability degree	Area(Hectare)	Area (%)
1	Built-up	1	Unsuitable	11978.01	58.21
2	Water body	0	Permanently Unsuitable	411.21	1.99
3	Urban agriculture	3	Moderate suitability	4512.42	21.92
4	Shrub land bushes	4	High suitability	3642.21	17.70
5	Bare land	5	Very high suitability	32.67	0.15

From 20578.9 hectare of total area of Bishoftu city, 58.21 % of total area was occupied by existing built-up and Unsuitable for future condominium housing site. As shown in table 12 Urban agriculture covers an area of 21.92%, shrub and bushes cover an area of about 17.70%, Water body area covers an area of about 1.99% and the bare land covers an area of about 0.15%(Figure 7).

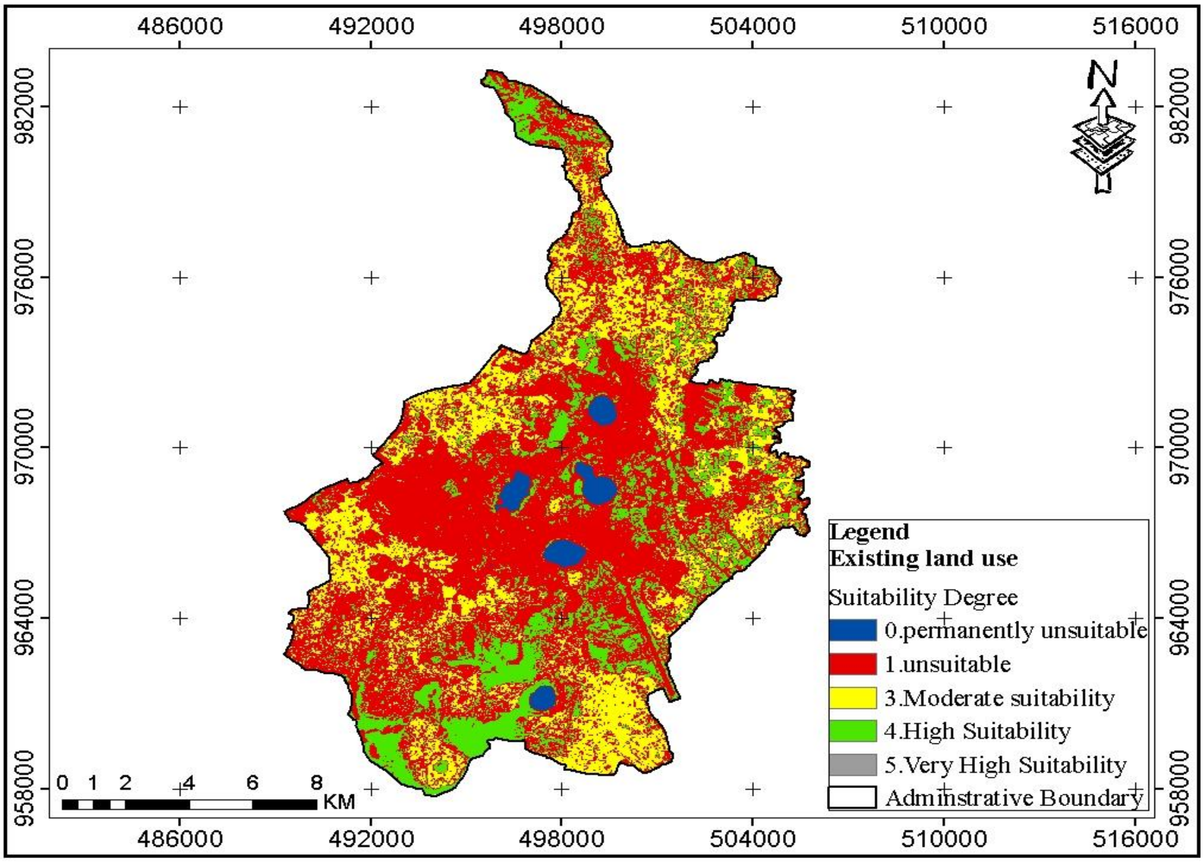


Figure 7: Existing LULC Suitability map

4.1.5. Suitability of Soil type

Soil is the most important parameter for determining an area's suitability for Condominium Housing construction. Soil types which have high fertility, nutrient deficiency and high-water holding capacity can be used for Condominium Housing construction areas (Puntsag et al., n.d.2014). The soil types of the study area were obtained from FAO data base. The soil types in the case study area are Eutric Nitosols and Pellic Vertisols. These soil types are classified according to their suitability for condominium housing construction site (table 13). Nitosols are deep, red, well-drained soil with a clay content of more than 30% and a blocky structure formed from fine-textured material weathered from intermediate to basic parent rock, kaolinite, halloysite and iron oxides dominate their clay mineralogy (Wikipedia). Nitisols are deep, stable soils with favorable physical properties. Thus, Nitosols soil is more suitable than Vertisols soil for urban construction.Vertisols are soils with a high content of clay minerals that shrink and swell as they change water content (plant and soil science eLibrary, lesson 5).

The clay minerals absorb water and increase in volume (swell) when wet, shrink as they dry and forming large, deep cracks (plant and soil science eLibrary, lesson 5). Surface materials fall into these cracks and are incorporated into the lower horizons when the soil becomes wet again. Thus, pellic Vertisols soil is less suitable when compared with Eutric Nitosols soil for urban construction.

Table 13: Reclassified soil and area coverage of suitability levels

s/no	Soil Type	Score	Suitability degree	Area(hectare)	Area (%)
1	Eutric Nitosols	4	High suitable	16131.22	78.44
2	Pellic Vertisols	2	Low suitable	4431.61	21.56

As shown in table 13 above out of 20578.9 hectare, 78.44% of the area is highly suitable and 21.56% of the area is less suitable for future condominium housing site (Figure 8).

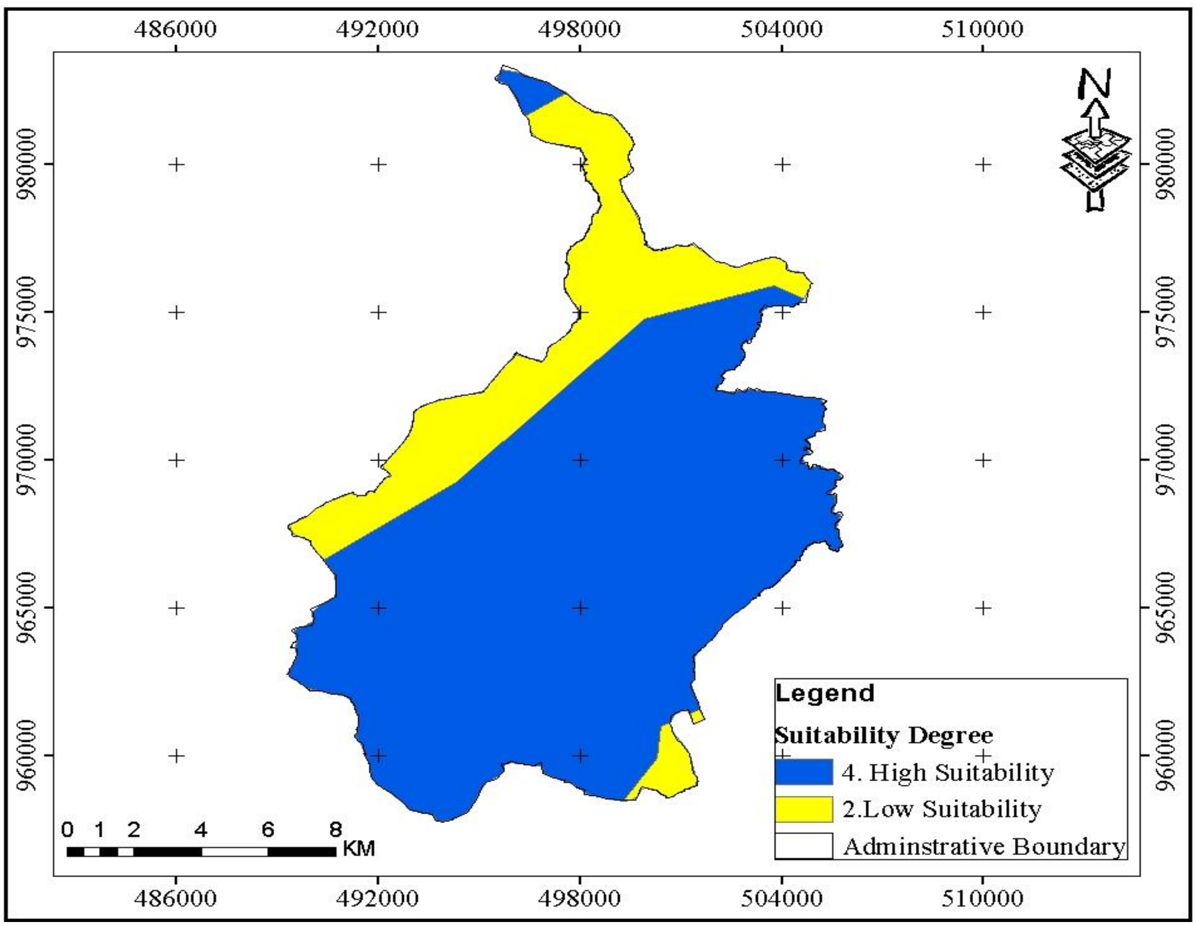


Figure 8: Reclassified Soil map

4.1.6. Proximity to education and health center

Undoubtedly, education and health are the basic requirements of each person; therefore, areas for future condominium housing should be reasonably close to existing educational institutions and health services (Chen, 2016). This goal is of great importance for urban development to save land required for those new projects and reduce the cost of constructing new schools and health care centers. To this end, maps of schools and health services were prepared from GPS data, and buffer zones were created in five classes. Areas with the closest distance to schools and health centers were considered highly suitable for urban development.

Table 14: Reclassified distance from School and health care center area coverage of suitability levels

s/no	Buffer(m)	Score	Suitability degree	Area(Hectare)	Area (%)
1	<250	5	Very high suitability	5406	26.27
2	250-500	4	High suitability	4538.75	22.05
3	500-750	3	Moderate suitability	3274	15.91
4	750-1000	2	Low suitability	2333.25	11.34
5	>1000	1	Unsuitability	5023	24.41

As shown in table 14 above out of 20578.9 hectare area coverage of Bishoftu, 26.27% of the area is very highly suitable, 22.05% of the area is High suitability, 15.91% moderately suitable, 11.34% of the area is less suitable and 24.41% of the area is unsuitable for future condominium housing site(Figure 9).

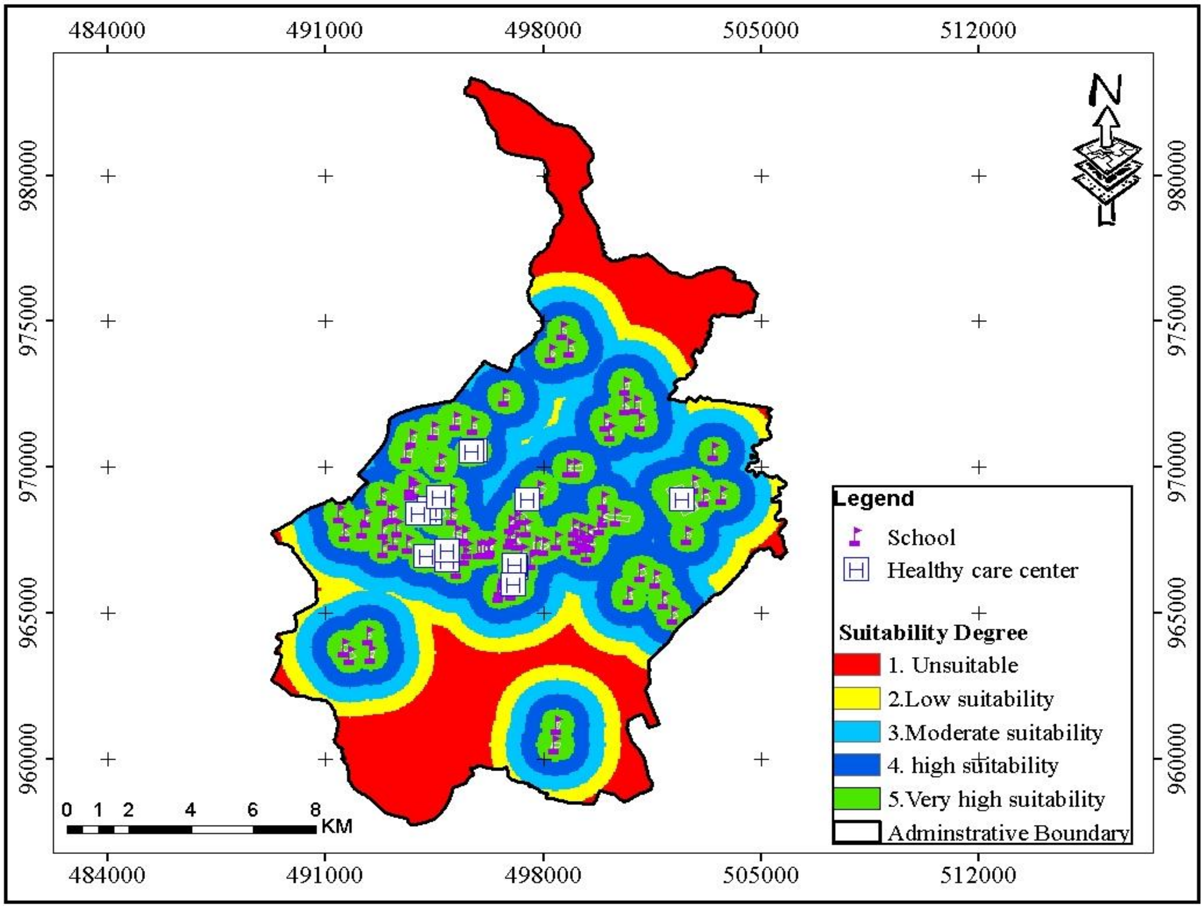


Figure 9: School and health care center Suitability map

4.1.7. Distance from High voltage electric stations

These are high voltage power station which harms near settlement as it emits electronic pollution to the environment that causes different diseases like cancers. To avoid these problems a buffer zone of 100 meters was created for existing high voltage stations to exclude from the analysis (Murseli & Isufi, 2014). Therefore, lands within the buffer zones are unsuitable for future condominium housing development, whereas, lands outside of the buffer zones are suitable.

Table 15: Reclassified High voltage electric stations and its area coverage

s/no	Buffer(m)	Score	Suitability degree	Area(Hectare)	Area (%)
1	<100	1	Unsuitability	243.50	1
2	100-200	2	Low suitability	300.56	1
3	200-300	3	Moderate suitability	413.38	2
4	300-400	4	High suitability	378.54	2
5	>400	5	Very high suitability	19242.63	94

As shown in table 15 above out of 20578.9 hectare area cover of Bishoftu, 94% of the area is very highly suitable, 2% of the area is High suitability, 2% moderately suitable, 1% of the area is unsuitable for future condominium housing site (Figure 10).

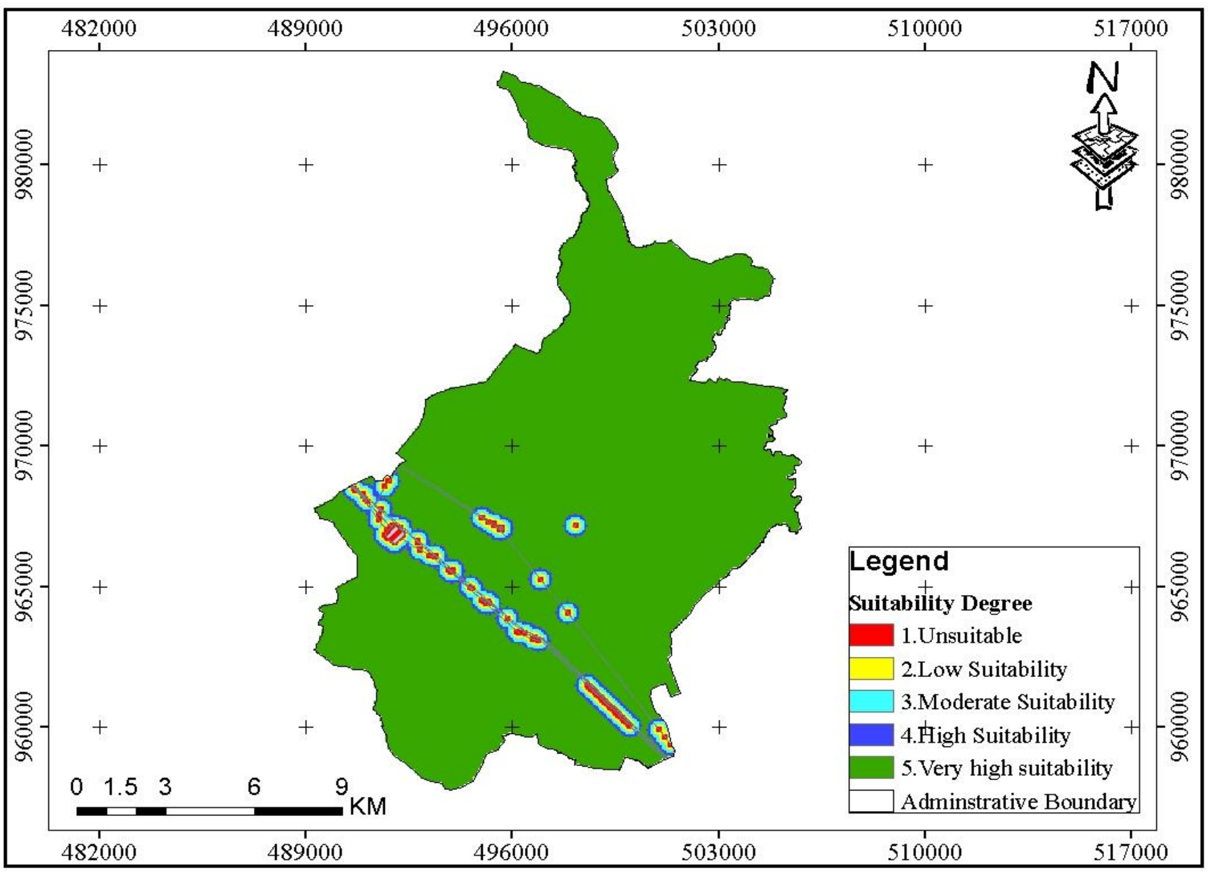


Figure 10: Reclassified Distance from High voltage electric stations map

4.1.8. Distance from Military camps and air force

Military camps locations were collected from the field using handheld GPS. Their plots were digitized from aerial photo of the study area. Buffer zones of 250-meter radius were created around each existing military camp to exclude the area from future residential use for the safety purpose. From the goal of safety, the location of the settlement must be far at least 500m from the military camps. (Al-Shalabi et al, 2006). Therefore, area within 250 meter buffer zones of military camps is unsuitable for condominium development.

Table 16: Reclassified Distance from Military camp and air force and area coverage of suitability levels

s/no	Buffer(m)	Score	Suitability degree	Area(Hectare)	Area (%)
1	<250	1	Unsuitable	1232.74	5.99
2	250-500	2	Low suitability	478.73	2.32
3	500-750	3	Moderate suitability	539.38	2.62
4	750-1000	4	High suitability	597.49	2.90
5	>1000	5	Very high suitability	17725.56	86.16

As shown in table 16 above out of 20578.9 hectare area cover of Bishoftu, 86.16% of the area is very highly suitable, 2.90% of the area is High suitability, 2.62% moderately suitable, 2.32% of the area is less suitable and 5.99% of the area is unsuitable for future condominium housing site(Figure 11).

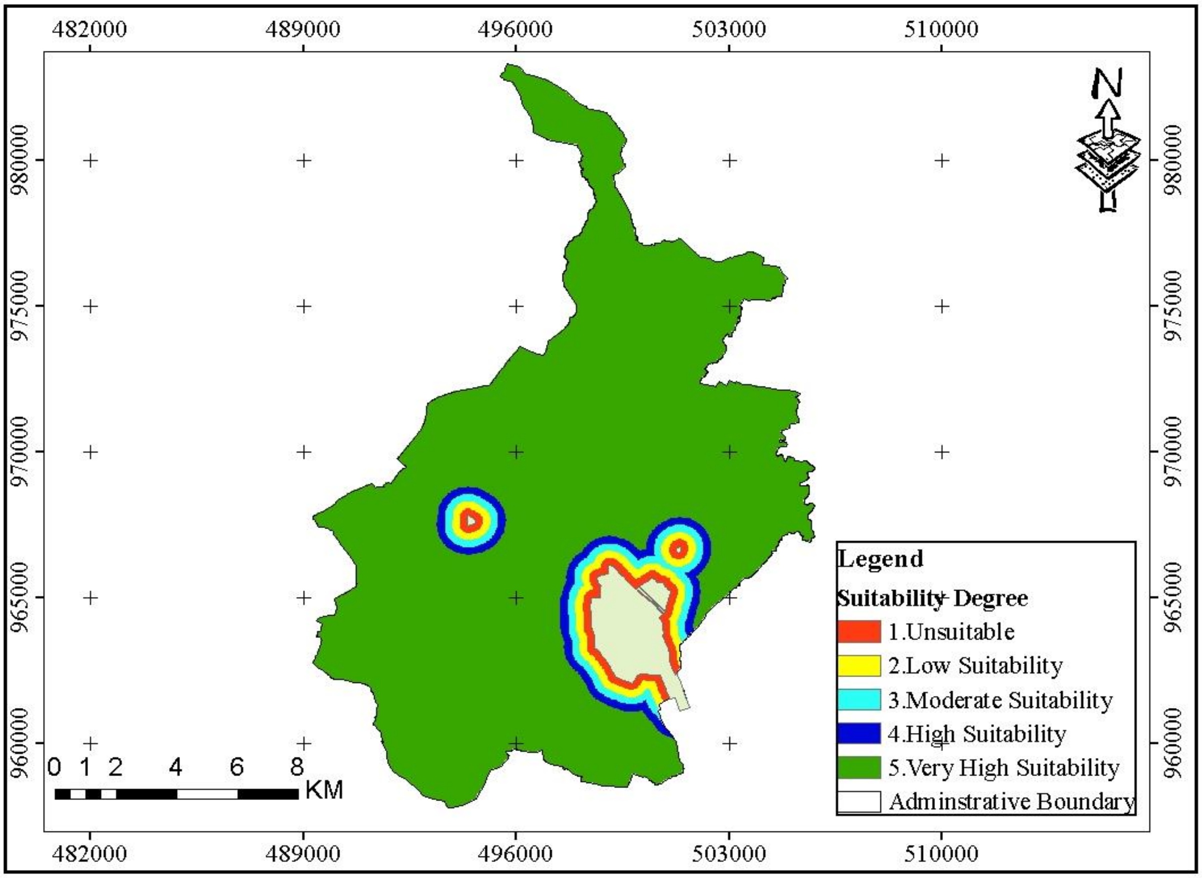


Figure 11: Reclassified Distance from Military camp and air force Map

4.1.9. Distance from Industrial areas

To minimize the adverse impact of heavy industries due to their noise disturbance and environmental contamination and create safer and attractive health conditions, the location of condominium houses is separated from the existing heavy industrial areas by creating buffer zones of restriction. (Rahim et al., 2014) suggested that residential area should be at least 500 meters far away from heavy industry. In this study, the locations of existing heavy industries like warehouses, textile factory, manufacturing plants were identified and a buffer distance of 500 meters was created to exclude from the analysis.

Table 17: Reclassified Distance from Industrial areas, area coverage of suitability levels

s/no	Buffer(m)	Score	Suitability degree	Area(Hectare)	Area (%)
1	<250	1	Unsuitability	2461.90	11.97
2	250-500	2	Low suitability	1519.37	7.38
3	500-750	3	Moderate suitability	1269.01	6.18
4	750-1000	4	High suitability	1151.29	5.59
5	>1000	5	Very high suitability	14173.00	68.89

As shown in table 17 above out of 20578.9 hectare area cover of Bishoftu, 68.89% of the area is very highly suitable, 5.59% of the area is High suitability, 6.18% moderately suitable, 7.38% of the area is less suitable and 11.97% of the area is unsuitable for future condominium housing site(Figure 12).

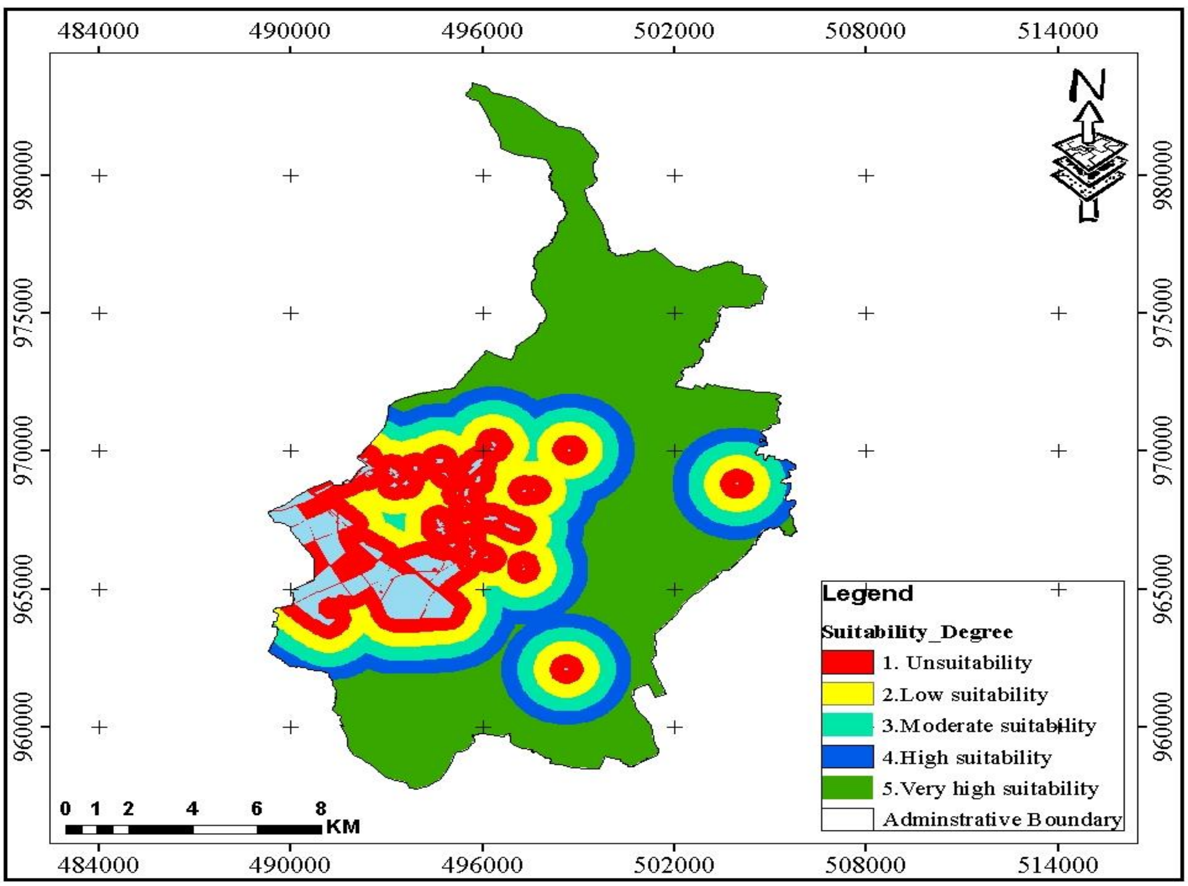


Figure 12: Reclassified Distance from poisoning industry Map

4.1.10. Distance from Highway and Railway station

Railway and highway plot was extracted from structural plan of the city. Residential areas should not be located near the railway to minimize noise disturbance and the safety of the residents (MoUDC, 2012). Hence, a buffer distance of 250 was created and protected to be free of condominium development (Murseli & Isufi, 2014). So, areas within the buffer zones are unsuitable while areas outside of the buffer zones are suitable for future condominium housing development.

Table 18: Reclassified Distance from Highway and Railway and area coverage of suitability levels

s/no	Buffer(m)	Score	Suitability degree	Area(Hectare)	Area (%)
1	<250	1	Unsuitability	1395.33	6.78
2	250-500	2	Low suitability	1045.98	5.08
3	500-750	3	Moderate suitability	787.13	3.82
4	750-1000	4	High suitability	729.95	3.55
5	>1000	5	Very high suitability	16616.18	80.76

As shown in table 18 above out of 20578.9 hectare area cover of Bishoftu, 80.76% of the area is very highly suitable, 3.55% of the area is High suitability, 3.82% moderately suitable, 5.08% of the area is less suitable, and 6.78% of the area is unsuitable for future condominium housing site(Figure13).

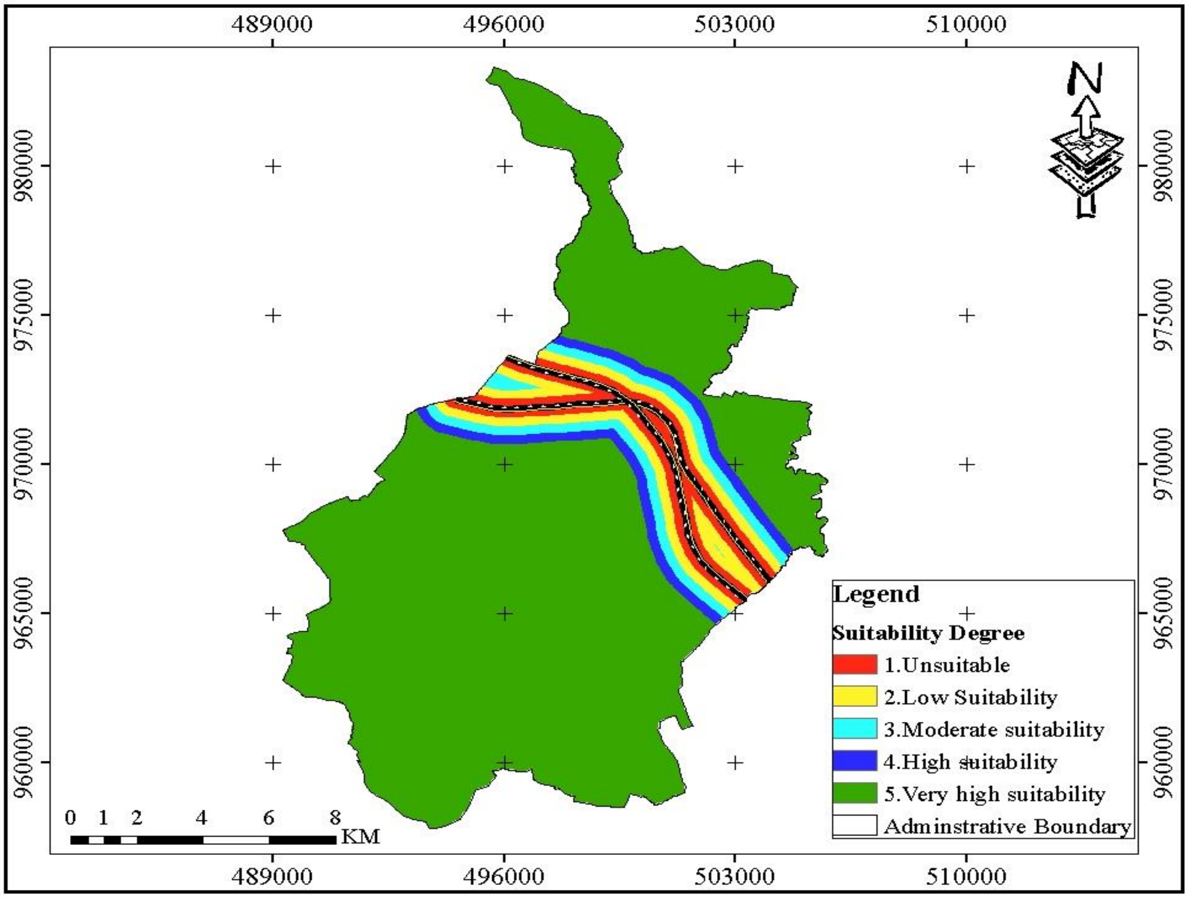


Figure 13: Reclassified Distance from Highway and Railway Map

4.2. The suitability level of the existing chelekleka condominium site in Bishoftu

As a result of field survey and observation done in Bishoftu city and surrounding areas, there are previously constructed condominium houses in unsuitable areas by some parameters, and other related problems are seen at these sites of condominium housing. For instance, suitability analysis was done for chelekleka condominium site as shown in (Figure 14 and 15) based on the major criteria identified and mapped.Accordingly, chelekleka condominium site is one of the areas located on restricted buffer zone based on the following four major classified criteria. Based on this analysis chelekleka condominium site which circled on the map shown in (figure 14) is located at low suitable buffer zone from noisy industry, water body, health center and on steep slope. This suggests that the site appropriateness investigation in Bishoftu city was not completed adequately with enough criteria for the development of condominium homes. Therefore, it was crucial to conduct additional research to find the optimal location for future condominium house development.

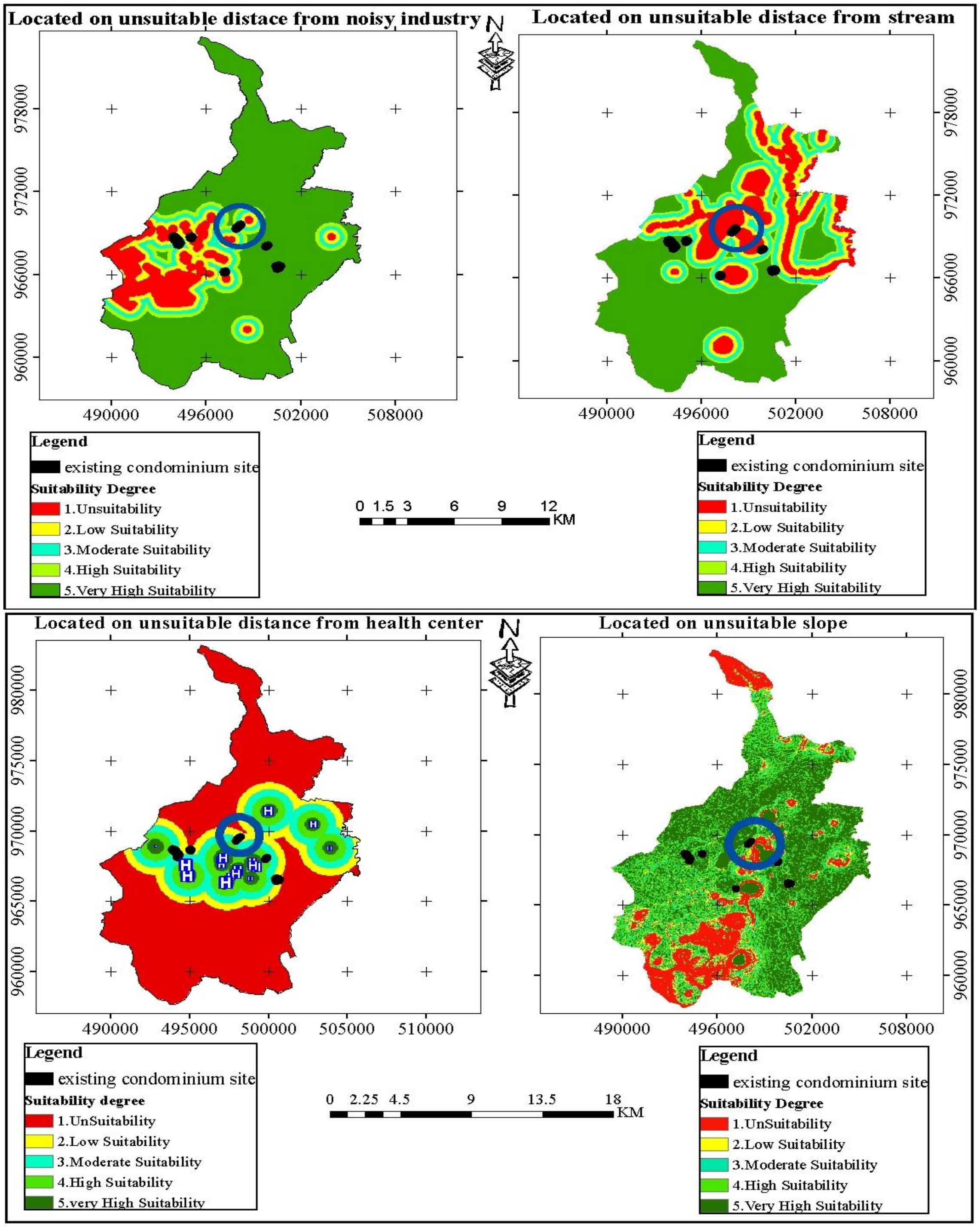


Figure 14: Suitability level of existing Chelekleka condominium site criteria map

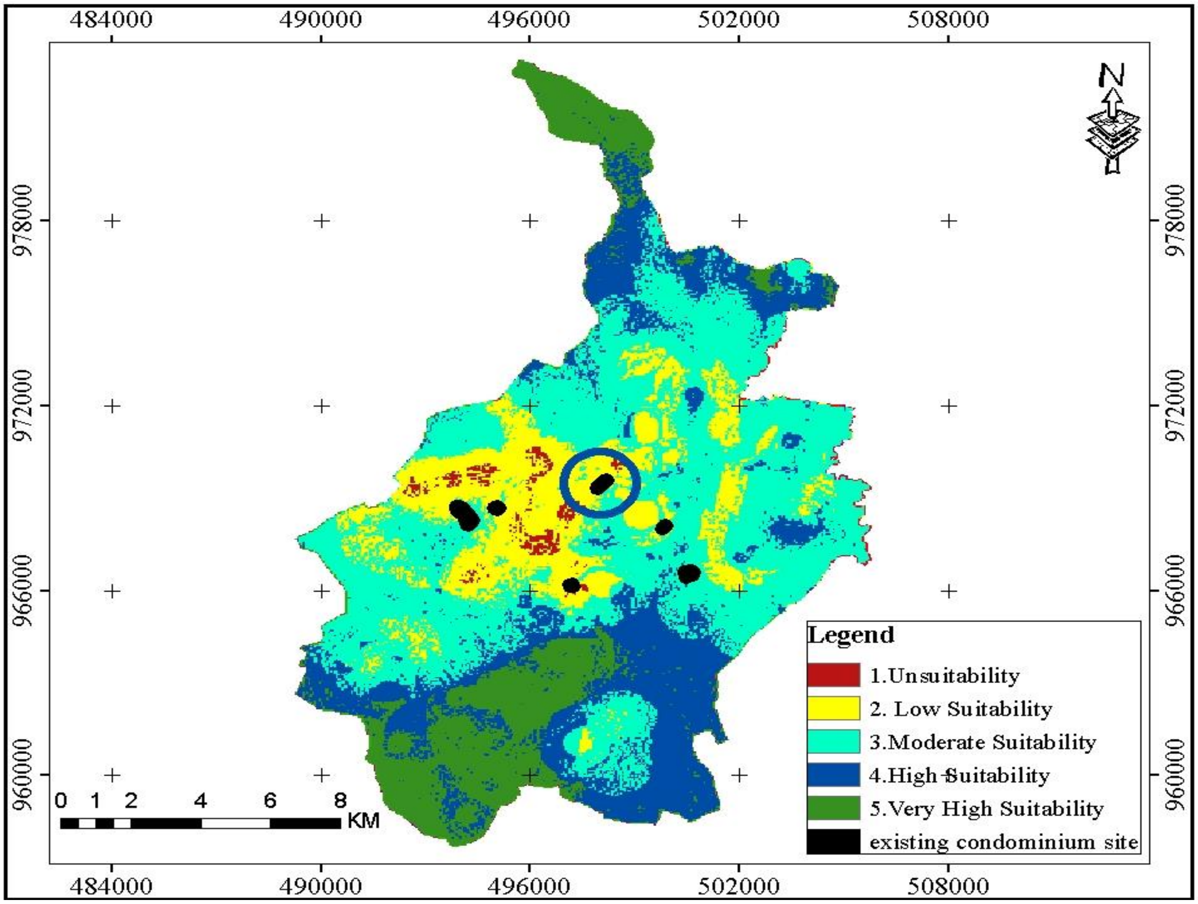


Figure 15: final suitability map of existing Chelekleka condominium site

4.3. Applying (AHP) based multi-criteria analysis (MCA) techniques to determine the best location for future condominium house site.

In order to find suitable site in Bishoftu city for future condominium house development, using (AHP) based multi criteria analysis (MCA) methods is very important. Analytic Hierarchy Process is a decision-making method for prioritizing alternatives when multiple criteria must be considered. It offers a methodology to rank alternative courses of actions based on the decision maker's judgments concerning the importance of the criteria and the extent to which they are met by each of the alternatives (Nydick and Hill, 1992). AHP is a powerful and flexible decision-making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. AHP was used in this study to derive weights for each parameter.

4.3.1 Calculating the Weights of parameters

A weight can be defined as a value assigned to an evaluation criterion which indicates its importance relative to other criteria under consideration (Sener et al., 2005). One of the components of GIS-Based Multi Criteria Decision Analysis (MCDA) methodology is assigning criteria weights for each factor maps. Assigning weights of importance to evaluation criteria accounts for the changes in the range of variation for each evaluation criterion and the different degrees of importance being attached to these ranges of variation (Sarath et al., 2018). A number of parameter-weighting procedures based on the judgments of decision makers have been proposed in the multi-criteria decision literature. Accordingly, one of the most promising is pair-wise comparison developed in context of a decision-making process is known as the AHP.

AHP is a decision-making technique utilized for solving complex problems, with many parameters of interrelated objectives or concerned criteria. The importance level of each parameter is not equal; some parameters are dominant over others. Different weights can generate difference in the level of suitability (Andi et al., 2017). In Ranking Method, every criterion under consideration is ranked as per decision maker's preference. To generate criterion values for each evaluation unit, each parameter was weighted according to the estimated significance for determining urban development site. The factors and their resulting weights were used as input for the MCDA module for weighted linear combination of overlay analysis. The larger the weight indicates the more important is the parameter in the overall utility of site and small weight indicates the less important is the parameter in the overall utility of site. The ranking of parameter is related to their relative importance as listed in Table 19 of Scale for pair wise comparison below. The relative importance ranges from 1 to 9; 1 means an equal contribution of the pair wise parameter and 9 means extreme important parameter (Saaty, 2008).

Table 19: Scale for pair wise comparison of Parameters (Saaty,1980)

Intensity of importance	Definition
1	Equal importance
2	Equal to moderately importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

The weight of each parameter was derived by taking the principal eigenvector of a square reciprocal matrix of pair-wise comparisons of the relative importance of factors to the suitability using IDRISI selva 17. These pair wise comparison was then analyzed to produce of weights that sum to 1 and the total weight should be added up to 100% in order for the output map to be meaningful and consistent (Saaty, 2008; as cited by Lamessa kenate, 2017 and Getahun Kafe, 2020). The AHP weight derivation interface to derive the weights for each parameter, with its consistency ratio, for urban development site selection was shown by figure 16 below.

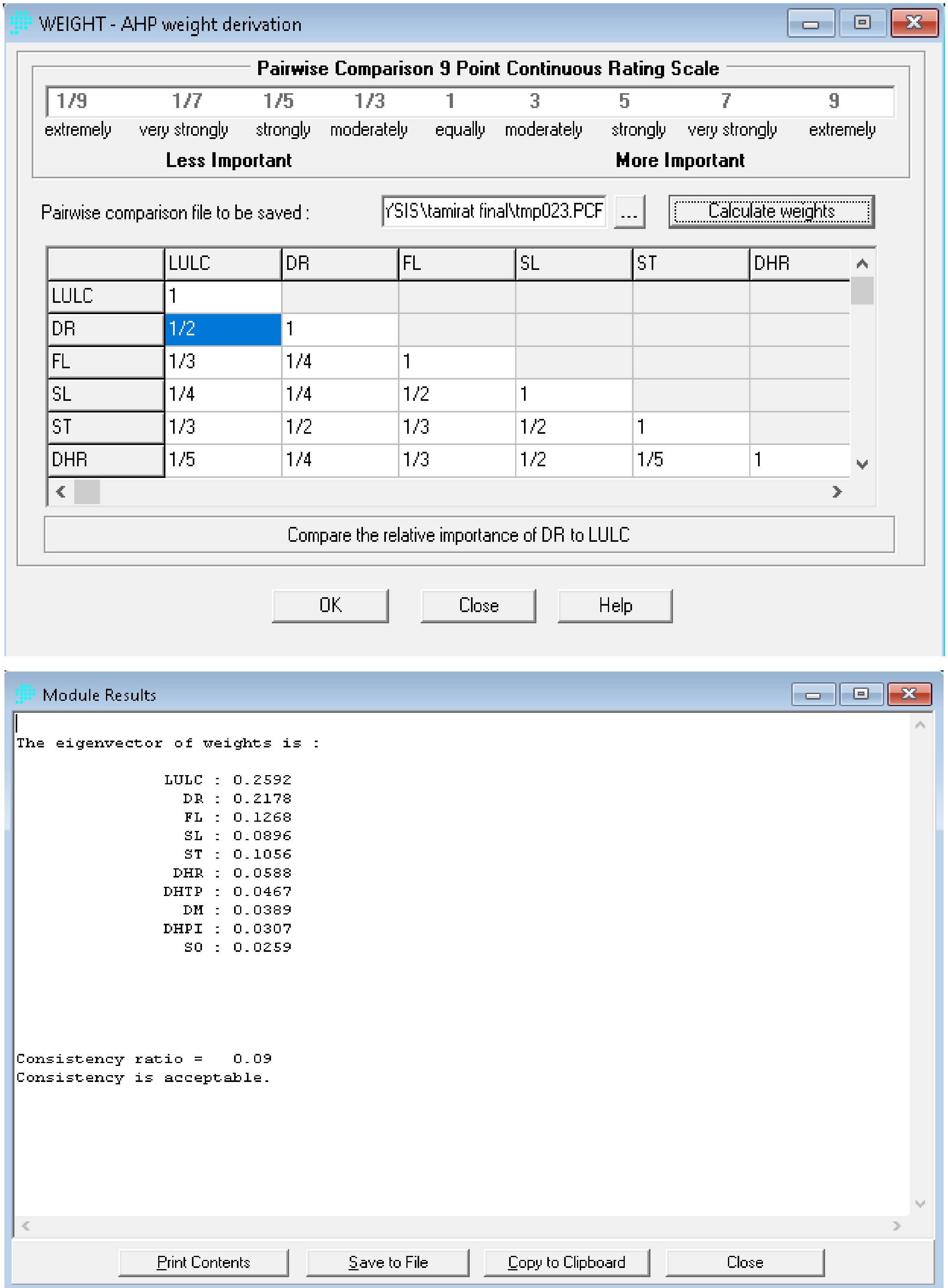


Figure 16: Pair wise comparison matrix

Table 20: Pair wise comparison matrix

Criteria	LULC	DR	FL	SL	ST	DHR	DHTP	DM	DHPI	SO	Weight (%)
LULC	1										**26**
DR	1/2	1									**22**
FL	1/3	1/4	1								**13**
SL	1/4	1/4	1/2	1							**9**
ST	1/3	1/2	1/3	1/2	1						**11**
DHR	1/5	1/4	1/3	1/2	1/5	1					**6**
DHTP	1/5	1/4	1/4	1/3	1/3	1/2	1				**5**
DM	1/5	1/5	1/3	1/3	1/5	1/3	1/2	1			**3**
DHPI	1/8	1/7	1/4	1/3	1/2	1/4	1/2	1/2	1		**3**
SO	1/7	1/7	1/2	1/2	1/4	1/2	1/4	1/4	1/3	1	**2**

Note: LULC = Land use/ land cover, DR = Distance from road, FL = Facility locations SL = Slope, ST = Stream, DHR = Distance from highway and railway, DHTP=Distance from high tension electric power, DM=Distance from Military camp and airport, DHPI = distance from high Noise Influence and poising industry, SO = Soil type

The above AHP result shows that the derived factors have a different degree of influence on condominium house development. As it is evident from (Table 20; figure 16), the weight assigned to the factors reveals the relative importance of each parameter in exposing an area to condominium site evaluation. As a result shows, land use/land cover with the weight of 26 has the highest priority, 22, 13, 9, 11, 6, 5, 3, 3 and 2 was obtained as a weight value for the distance from roads/transportation, distance from facility locations, suitability of slope, distance from the stream, distance from highway and railway, distance from high tension electric power, distance from military camp, distance from factory/noise influence, suitability of soil type respectively.

Consistency ratio of 0.1 or less is acceptable to continue the AHP analysis (Saaty, 2008). In this study, consistency ratio (CR) of conducted AHP comparisons has obtained 0.09, which is smaller than 0.1 therefore the comparisons can be acceptable. Based on the result of this study, AHP is a highly effective instrument for determining factor weights and is more helpful than alternative approaches since the inconsistency of the factor weight's pair-wise comparison matrix can be calculated and controlled by the Consistency Ratio (CR). In various studies (Kumar & Shaikh, 2013; M. T. Abebe & Megento, 2016; Ustaoglu and Aydinoglu, 2020), this has been confirmed. The value obtained here were an estimate of the relative weights of the criteria being compared. As shown in table 20 above the last column indicates the weight of each parameter.

4.4. Weighted Overlay Analysis

After weighting the parameter, as regards the relative importance of each parameter as well as suitability index, all the reclassified parameters were overlaid in order to select suitable sites for condominium houses development using the weighted overlay tool or a raster calculator in Arc GIS and final condominium housing site suitability map was prepared (Figure 17).

Table 21: Final suitability area and percent of total area coverage

Level of Suitability	Area (ha.)	Percent of total area (%)
Unsuitability	40.26	0.2
Low Suitability	8376.97	41.27
Moderate Suitability	7513.15	37.01
High Suitability	3386.15	16.68
Very High Suitability	982.85	4.84

According to GIS-based multi-criteria analysis, the result obtained from the overall suitability map shows 982.85 and 3386.15 hectares are very high and high suitable for condominium house development respectively. The large area is less suitable for condominium house development in the existing situation which covers 41.27% (20578.9 hectare) of the area. The remaining 0.2% is not suitable for future condominium house development sites (Table 21; Figure 17).

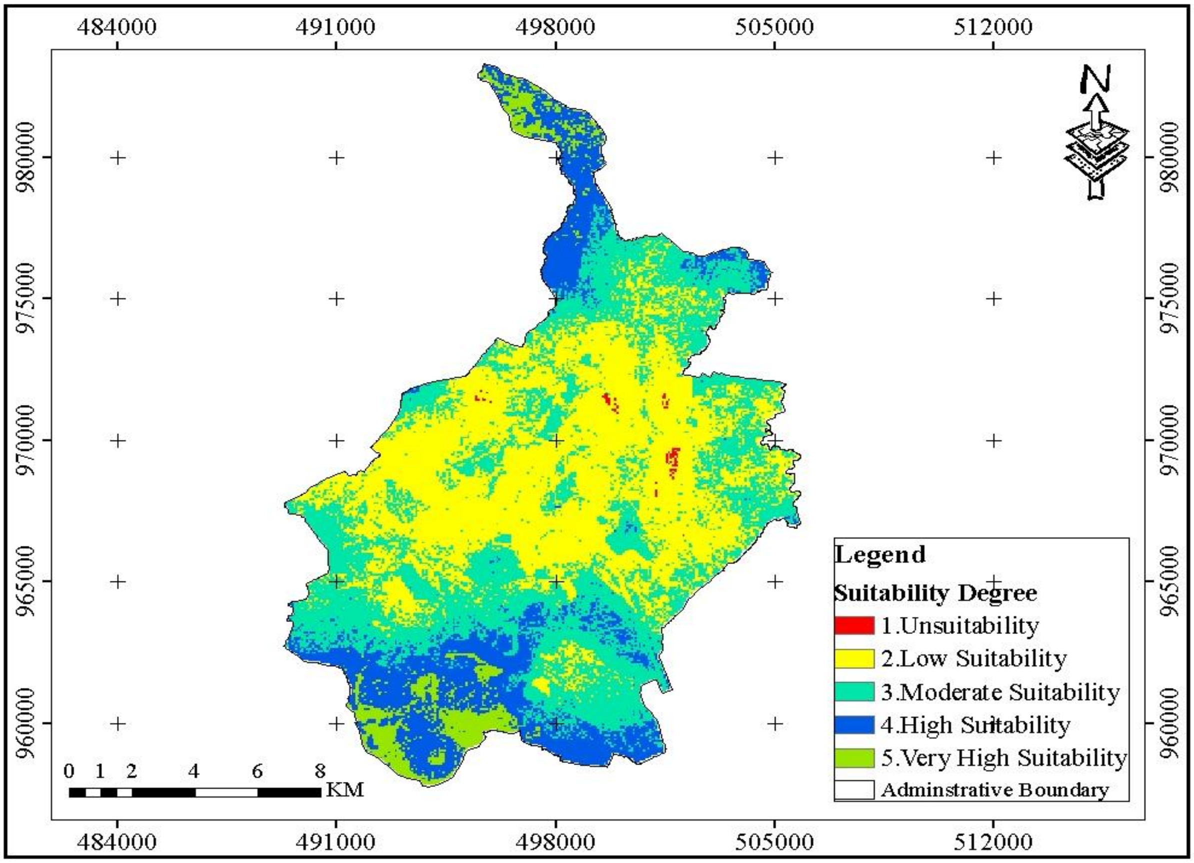


Figure 17: Final Site suitability map for Condominium housing development

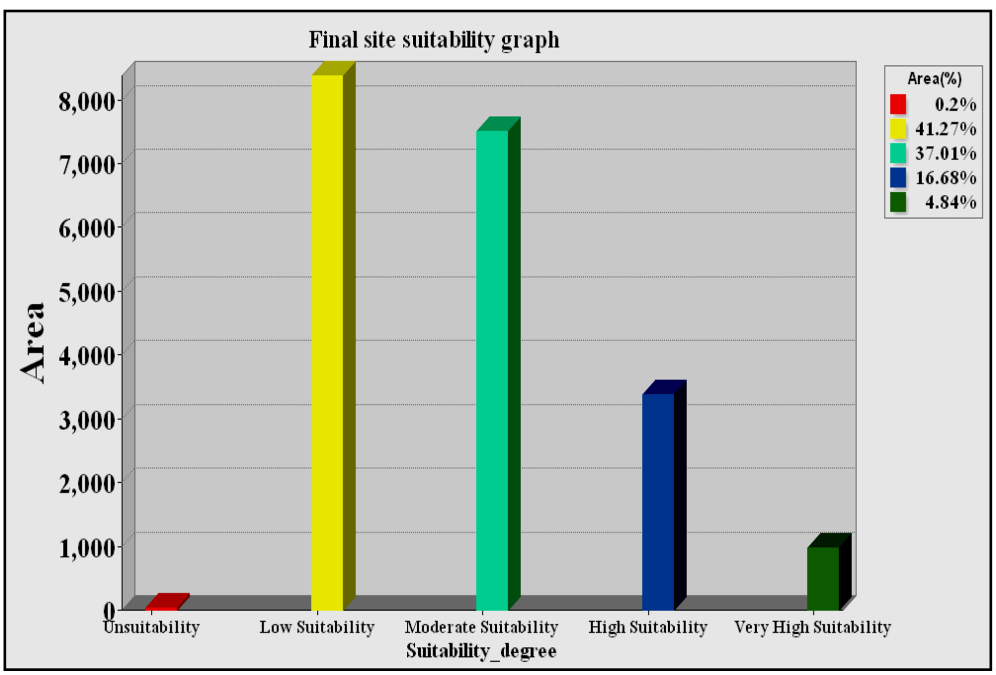


Figure 18: Candidate site for future condominium houses development suitability index

4.5. Validation of the result

It is essential that the results should be validated; this is done with sensitivity analysis and field verification. Validation helps to assess the reliability of the output and is usually assessed by ground truth verification and sensitivity analysis (Abebe and Megento, 2017).

4.5.1. Sensitivity analysis

It should be recognized that MCDM-derived rankings are often conditional. The uncertainty can come from many different sources, such as original data, data processing, criteria selection and their thresholds. Criteria weights are often the greatest contributor to controversy and uncertainty. This could be because decision makers are not absolutely aware of their preferences regarding the criteria, and may be because nature and scale of the criteria is not known. Or, especially when multiple decision makers are involved, it is often not possible to derive only one set of weights, but ranges of weights, and thus more than one set of results.

Sensitivity Analysis (SA) determines the reliability of the model through assessment of uncertainties in the reproduction results (Chen et al., 2009). It is well-known that SA is crucial to the validation and calibration of numerical models. SA can be used as a tool to check the robustness of the final outcome against slight changes in the input data. Thus, SA can help reduce uncertainty in how a MCDM method operates and the stability of its outputs by illustrating the impact of introducing small changes to specific input parameters on evaluation outcomes (Crosetto et al., 2000). In this study SA was carried out by changing the weight values of each input criteria in four scenarios (Table 22 and Figure 19). The weight value for each criterion was calculated using a pair-wise comparison matrix of AHP with a consistency ratio of less than 0.1 as provided by Saaty (2008).

Table 22: Weight value (%) for each input criteria in four scenarios

s/no	Criteria	Scenario (%)			
		A	B	C	D
1	LULC	26	25	25	35
2	Distance from major road	22	22	24	24
3	Distance from school and health center	13	16	12	10
4	Slope	9	11	12	8
5	Distance from stream	11	8	9	6
6	Distance from highway and railway	6	4	4	4
7	Distance from high tension electric power line	5	6	6	3
8	Distance from military camp and air force	3	3	4	3
9	Distance from poisonous and noisy industries	3	3	2	6
10	Soil Type	2	2	2	2
Consistency ratio		**9**	**8**	**6**	**5**
Total suitable area (%)		**21.52**	**18.79**	**20.92**	**19.66**

Scenario A, which comprises 21.52% of the total area, was chosen as the base scenario in order to assess the effects of changes in weight value across four scenarios. The total suitable size decreases from 21.52 to 18.79% when the LULC (scenario B) diminishes. The total suitable area grew to 20.92% of the total area in scenario C due to an increase in Slope and distance from the road. The total area that is suitable dropped to 19.66% of the total area in (scenario D) because the slope and distance from stream were given the lowest weight values. Therefore, Slope, distance from stream, LULC, distance from major road were identified as the criteria that are especially sensitive to weight changes.

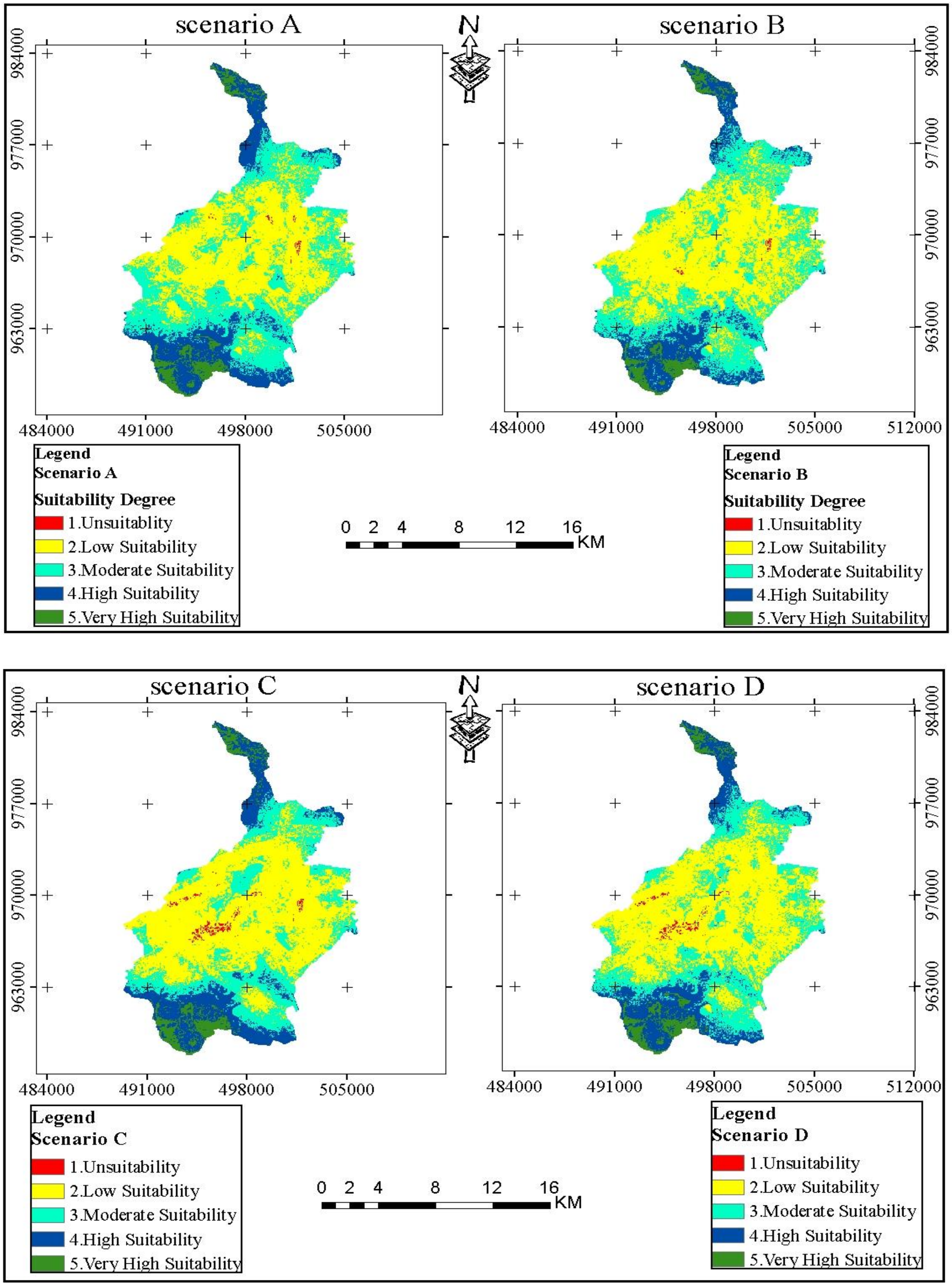


Figure 19: Sensitivity analysis map of four scenarios

4.5.2. Field verification

Field verification is visiting the location and comparing results to your observations. Remote Sensing often calls this process “ground-truthing”. Field verification was made to assess the ground truth of the suitable area using GIS-MCA techniques with reference to the Abyssinia metal industry and a palace called kajima and kurkura are among the best suitable sites, and the south western part of the city following roads to Bishoftu automotive industry also suitable site for condominium housing development. The coordinate of place collected by handle GPS shown in table 23 indicates the selected suitable site for future condominium development.

Table 23: Coordinate of selected suitable site for future condominium development

Candidate Site	**Easting**	**Northing**	Name o**f Place**
1	49547.209	964763.171	Kajima
2	495633.119	963972.903	Kajima
3	495050.202	964537.907	Kajima
4	493642.333	966455.688	Kurkura

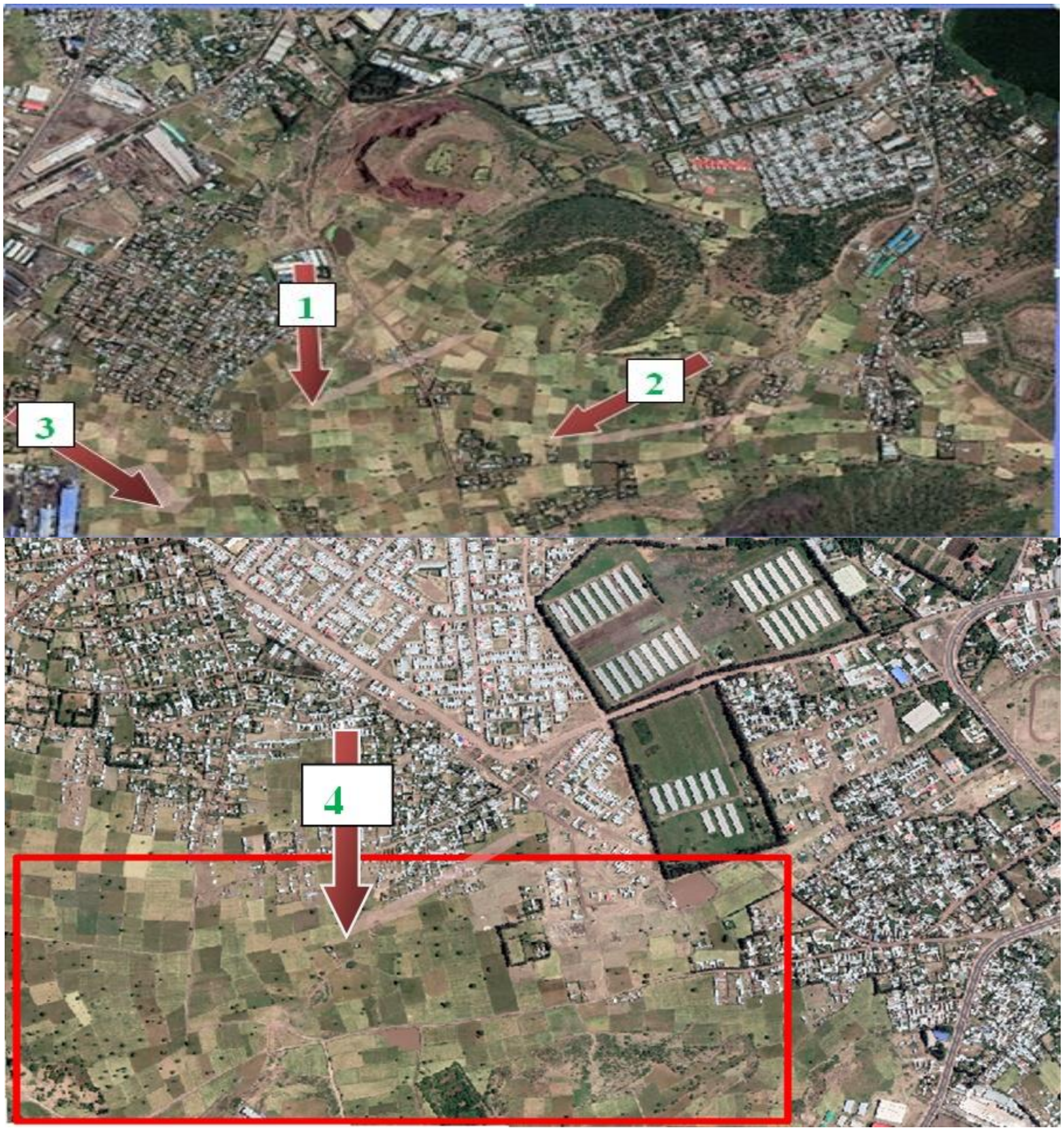


Figure 20: Area demarcating suitable site for future condominium houses development

The validated result of the final suitability map (Figure 17) reveal 982.85 and 3386.15 hectares of proposed condominium site which is still not constructed or undeveloped exist under very high suitability and high suitability respectively. This indicates that currently, Bishoftu city has 21.52 % (4369 hectares) of its land have appropriate potential for future condominium house needs. The finding (Figure 17) reveals 40.26 hectares exist under unsuitability which needs further investigation before land distribution for condominium housing purposes. This is due to either its location under a constraints zone or being constructed or developed.

4.5. Comparison of Suitability Scenario Map VS. Proposed Structural Plan for Residential Area

The analysis of condominium settlement sites, which are a part of residential areas, by using geospatial technology, is part of structural plan analysis and its poor implementation. Therefore, after the best suitability scenario was selected, it was important to compare it with the proposed structural plan (2021)residential area of the city. A comparison of proposed structural plans (2021) in the study area was conducted by considering the locational aspects of the condominium site in the suitability map. Figure 21 shows the comparison between the best suitability scenario and the proposed structure plan (2021) of Bishoftu city. The extracted proposed structural plan (2021) residential area was overlaid on the best suitability scenario condominium site map of the city in the ArcGIS environment. Each suitability level was clipped from the best suitability scenario and intersected with the proposed structural plan residential area. Accordingly, of the city's total area of 20578.9 hectares, 524.6434 hectares are proposed as a residential area. Therefore, as the result shows, 348.5103 hectares of proposed residential area are found in a low-suitable area, 125.6179 ha in a moderate-suitable area, and only 51.9 hectares in a highly suitable area. The majority of the proposed structural plan (2021) residential area was in the less suitable and moderately suitable domains of the study area, according to the comparison of suitability scenario map and proposed structural plan (2021) residential area. This indicates that the site suitability analysis for the development of condominium (residential) houses in Bishoftu city was not effectively conducted with enough criteria.

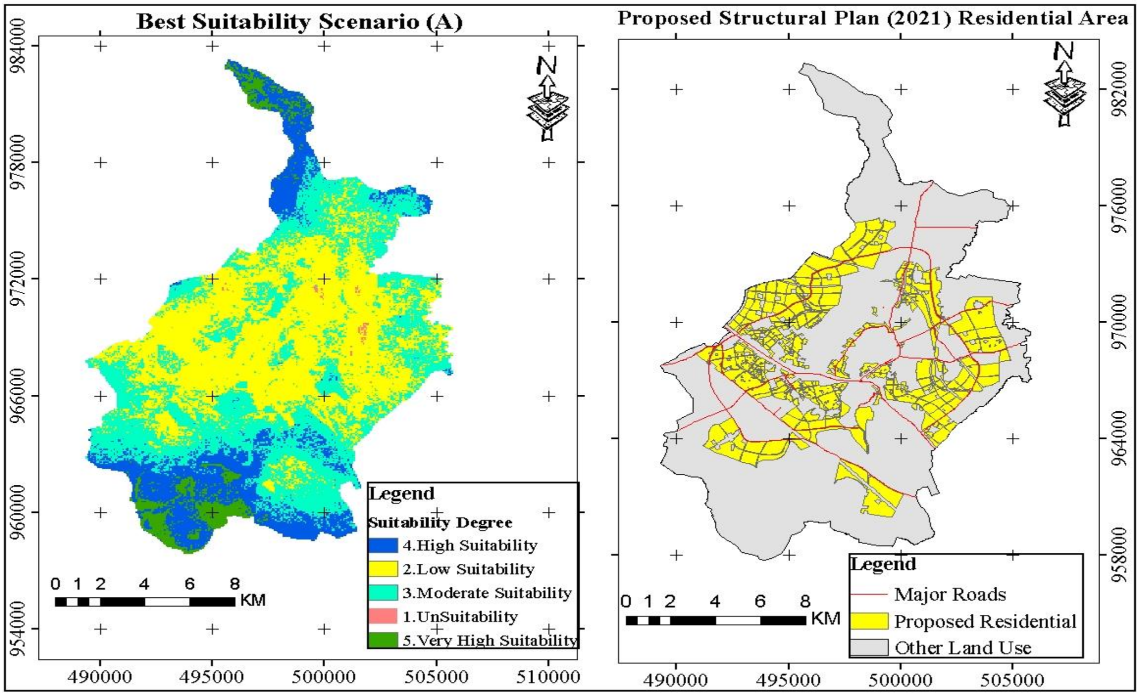


Figure 21: Comparison between suitability scenario (A) and proposed structure plan (2021)

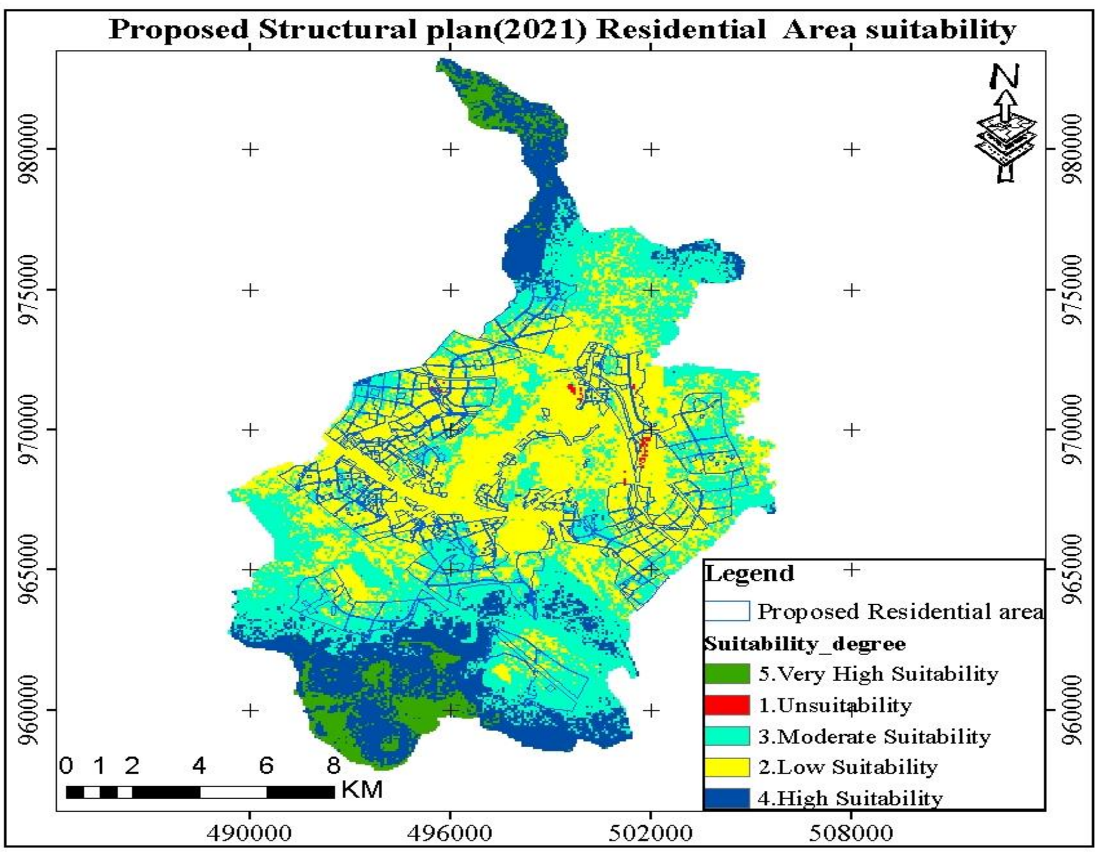


Figure 22: Proposed structural plan (2017) Residential suitability level

4.6. Discussion

Urbanization and population expansion have increased dramatically worldwide. In the course of the urbanization processes, the patterns of land use and land cover (LULC), industrialization, and social change take place. One of the main effects of urbanization is an increase in demand for residential land as a result of the city's population growth. Due to the enormous demand for housing, it became difficult for the government to house everyone who lived in cities. Overcrowding, poor, and insufficient social amenities, unfavorable environmental conditions and urban squalor, a lack of open space, the development of land area leading to overcrowding of buildings, inaccessibility within residential areas, and scarcity and high cost of building materials are other ways that housing problems and needs are manifested. Hence, the study is important to indicate the Suitable site for affordable house construction particularly condominium houses development.

Therefore, this study used ten site selection criteria (proximity to main road, proximity to river, existing land use land cover, proximity to school and health care center, slope, soil, and distance from military camp and air force, distance from highway and railway, distance from high tension electric power line and distance from high poisoning and noisy industries) to select and evaluate potential site for condominium housing development. The final suitability map has shown that, five suitability classes (unsuitable, less suitable, moderate suitable, highly suitable, very high suitable) from all surface of study area and four very highly suitable candidate sites (see figure20).The class selected as highly suitable sites can be used for future condominium housing development. According to (Santosh et al., 2018),more settlement develops near the road because of the transportation facilities and very easy access to the nearby places and city centers(Santosh et al., 2018),discussed in their study Buffer zone falling under 500m distances from road is highly suitable for condominium housing development. The urban development sites are not be located on an area where the average surface slope is steeper, it must be 250m away from drainage to prevent flood vulnerability (Culshaw and Price, 2011; Akbulut et al., 2018; Mesfin Girma, 2019; Kamal jain & Y. Venkata subbaiay, 2007; Ishaq & Hakan, 2019; Santosh et al., 2018).

However, the analyzed result of this study showed that, candidate Site 1, 2,3 and 4 are about 500m close to the roads, enough faraway from river and railway and highway, they are not lay on protected area, they are located on gentle slope. So, candidate Site 1, 2, 3 and 4 are more acceptable for condominium housing development and growth; because those sites meet the minimum required criteria set out to condominium housing development site selection when evaluated in terms of proximity to road, distance from river, slope and proximity to facilities. Consequently, the newly proposed condominium housing development sites are at safe distance from river, distance from poisoning industry, distance from military camp and protected area and located on area of gentle slope, allowable LULC, reasonably close to road, existing urban area, existing school and health care center. Thus, appropriate condominium housing development location of Bishoftu city was generated with considering physical, environmental, economic and socially acceptable.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Due to the current overpopulation that Bishoftu city faces nowadays, the dependency on the traditional ways of planning will not last long; there is no other way except using new technologies in supporting the decision makers. Using the previously mentioned methodology and applying it on the area of interest gives results for proposing different locations for the new condominium housing developments.

The selection of suitable locations to build condominium houses can be best achieved by the combination of GIS and MCDA. The municipality hardly uses MCDA in selecting locations suitable for building condominium houses. The method of using the certain criteria such as land owner, environmental factors, valuable green area, cultural heritage and physical boundaries (roads and utilities) surrounding the landed property as factors in selecting suitable area is not only a technical method of selecting suitable area to build condominium houses. Certain locations may have positive aspects in terms of the land owner, environmental, cultural heritage and physical boundaries, but in terms of the soil type, the direction of slope, distance from military camp, distance from railway and highway, distance from high tension electric line and the land use type it may become a problem selecting such areas as suitable areas. In the Bishoftu context, there are several areas with various spatial issues when locating the condominium house residents.

For instance, the existing chelekleka condominium site in Bishoftu city is located on unsuitable buffer zone in terms of slope, distance from water body, distance from health center and distance from noisy and poisonous factory. This indicates that the Bishoftu city site appropriateness investigation was not effectively completed with enough criteria for the development of condominium houses. However, the main objective of this research was to assess the availability of suitable sites for future condominium house development in the Bishoftu urban council area. This research also identified criteria used for selecting suitable areas and the extent to which their impact has influenced the creation of relevant condominium housing sites. Following the analysis, it was determined that 4.84 percent (982.85 hectares) of the total area of consideration (20578.9 hectares) was very high potential area for condominium development, 16.68 percent (3386.15 hectares) was a high potential area for condominium development, 37.01 percent (7513.15 hectares) was the a moderate potential area for condominium house development, 41.26%(8376.97) was a least potential area for condominium development in the Bishoftu urban district. Moreover, 0.2% (40.26 hectare) of the total area of consideration could be observed as unsuitable area for residential development. Finally, it could be concluded that 21.52 % (4369 hectare) of the total land area in the Bishoftu urban council is appropriate for future condominium houses development under different levels of suitability. According to the results of this study, geospatial technology can be extremely useful in determining the best locations for condominium house developments. It can also assist in obtaining current data about urban land use. Multi-criteria analysis (MCA) methods based on AHP have also been shown to be a flexible and practical tool for determining the best locations for condominium house developments in the study area. Additionally, numerous parties can benefit from the research's conclusions, especially those working in the real estate development sector.

5.2. Recommendation

The GIS Analysis method is a systematic way to make spatial decisions such as residential suitability. Since residential activities are continuing to expand in the Bishoftu urban council area, and due to the horizontal expansion in the residential areas, it has affected several fertile agricultural lands. Because horizontal construction requires more land space to build, since these structures usually have a greater width and length than height. Vertical construction is typically associated with structures that are built vertically and stretch upward more. The reason for this condition is the increasing land use for residential activities and the use of wheat and teff cultivation lands for residential purposes. Therefore:-

- It is recommended to build residential activities vertically, such as condominium houses, which can have more than four floors and can house more than 10 families on a single plot of land.
- The government should also prepare proper policies and standards related to the context, the Vertical, expansion in the residential areas .for example, environmentally sensitive, natural hazards and prime agricultural lands should not be transformed into other land uses due to their special features. This method will help to improve the

efficiency of using limited land resources and minimizes the adverse impact of urban spatial development.

- In this study, urban land suitability analysis was done for condominium housing development only which by itself is not sufficient for sustainable urban land use and development. It is recommended that suitability analysis for all other land use types should be conducted, as a comprehensive and comparative analysis would provide an increased understanding of the nature and effectiveness of urban land uses.
- For urban land suitability to be more feasible, a land and land-related resources database should be established and implemented. If the public has easy access to these databases, it will contribute to wider public participation in the urban planning process.

REFERENCE

Abdollahi, S., Ildoromi, A., & Salmanmahini, A. (2019). A GIS Based Multi Criteria Evaluation to Ecotourism Suitability Site Selection in Arasbaran Protected Area, Iran. .https://dergipark.org.tr/en/download/article-file/2014943.

Abdula, M. A., Johari, M., Yusof, M., Bakar, S. A., Ahmad, N. Bin, Abdullahi, S., & Omer, N. Q. (2015). The Impact Of Social And Security Factors On Residential Site Suitability By Using Gis-Based Mcdm Approach : A Case Study The City Of Kirkuk , Iraq Faculty of Design and Architecture , Universiti Putra Malaysia , Serdang , Selangor , Malaysia Faculty of E. 8(1), 14–19.

Abebe, G., & Hesselberg, J. (2014). Implications of Urban Development-Induced Resettlement on Poor Households in Addis Ababa. Ghana Journal of Geography, 5(1), 32–50. https://doi.org/10.4314/gjg.v5i1.

Abebe, M. T., & Megento, T. L. (2016). The city of addis ababa from ‘forest city’ to ‘urban heat island’: Assessment of urban green space dynamics. Journal of Urban and Environmental Engineering, https://doi.org/10.4090/JUEE.2016.V10N2.254262.

Alesheikh, A. A., Soltani, M. J., Nouri, N., & Khalilzadeh, M. (2008). Land assessment for flood spreading site selection using geospatial information system. International Journal of Environmental Science and Technology. https://doi.org/10.1007/BF03326041.

Belal, A. A., & Moghanm, F. S. (2011). Detecting urban growth using remote sensing and GIS techniques in Al Gharbiya governorate, Egypt. Egyptian Journal of Remote Sensing and Space Science, 14(2), 73–79. https://doi.org/10.1016/J.EJRS.2011.09.001.

Chakma, S. (2014). Analysis of urban development suitability. Dhaka Megacity: Geospatial Perspectives on Urbanisation, Environment and Health, 147. https://doi.org/10.1007/978-94-007-6735-5_8.

Ekanayaka, L. R. K., & Weerakoon, K. G. P. K. (2019). Analysis of Locational Suitability for Residential Development in Colombo Sub Urban Area: Application of Analytic Hierarchy Process. Sri Lankan Journal of Real State, 17.

Feng, T., transportation, J. Z.-J. of advanced, & 2014, undefined. (2014). Multicriteria evaluation on accessibility-based transportation equity in road network design problem. Wiley Online Library, 48(6), 526–541. https://doi.org/10.1002/atr.1202.

Gebrewold, T. A. (2015). Condominium Dwellers ’ Housing Quality Perception and

Satisfaction in Addis Ababa Quality Perception and Satisfaction. March.

Haregewoin, Y.M. (2007) Integrated Housing Development Programs for Urban Poverty Alleviation and Sustainable Urbanization The Case of Addis Ababa. ENHR International Conference on Sustainable Urban Areas, Institute for Housing and Urban Development St.https://www.scirp.org/(S(czeh2tfqw2orz553k1w0r45))/reference/referencespapers.

Islam, M. S., Uddin, M. A., & Hossain, M. A. (2021). Assessing the dynamics of land cover and shoreline changes of Nijhum Dwip (Island) of Bangladesh using remote sensing and GIS techniques. e Science,https://doi.org/10.1016/J.RSMA.2020.101578.

Kahlmeier, S., Schindler, C., Grize, L., & Braun-Fahrländer, C. (2001). Perceived environmental housing quality and wellbeing of movers. Journal of Epidemiology & Community Health, 55(10), 708–715. https://doi.org/10.1136/JECH.55.10.708

Kaiser, E. J., Chapin, F. S., & Godschalk, D. R. (1995). Urban land use planning / Edward J. Kaiser, David R. Godschalk, and F. Stuart Chapin, Jr. xv, 493 p. :

Kallali, H., Anane, M., Jellali, S., & Tarhouni, J. (2007). GIS-based multi-criteria analysis for potential wastewater aquifer recharge sites. Desalination, 215(1–3), 111–119. https://doi.org/10.1016/J.DESAL.2006.11.016.

Keller, E. J., & Mukudi-Omwami, E. (2017). Rapid urban expansion and the challenge of pro-poor housing in Addis Ababa, Ethiopia. Africa Review, 9(2), 173–185. https://doi.org/10.1080/09744053.2017.1329809.

Kindu, M., Schneider, T., Teketay, D., & Knoke, T. (2013). Land Use/Land Cover Change Analysis Using Object-Based Classification Approach in Munessa-Shashemene Landscape of the Ethiopian Highlands. Remote Sensing 2013, Vol. 5, Pages 2411-2435, 5(5), 2411–2435. https://doi.org/10.3390/RS5052411.

Klinphan, S. (2009). The Feasibility Study of the Investment on a Condominium Project, Nonthaburi. Master’s Thesis, Department of Architectural Technology, Silpakorn University. https://www.google.com/search?q=Klinphan%2C+S.+(2009).

Kono, T., & Joshi, K. K. (2018). Spatial externalities and land use regulation: an integrated set of multiple density regulations. Journal of Economic Geography, 18(3), 571–598. https://doi.org/10.1093/JEG/LBX021.

Kordi, M., & Brandt, S. A. (2012). Effects of increasing fuzziness on analytic hierarchy process for spatial multicriteria decision analysis. Computers, Environment and Urban

Systems, 36(1), 43–53. https://doi.org/10.1016/J.compenvurbsys.2011.07.004.

Kowaltowski, D. C. C. K., da Silva, V. G., Pina, S. A. M. G., Labaki, L. C., Ruschel, R. C., & de Carvalho Moreira, D. (2006). Quality of life and sustainability issues as seen by the population of low-income housing in the region of Campinas, Brazil. Habitat International, 30(4), 1100–1114. https://doi.org/10.1016/J.habitatint.2006.04.003.

Krishnaveni, K. S., & Anilkumar, P. P. (2020). Managing Urban Sprawl Using Remote Sensing and GIS. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, 42(3/W11), 59–66. https://doi.org/10.5194/isprs-archives-XLII-3-W11-59-2020.

Kumar, M., & Shaikh, V. R. (2013). Site Suitability Analysis for Urban Development Using GIS Based Multicriteria Evaluation Technique: A Case Study of Mussoorie Municipal Area, Dehradun District, Uttarakhand, India. Journal of the Indian Society of Remote Sensing, 41(2), 417–424. https://doi.org/10.1007/S12524-012-0221-8.

MadurikaH. (2017). GIS Based Analysis For Suitability Location Finding In The Residential Development Areas Of Greater Matara Region Demarcation of GN Divisions' Boundary of Sri Lanka View project Tsunami Housing Reconstruction Project View project Gis Based Analysis For Su.

Malczewski, J. (2004). GIS-based land-use suitability analysis: A critical overview. Progress in Planning, 62(1), 3–65. https://doi.org/10.1016/J.PROGRESS.2003.09.002.

Meng, Y., Malczewski, J., & Boroushaki, S. (2011). A GIS-Based Multicriteria Decision Analysis Approach for Mapping Accessibility Patterns of Housing Development Sites: A Case Study in Canmore, Alberta. Journal of Geographic Information System, 03(01), 50–61. https://doi.org/10.4236/JGIS.2011.31004.

Mesfin Girma. (2019). Integrated Site Suitability Analysis for Urban Development Using Remote Sensing and GIS Based Multicriteria Evaluation Technique in Wolaita Sodo Town and Surrounding Area, SNNPR, Ethiopia. Journal of Environment and Earth Science. https://doi.org/10.7176/JEES/9-5-01.

Metternicht, G. (2017). Global Land Outlook Working Paper Land Use Planning Disclaimer.

Ministry of Urban Development and Construction. (2012). Revised Standards for Structure Plan Preparation and Implementation. 1–59.

Mridha, A. M. M. H., & Moore, G. T. (2011). The Quality of Life in Dhaka, Bangladesh:

Neighborhood Quality as a Major Component of Residential Satisfaction. 251–272. https://doi.org/10.1007/978-94-007-1742-8_11.

Murseli, R., & Isufi, F. (2014). Land suitability location analysis for housing development using GIS. 187–198. https://doi.org/10.33107/UBT-IC.2014.18.

Nikolakaki, P. (2004). A GIS site-selection process for habitat creation: Estimating connectivity of habitat patches. https://doi.org/10.1016/S0169-2046(03)00167-1.

Nosal, B. (2009). Protecting Health: Air Quality and Land Use Compatibility.

Paudel, B., Zhang, Y. li, Li, S. cheng, Liu, L. shan, Wu, X., & Khanal, N. R. (2016). Review of studies on land use and land cover change in Nepal. Journal of Mountain Science, 13(4), 643–660. https://doi.org/10.1007/S11629-015-3604-9.

Pereira, J. M. C., & Duckstein, L. (1993). A multiple criteria decision-making approach to gis-based land suitability evaluation. International Journal of Geographical Information Systems, 7(5), 407–424. https://doi.org/10.1080/02693799308901971.

Puntsag, G., Kristjánsdóttir, S., & Dögg Ingólfsdóttir, B. (n.d.). Land Suitability Analysis For Urban And Agricultural Land Using Gis: Case Study In Hvita To Hvita, Iceland. ohttp://www.unulrt.is/static/fellows/document/Puntsag2014.pdf.

Qashqo, B. (2018). GIS-Based Multi-Criteria Decision Analysis for identifying water distribution points: a case study in Lapilang & Suspa regions, Nepal. Master Thesis, 41. http://unigis.sbg.ac.at/files/Mastertheses/Full/104279.pdf.

Richard, J., Eng, C. O.-J. G. G., & 2016, undefined. (2016). Analysis of accuracy of differential global positionin g system (DGPS) and Google Earth digital terrain model (DTM) data using geographi c information system. Davidpublisher.Com, 2, 52–61. https://doi.org/10.17265/2332-8223/2016.02.006.

Richards, R., O'Leary, B., & Mutsonziwa, K. (2007). Measuring quality of life in informal settlements in South Africa. Social Indicators Research, 81(2), 375–388. https://doi.org/10.1007/S11205-006-9014-1.

S, J., R M, B., & P, S. E. (2018). Mapping of Tourism Place in Puducherry using GIS. https://doi.org/10.14445/23488352/ijce-v5i6p105.

Saaty, T. L. (2002). Decision making with the Analytic Hierarchy Process. Scientia Iranica, 9(3), 215–229. https://doi.org/10.1504/IJSSCI.2008.017590.

Santosh, C., Krishnaiah, C., & Deshbhandari, P. G. (2018). Site suitability analysis for urban development using GIS based multicriteria evaluation technique: https://doi.org/10.1088/1755-1315/169/1/012017.

Sarath, M., Saran, S., & Ramana, K. V. (2018). Site suitability analysis for industries using GIS and multi criteria decision making. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 4(5), 447–454. https://doi.org/10.5194/isprs-annals-IV-5-447-2018.

Serag, H., Din, E., Shalaby, A., Farouh, H. E., & Elariane, S. A. (2019). Principles of urban quality of life for a neighborhood. Https://Doi.Org/10.1016/j.Hbrcj.2013.02.007, 9(1), 86–92. https://doi.org/10.1016/J.HBRCJ.2013.02.007.

Sirgy, M. J., & Cornwell, T. (2002). How neighborhood features affect quality of life. Social Indicators Research, 59(1), 79–114. https://doi.org/10.1023/A:1016021108513.

Smith, J. T., & Tighe, S. L. (2006). Analytic hierarchy process as a tool for infrastructure management. Transportation Research Record, 1974, 3–9. https://doi.org/10.3141/1974.

Stephen, A. O. (2013). Spatial MCDA for Finding Suitable Areas for Housing Construction.

Turan, İ. D., Dağıstanlı, C., İnci, &, Turan, D., & Dengiz, O. (2018a). Evaluation of the suitability of sites for outdoor recreation using a multi-criteria assessment model Development of Periglacial Landforms on Yalnızçam Mountains (Lesser Caucasus-Turkey) https://doi.org/10.1007/s12517-018-3856-0.

Turan, İ. D., Dağıstanlı, C., İnci, &, Turan, D., & Dengiz, O. (2018b). Evaluation of the suitability of sites for outdoor recreation using a multi-criteria assessment model. Springer, 11(17). https://doi.org/10.1007/s12517-018-3856-0.

Veronesi, F., Schito, J., Grassi, S., geography, M. R.-A., & 2017, undefined. (2017). https://doi.org/10.1016/j.apgeog.2017.04.001.

Webb, B., & Webber, S. (2017). The implications of condominium neighbourhoods for long-term urban revitalisation. https://doi.org/10.1016/J.CITIES.2016.11.006.

Weerakoon, K. (2014). Suitability Analysis for Urban Agriculture Using GIS and Multi-Criteria Evaluation. https://doi.org/10.14355/ijast.2014.0302.03

Weldu, G. (2020). Identification of Potential Sites for Housing Development Using GIS Based International Journal of Sciences : Identification of Potential Sites for Housing Development Using GIS Based Multi-Criteria Evaluation in Dire Dawa City , Ethiopia. January 2016.

Witlox, F. (2005). Expert systems in land-use planning: An overview. Expert Systems with Applications, 29(2), 437–445. https://doi.org/10.1016/J.ESWA.2005.04.041

Woldemariam, G. W., Iguala, A. D., Tekalign, S., & Reddy, R. U. (2018). Spatial Modeling of Soil Erosion Risk and Its Implication for Conservation Planning: the Case of the Gobele Watershed, East Hararghe Zone, Ethiopia. Land 2018, Vol. 7, Page 25, 7(1), 25. https://doi.org/10.3390/LAND7010025

Zainal, N. R., Kaur, G., Ahmad, N. ‘Aisah, & Khalili, J. M. (2012). Housing Conditions and Quality of Life of the Urban Poor in Malaysia. Procedia - Social and Behavioral Sciences, 50, 827–838. https://doi.org/10.1016/J.SBSPRO.2012.08.085.

Zebardast, E. (2009). The housing domain of quality of life and life satisfaction in the spontaneous settlements on the Tehran Metropolitan Fringe. Social Indicators Research, 90(2), 307–324. https://doi.org/10.1007/S11205-008-9260-5

Zurmotai, H. (2016). GIS , Remote Sensing and GPS : their activity , Integration and Fieldwork. April.

APPENDICES

Appendix I: Coordinates of factory locations

Name of Factories	Latitude	Longitude
Ahaduks Food Product Plc	8.7413	38.9284
East Africa Lions Brand Manufactury	8.7611	38.9148
Habesha Steel Mill Plc	8.7765	38.9285
Leos Edible Oil Factory	8.7724	38.9621
Murar Paint Factory	8.7505	38.9516
Gg Supper Garment Factory	8.7490	38.9525
Bora Feed Factory	8.7624	38.9760
Sentinel Steel Plc Factory	8.7391	38.9386
Alema Koudijs Factory	8.7400	38.9537
Bishoftu Automotive Industry	8.7391	38.9386
Excel Plastic Manufactury	8.7341	38.9416
Abyssinia Integrated Steel Plc	8.7282	38.9658
Sawaya Ethiopia Indomie Factory	8.7115	39.0317
Crown Packaging And Plastic Plc	8.7082	39.0277
Sheba Steel Factory	8.7342	38.9388
Smr Agricultural Plc	8.7476	38.9726
Kanoria Africa Textile	8.7293	39.0312
Ekos Steel Mill Plc	8.7811	38.9320
Elfora Agro Industry	8.7532	9542

Appendix II: Coordinates of health facility locations

Name of Health Facilities	Latitude	Longitude
Bishoftu Hospital	8.7548	38.9824
Dr.Asfaw Medium Clinic	8.7569	38.9524
Kalkidan Primary Clinic	8.7876	39.0005
Chelekleka Clinic	8.7589	38.9728
Fitsum Clinic	8.7489	38.9783
Geleta Medium Clinic	8.7608	38.9482
Beteseb Medium Clinic	8.7518	38.9820
Hora Clinic	8.7486	38.9901
Adea Clinic	8.7511	38.9808
Tedla Medium Clinic	8.7542	38.9613
Ketta Health Center	8.7459	38.9963
Wajituna Deben Debe Clinic	8.7895	38.9048
Maranata Clinic	8.7818	38.9660
Alem Mediumclinic	8.7971	38.8997
Edom Medium Clinic	8.5387	38.2549

Appendix III: Coordinates of School locations

Name of Schools	Latitude	Longitude
Bishoftu Secondary School	8.7517	38.9806
Tbeza School	8.7599	38.9371
Rispin International School	8.7534	38.9528
Inter Lakes International School	8.7684	38.9440
Babugaya Preparatory School	8.7600	38.9389
Besebarok School	8.7557	38.9931
Dibayu Elementary School	8.7172	38.9319
Kurkura Secondary School	8.7614	38.9385
Jorgo Academy	8.7678	38.9435
Admas University	8.7540	38.9588
Bishoftu TVET College	8.7508	38.9632
Kenenisa Elementary School	8.7600	38.9995
Nafiyad	8.7526	38.9385
College Of Veterinary Medical And Agriculture	8.7607	39.0000
Ethiopia Defense University	8.7588	38.9990
Rift Valley University Collegy	8.7521	38.9666

Appendix IV: Coordinates of Bishoftu city existing condominium site

Name of Condominium Site	Latitude	Longitude
Sunshine	8.7621	38.9462
Dembiyatu	8.7449	38.9451
Berbere Tera	8.7391	38.9744
03	8.7414	38.9742
Chelekleka	8.7710	98.9819