SUITABLE SITE SELECTION FOR URBAN FACILITY LOCATION USING AHP-MCDA IN BISHOFTU CITY: THE CASE OF PUBLIC HOSPITAL

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Suitable Site Selection for Urban Facility Location Using AHP-MCDA in Bishoftu City: The Case of Public Hospital

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Adama, Ethiopia

DECLARATION

I hereby declare that this Master Thesis entitled **"Suitable Site Selection for Urban Facility Location Using AHP-MCDA in Bishoftu City: The Case of Public Hospital"**, 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.

HailemelekotKassaye _____ _____

Signature Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "**Suitable Site Selection for Urban Facility Location Using AHP-MCDA in Bishoftu City: The Case of Public Hospital**" prepared under my guidance by **Hailemelekot Kassaye Ayenew** 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.

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APPROVAL SHEET

I, the advisors of the thesis entitled **"Suitable Site Selection for Urban Facility Location Using AHP-MCDA in Bishoftu City: The Case of Public Hospital"** and developed by **Hailemelekot Kassaye Ayenew**, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis **Hailemelekot Kassaye Ayenew**, have read and evaluated the thesis entitled "**Suitable Site Selection for Urban Facility Location Using AHP-MCDA in Bishoftu City: The Case of Public Hospital**" 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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LIST OF ACRONYMS

AHP	Analytical Hierarch Process
ASTU	Adama Science and Technology University
CAD	Computer-Aided Design
CSA	Central Statistical Agency
DEM	Digital Elevation Model
EMA	Ethiopia Map Agency
ERDAS	Earth Resource Data Analysis System
GPS	Global Positioning System
GST	Geospatial technology
GP	Growth plan
GCP	Ground Control Point
GIS	Geography Information System
TIFF	Tagged Image File Format
LULC	Land Use Land Cover
RS	Remote Sensing
UN	United Nation
MCA	Multi Criteria Analysis
MCDM	Multi Criteria Decision Making
WGS	World Geodetic system
USGS	United States Geological Survey

ABSTRACT

One of the most important policy-related decisions made by urban planners and policy makers is where to locate urban facilities. The success or failure of a facility is frequently determined by the location that is chosen for a potential facility. Hence, before choosing a site, it is crucial to assess potential locations from a variety of dimensions, taking into account both subjective and objective variables; however, such rational allocation of facilities is uncommon in Ethiopia. The problem observed in Bishofu in this regard a negligent site eventually harms the environment and imposes excessive costs and challenges for both the initial implementation and any necessary subsequent revisions. This study aims to identify the best site to establish a public hospital using an Analytical Hierarchy Process (AHP) and multi-criteria decision analysis (MCDA) in Bishoftu City, Ethiopia. Seven determinant factors for public hospital site location were selected based on a literature review and expert interview and used for the location selection evaluation. The factors were developed and standardized based on suitability rankings. AHP was employed to determine the relative importance of the factors. Suitable sites for public hospital development were determined through weighted spatial overlay analysis in a GIS environment. The findings show that among the factors, land use and land cover, population density, proximity to roads, and distance from an existing hospital are found to be the most significant factors. The results also reveal that and 9.49%, and 60.03% of the study area are identified as highly suitable and suitable for locating a new public hospital, respectively. This study would provide planners and stakeholders with important information regarding appropriate alternative sites for a public hospital in the future in Bishoftu City. A decision on urban facilities' location based on the results of scientific research enables effective use of existing limited resources.

Keywords: AHP, GIS, Multicriteria, public Hospital and suitability analysis.

CHAPTER I. INTRODUCTION

1.1 Background of the Study

Hospital is a medical facility that provides service care for both inpatients and out-patients and treats many types of diseases with professionals. Hospital an institution that is built, staffed and equipped for the diagnosis of disease for the treatment both medical and surgical of the sick and the injured; and for their housing during this process (Perry and Gesler 2012). The modern hospital also often serves as a centre for investigation and for teaching.

Hospitals are one of the most important health facilities in every society Therefore these facilities should be located in a rational manner. Hospital site selection plays a vital role in the hospital construction and management. From aspect of the government, appropriate hospital site selection will help optimize the allocation of medical resources, matching the provision of health care with the social and economic demands, coordinating the urban and rural health service development, and easing social contradictions. From aspect of the citizen, proper hospital site selection will improve access to the health care, reduce the time of rescue, satisfy people's medical needs as well as enhance the quality of life (Murad2007).

One of the most important facilities in a community is the hospital. Due to the complexity of clinical buildings, in order to find suitable site for construction of hospital, it is required to use sophisticated analysis with consideration of large numbers of critical issues such as technical, environmental, physical and social issues and many others. Site suitability analysis is the process of determining the fitness of a given tract of land for a defined use (Steiner and McSherry 2000).

GIS is known as a benefit tool for spatial analysis issues, there are some disputes regarding whether the GIS decision support capabilities are sufficient (Jankowski 1995). That is because spatial decision problems typically involve a large set of feasible alternatives and multiple, conflicting and incommensurate evaluation criteria (Malczewski 2006). In fact, GIS is a decision support system and not a decision-making system. Therefore, it is required to integrate some weighting or decision techniques such as Multi Criteria

Decision Methods (MCDM) with GIS to increase their analysis capability in site suitability process. On the other hand, GIS is used for detailed analysis of the spatial decision context where as MCDM is applied to compare the set of identified alternatives (Joerin et al. 2001).Based on weighting process, MCDM can be helpful to provide results in the form of suitability map to the specific objective (Fung and Wong 2007). The choice of the MCDM is very important since it has a significant effect on the outcome (Al-Shalabi et al. 2006). The MCDM characteristics and properties should be compatible with the specific nature of the decision problem (Laaribi et al. 1996 and Salminen et al. 1998).

Many countries and institutions pay great attention to hospital site selection choosing the location of a new service, such as hospital site, is an important decision-making problem for the urban planner and decision makers. Determining the best site from a number of alternative sites is a difficult and complex process. Site selection is a kind of decision-making process that requires many criteria to be weighted and alternatives to be evaluated and ranked. (Ibrahim E.H, Mohamed and Atwan, A.A.2011)

Hospitals are one of the most important health facilities in every society. Therefore, these facilities should be located in a rational manner. The present study aims to select new site for establishing new hospitals and assess the location of the existing hospitals in using the geographical information system (GIS) Methods: The increased focus of people on the quality of health care in recent years has led hospital owners to develop strategies and policies to improve medical services through the establishment of new hospitals. For hospitals to be competitive, the hospitals location and proximity to potential patients are considered crucial factors in establishing new hospitals. (Ajanaw, 2021).

GIS technology allows us to make informed decisions based on the importance and priority of resources most of which are limited in nature. GIS technology may be used to create intelligent maps and models that may be interactively queried to get the desired results or may be used to advocate social investigations and policy based research. It may be used to reveal spatial patterns that are embedded in large volumes of data that may not be accessed collectively or mapped otherwise. GIS technology has become an essential part of everyday life. It’s used to track everything from personal fitness to transportation to changes on the surface of the earth. “It’s one of the hottest technologies out there,(said Professor Sunil Bhaskaran, founding director of the Geospatial Center of the CUNY).

In the location selection process, locations are evaluated with respect to certain specified criteria. These criteria are significantly different from location to the other. Selecting the criteria that the locations will be evaluated against them is affected by some factors. Some locations require a location with certain geographical specifications, in a good environment. Some criteria will be defined with respect to the objectives of the facility.(Pérez et al. 2001).

1.2 Statement of the Problem

The outbreak of the novel corona virus (COVID-19) has rapidly spread, causing million confirmed cases, thousands of deaths, and economic losses. The number of cases of COVID-19 in Bishoftu is increase in day to day and Ethiopia is one of the countries in the world in which the global deaths occur (Gaym 2012&Shiferaw2013).

Increasing urbanization with an increase in the number of residence needs health services with new site facility site selection which results increase in accessibility of the selected site. In the past, site selection was based on economic and technical criteria but today city of the world experiencing different site selection methods (Ilija Cosic & Aleksandar Rikalovic 2013)

According to the standard set by the ministry of health, one district hospital is for 250,000 people, one regional hospital for 1,000,000 people and one specialized hospital for 5,000,000 million people as a result, Bishoftu is the capital city of ada wereda which has construct new hospital is good for the people of the city. To build new hospital there is need for GIS analysis to locating allocation and evaluate for new Referral Hospitals.

The current public hospital site area of the study not placed in appropriate site, the elevation of the site is not suitable to construct new building and Covers small amount hectare itsown disadvantage to all facilities. According to Ethiopian Standard Agency in (October 2018) the hospital shall be built preferably in a terrain with a geographical elevation. The hospital shall be provided with road access, high people concentration, not far from residential places water supply, electric city and communication facilities

New hospital constructions should take this criterion seriously. Keeping the distance from other existing hospitals as well as anticipating impact from each other, is not only

relevance to rational resource allocation, but also does matter to the fair competition in the market economy. “There is an oral agreement that normally the distance is 500 meters. (Ji-Shun 2011)

A hospital should be located near the roads, especially the main roads nearer the better. However, the noise from motor vehicles passing by influences the patients in the hospital. Therefore a quiet distance of 100 meters is set. The nearer is the better. (Ali & Ibrahim, 2011)Road here means main thoroughfare or trunk road.

The experience of public services delivery upon realistic scientific studies is not yet fully developed in Ethiopia. The current condition of rapid population growth in Ethiopia requires a special means of providing services and facilities such as health institutions (Clinics, health centers, Hospitals etc.), schools, water, market centers, power, infrastructures, fuels etc. in both urban and rural areas where as they are still considered as necessary material conditions for good human health (David H. Petersetal 2008)

The current studies fills this gap by considering the growth of urban aspect by identify major influential factors related to the existing problem of the public hospital site and identify the urban growth stage to build or to locate suitable site selection for public hospital site occurred during the study period. Because a better understanding of those factors that are essential to locate new public hospital site. In this regard, researchers carried out a number of studies on the case of site selection for public Hospital site in Ethiopia and the World at large. For instance a study like GIS site selection was conducted at Adama, Ethiopia (Temesgen2021), and site selection based on GIS, at Middle East technical university (Basak2002). But these studies could not saw the economical and future situation of the country. Therefore, to analyze the result must include city level in related to future situational structure and its main driver using spatial overlay analysis model will be applied in the GIS environment. As for the aspects of suitability analysis, hospital site selections should take into account numerous parameters, such as the existing hospitals, population, economic factors, temporal administrative laws and regulations. How to classify and analyze these parameters then integrate them together for the whole projectmany studies are devoted to this problem: (Nobreetal. 1999) adopted multi-criteria analysis to assess priorities in health care.

1.3 Objective of the Study

1.3.1 General objective

The main objective of the study was Suitable Site Selection for Urban Facility Location Using AHP-MCDA in Bishoftu City: The Case of Public Hospital

1.3.2 Specific Objectives

The specific objective of the study is to:

- Identify the criteria's which affects the site selection for public hospital site in Bishoftu City
- Standardize suitability of the main determinant factors for public Hospital development in study area
- Determine suitable sites for locating new public hospital in the study area

1.4. Research Questions

- What are the main factors to be considered in selecting suitable site for locating new public hospital in Bishoftu city?
- How can suitability of the main determinant factors for site selection for public hospital development in the study area be standardized?
- How can suitable site for public hospital location in Bishoftu City be determined?

1.5. Significance of the Study

The result of this study will benefit three different groups:

- Individual researchers, urban planners, and decision makers considering the significant factors that are governing the city location for public hospital for further analysis on different criteria and also use the result as reference for teaching learning process.
- Government: the result of this study also helps the city administrator and urban planning institute for decision making in order to protect disorder development of the city and maintain sustainable development.
- Society: society will be benefit from this study result if the government takes appropriate action to maintain the quality of urban life and pleasantness to live.

1.6. The Scope of the research

The spatial scope of this study was limited to Oromia Regional State, Bishoftu city Administration. Whereas the contextual scope was urban facility location using AHP and MCDA system for a case of public hospital particularlyfor Public hospital site during the study period and the study is concerned to indicate the geographical barriers of existing hospital site.

1.7. Limitation of the study

The study is constrained by the following limitations

- One of the major limitations was that parameters or criterion of Public Hospital development were set by reviewing different literature and prior knowledge of the study area instead of common standards.
- Lack of organized secondary data due to the absence of documentation and organized database system in the study area.
- The data collected from administrative offices it's have different boundary so that the data lack well representation of the area

1.8. Organization of the thesis

This organization of the thesis is included to give the reader a brief overview of the thesis and to give an understanding for how the work was structured. There are five chapters of the thesis that follows by ASTU format. Details of each chapter are given below: Chapter one includes Introduction- which introduced the background of the study, problem statements, and the general objective of the research include the specific objectives and the research questions, significance of the study, scope of the study and organization of the thesis. Chapter two Literatures review - The second part of the research is literature study, reviewed related papers to find the scientific support and the theories. Presents the literature review of site selection, AHP, and MCDA based site selection in GIS, Chapter 3: Materials and Methods - The chapter three gives an account of geographical study area, method of data collection and source of data, software used, methods, method of data analysis and GIS based MCA model used for the research. Chapter Four Data analysis, results and discussion presents the model for the proposed site selection and discusses the function of each component and their relation. The implementation detail of the model such as tools, techniques and methods used to develop the system will describe in Chapter

Four. Chapter five Conclusions and Recommendations Finally this chapter includes Conclusion and some recommendations.

CHAPTER II. LITERATURE REVIEW

2.1 General Overview

The site selection for public hospital is strategic matter identification of suitable site commonly believed as the most vital factor in leading facilities in the success of any region. Appropriate sites help keep to reduce overhead costs and improves accessibility. In addition, a good suitable site can improve access facilities, such as healthcare centers, fire stations, schools, hospitals, emergency response services, and libraries, which can deliver excellent service to the public at a low cost (ESRI 2016). The spatial planning of healthcare services implies that the use of GIS has been increasing for identifying a suitable site for a given number of services in a defined region. Any healthcare needs spatial distribution of population can be served in an essential factor (Amer 2007).Land suitability evaluation can contribute towards better land management; mitigation of land degradation; and designing land use pattern that prevents environmental problems through segregation of competing land uses. The output of suitability analyses provided not only the type of land use for which the land was suitable, but also information about the type of limitation facing the utilization of land (Safa and Majed, 2019).

The following terminologies are of special concentration throughout the section for public hospital site. They are described by (Arifin2011) as follows:

Urban Facilities Basic facilities that support urban development in accordance with a Comprehensive Plan and that are primarily planned for by cities but also may be provided by counties or districts.

Facility**:** - is used in service area problem to define an object whose spatial position is optimized through model or algorithm considering interaction with other pre-existing objects. In many service area models, one of the properties of the facility is the number of new facilities that need to be established in the area of interest. Thus a single facility problem inside the location allocation model needs to establish only one new facility considering the existing facilities. This is very simple instance of location allocation model. Multi facilities inside service area model are more common where more than one facility is located simultaneously. Another important property of facility is type. Facility type includes the capacity of the facility and the services of the facility. Facility can be characterized as capacitated and incapacitated considering how much demand it can meet.

Public hospital: **a** public hospital is hospital which is owned by Government and receives governmental findings this type of hospital provides medical care for publics. Hospital has become a most important facility to cure people health related problems and improvement standards healthy life.

Factor is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration. It is therefore measured on a continuous scale. For example, a forestry company may determine that the steeper the slope, the more costly it is to transport the wood. As a result, better areas for logging would be those on shallow slopes the shallower the better. Factors are also known as decision variables in the mathematical programming literature (Fiering, 1986) and structural variables in the linear goal programming literature (Ignizio, 1985).

Accessibilityis quite complex term to define and it becomes more complex because the measure of access does not simply indicate the presence of a health care facility. The presence of service does not ensure the utilization of these facilities in relation to need and health care service users and service provider professionals (Penchansky and Thomas 1981) observed that access most frequently viewed as a concept that somehow relates to the consumers‟ ability or willingness to use health care services and should consider the personal, financial and organizational barriers to health care service utilization. In contrast, (Murad 2004) argued that access is a question of supply whereas, utilization is a function of both supply and demand. Equity of access is purely a supply side consideration in the sense that equal services are made available to patients who have equal health concern (Goddard and Smith, 2001).

Access described as the degree of fit between users and a service. The degree of fit might be influenced by the availability, accessibility, accommodation, affordability and acceptability of service (Penchansky and Thomas, 1981). Furthermore, access is linked with the demographic, socio-economic and cultural characteristics of the population, locations of the health care facilities and of the transportation network. In other words, access is patterned both spatially and socially (Field, 2004). Spatially, the more resources that are provided into an area for use the greater the likelihood that people will use those resources and live in that surroundings. Access to an existing resource or facility (e.g. a hospital or a road network) is generally understood as the capacity of an individual to obtain a service when it is needed (Samat and Shattar, 2014). The meaning of access, however, can vary among researchers, policy

makers, politicians and publics due to differences in their education, history, workplace condition and cultural context.

Accessibility can be defined in terms of mobility, which includes a number of spatial and non-spatial attributes as well as temporal constraints, of individuals or groups. Accessibility can be measured by either Euclidean and Manhattan distance or travel (driving or walking) time or travel cost. Accessibility can be described as travel impedance (travel distance or travel time) between patient location and health care service points (Guagliardo,2004). Accessibility and availability are not similar terms and accessibility may depend on availability of services.

2.2Healthcare Accessibility in Ethiopia

In Ethiopia, 64.7, 40.1, 38.0 and 14.2 percent of households are within the five-kilometer radius from nearest health posts, clinic, health center and hospital, respectively (Table 2.1). From the total households 83.9, 63.1, 59.6 and 20.8 percent are within a distance of less than 10kms from health posts, clinics, health centers and hospitals, respectively. There are also rural urban disparities in health facility distribution. In urban areas health posts, clinics, health centers and hospital are available within a distance of less than 5kms for about 88.2, 87.7, 87.7 and 49.4 percent of the household, respectively (CSA, 2012)

Table 2.1 Percentage distribution of households

Type of institution		Below 1 km	1-4km	5-9km	10-14km	15-19km	>20km	Not stated
Country	Health post	15.29	49.39	19.23	4.06	1.71	0.72	9.61
	Health center	9.42	28.56	21.63	11.53	9.67	10.28	8.91
	hospital	2.39	11.87	6.56	4.63	5.93	64.83	3.83
Rural	Health posts	14	48.6	20.4	4.3	1.8	0.8	10.0
	Health center	5	19.3	26.1	14.6	12.3	13.1	9.5
	hospital	0.3	1.2	4.7	5.1	6.3	78.9	3.7
Urban	Health posts	30.1	58.1	3.5	1.2	0.2	0.3	4.7
	Health center	25.4	62.3	5.3	0.3	0.1	0.1	6.6
	hospital	8.2	41.8	11.9	3.4	4.8	25.6	4.4

Source: (CSA, 2012)

2.3 The Site Selection Process

According to (Taylor et al 2003), site selection using GIS technology process requires two stages. The first is the GIS stage, which involves two primary screening steps leading to the identification of target areas for the location of landfills, and a secondary screening step in order to identify suitable individual sites, utilizing output from the previous steps, and involving more detailed local information and site-specific analysis. Secondly, geotechnical evaluation stage, involving a rigorous geological/ hydro-geological assessment of individual sites identified within the target areas, employing a combination of site investigation and laboratory techniques.

2.4 A Review on Site Selection Methods

The distribution of location for city is one of the major challenges for urban planners. The cities of the Global countries are so diverse and complicatedly rigid that land-use flexibility diminishes. Most of the time, it becomes complicated and intricate to make decisions about land use and its suitability in a short period (Int. J. Geogr. 2006.). Also, different factors like physical, economic, social, environmental, and political issues are involved in distributing and allocating land for a particular purpose (Al-shalabi& S. Bin Mansor 2006). The uncertainty of location suitability is not only concerned within urban areas. It is also related to climate and disaster-related subjects like selecting a suitable location for a (Trans. GIS, vol. 2012). But the complexity of the current urban system is so overly interrelated that the urban planning practitioners need to find a method of locating a suitable site for facilities like schools, hospitals and fire stations (abdullahi and ArbinMahmud 2014). Over time and the evolving phase of Geo technology and participatory method, many models and theories are available for site suitability analysis.

2.5 GIS applied on site selection

According to Environmental Systems Research Institute (ESRI, 1990), a geographic information system (GIS) is “an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.” From the perspective of application, GIS is consisted of five key parts: hardware, software, data, methods and people. The data and information in GIS is geographically referenced (geo-coded). For the GIS methods, as (Lakhoua2011) concluded that “A GIS has considerable

capabilities for data analysis and scientific modeling, in addition to the usual data input, storage, retrieval, and output functions"

2.6 Multi-Criteria Analysis (MCA)

MCA is a procedure that typically multiplies conflicting criteria that are essential to be evaluated in decision-making. It has a wide application whether in our daily lives or in professional settings. As (Yassine and Adel 2011) elaborated, "The principal of the MCA is to condense complex problems with multiple criteria into finest ranking of the best scenarios from which an option is selected". The criteria are weighted according to their importance, and their weights have a more or less favorable on the final decision than another (Diakoulaki&Karangelis 2007).

GIS-based MCA includes two essential parts: factor criteria and constraint criteria. Each of the criteria is appeared as a map layer, no matter for factor or constraint criterion. Factor maps are represented as spatial distributions to display the opportunity criteria and the quality of achieving an objective. Constraint maps are limitations or restrictions which prohibit certain elements to be taken into account the analysis (Malczewski, 1999). Correspondingly, the GIS-based MCA includes two major methods: weighted summations procedures and Boolean overlay operations (Yassine& Adel 2011).

Decision making about proposals for future action should normally follow the sequence below stated below. The following process might apply to the development of a policy, a program or a project(Malczewski, 1999).

- Identification of decision makers (DMs), actors, and stakeholders.
- Identification of criteria.
- Identification of alternatives and options for achieving the objectives.
- Assignment of criteria performance values.
- Weighting the criteria.
- Ranking the alternatives.
- Making Analysis

2.7Analytical Hierarchy Process

The work in (Jack Malczewski, 2008) (Ali Asghar2008) (Busief Mohamed andA. Shouman Ibrahim 2012) defined AHP is:

- The quantitative method for selecting among alternatives based on their relative performance with respect to one or more criteria of interest.

- A simple systematic engineering method to quantitatively analyze non-quantitative objects

The hierarchy of AHP is constructed through pairwise comparisons of individual judgments, rather than attempting to prioritize the entire list of decisions and criteria simultaneously.

The AHP procedure generally involves six steps (Wen-Chin 2008)

- Define the unstructured problem, identification of input/output parameters

In this step the unstructured problem and their characters should be recognized and the objectives and outcomes stated clearly.

- Representation of a structure by hierarchy

The first step in the AHP procedure is to decompose the decision problem into a hierarchy that consists of the most important elements of the decision problem. In this step the complex problem is decomposed into a hierarchical structure with decision elements (objective, attributes i.e. criterion map layer and alternatives)

- Paired comparison between elements at each level

For each element of the hierarchy structure all the associated elements in low hierarchy are compared in pair wise comparison matrices

- Calculations of the weight at each level

Some methods like eigenvalue method are used to calculate the relative weights of elements in each pairwise comparison matrix

- Test the consistency of each matrix

In this step the consistency property of matrices is checked to ensure that the judgments of decision makers are consistent

- Priority of an alternative by a composition of weights

  In last step the relative weights of decision elements are aggregated to obtain an overall rating for the alternatives

Decision is a choice between alternatives. Criterion is some basis for a decision that can be measured and evaluated. It is the evidence upon which a decision is based. Criteria can be of two kinds: factors and constraints.

- A factor is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration. It is therefore measured on a continuous scale.

A constraint serves to limit the alternatives under consideration. In many cases constraints will be expressed in the form of a Boolean (logical) map: areas excluded from consideration being coded with a „0“ and those open for consideration being coded with 1 (Jie Wu Lina Zhou 2012)(AleksandarRikalovic 2013)

2.8 Site Selection of New Hospital (China Experience)

According to Environmental Systems Research Institute (ESRI, 1990), a geographic information system (GIS) is “an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.” From the perspective of application, GIS is consisted of five key parts: hardware, software, data, methods and people. The data and information in GIS is geographically referenced (geo-coded). For the GIS methods as (Lakhoua2011) concluded that “A GIS has considerable capabilities for data analysis and scientific modeling, in addition to the usual data input, storage, retrieval, and output functions”. 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 (Louviere etal 2000) or Index Overlay operations (Nikolakaki 2004, Alesheikhetal2008,Alesheikh and Sadeghi 2007)Nowadays, the GIS approaches used in the site selection usually are network analysis, spatial analysis, proximity analysis.

Existing hospital: new hospital constructions should take this criterion seriously. Keeping the distance from other existing hospitals as well as anticipating impact from each other, is not only relevance to rational resource allocation, but also does matter to the fair

competition in the market economy. “Although the civil service in haidian District has not expressly stipulated the exact distance for the new hospital to keep from the existing hospitals, there is an oral agreement that normally the distance is 500 meters.” said by (Ji-Shun 2011), the deputy chief of the Medical Affairs Section in haidian Health Bureau. Hence, in this study, the new hospital is also wished to keep a distance of 500 m from the existing hospitals, the further away the better.

Residential area: the residential area in a way that means the resident population, so the nearer from the residential area, the better. Here are two reasons for taking the residential data to replace the population data. First, the latest detailed population data (the sixth census of China) has not been officially released. Second, the population data need to be converted to geo-referenced thematic map, if not detailed enough, the map will tend to show an average population level in a comparatively large area. Thus it will lead to a less precise result. On the other way around, the location and density of the residential areas can compensate these temporary drawbacks to some degree.

Road: theoretically, a hospital should be located near the roads, especially the main roads the nearer the better. However, the noise from motor vehicles passing by influences the patients in the hospital. Therefore a quiet distance of 100 meters is set. Outside the buffer zone, the nearer the better. Road here means main thoroughfare or trunk road.

Metro: normally, metro is the fastest way of transportation in the urban area of big cities. More and more people prefer to go by metro than other transport methods because of the frequent traffic jam. Fast growing metro construction in Beijing also calls attention to hospital building decision makers.

River: in case the new hospital drains sewage to river, at least 300 meters distance along the river should be used. Outside the buffer zone, the further away, the better.

Public toilet: to avoid the new hospital being polluted by bad air and drainage around the toilet, a safe clearance of 200 meters is necessary. Outside the zone, the further away, the better. All in all, the criterion of existing hospital mainly considers its distance from and impact allocation. Road, street, sub-street and metro refer to the access to the public transit routes. River and public toilet are related to the contamination or population. River and

public toilet are related to the contamination or population. The specific buffer requirements for these factor criteria are shown in the Table 2.2 on the new hospital. Residential area is corresponding to the population density.

Table 2.2 Hospital's residential area

Factor Setting	Setting
Existing hospital	The further away from the existing hospital (>=500m), the better
Residential area	The nearer away from the residential area, the better
Road	The nearer away from the road (>=100m), the better
Metro	The nearer away from the metro station (>=100m), the better
Water body	The further away from the river (>=300m), the better
Public toilet	The further away from the public toilet (>=200m), the better

Source: adopted from (Lakhoua 2011)

2.9 Site Selection Context and Site Selection Requirements in Ethiopian

The entry point to the health center shall be clearly defined from all major exterior circulation 1modes (roadways, bus stops, vehicle parking). 2. The entrance and exit of the health center shall be easily accessible,clearly marked/labeled and located. 3. Boundaries of the health center between public and private areas shall be well marked and clearly distinguished. And clearly visible and understandable signage and visual land marks for orientation shall be provided 4. Health centers shall be located away from unordinary conditions of undue noises, smoke, dust or foul odors, and shall not be located adjacent to railroads, freight yards, grinding mills, chemical industries, gas depot and waste disposal sites. 5. The locations of a health center shall comply with all national and state level regulations applicable to health facilities. 6. In addition to these requirements stated above the site selection criteria shall consider or include the followings, but not limited to: a) the minimum size of a health center premises shall be 2,000-5,000 m^2 with at least one adjacent road access. b) The health center shall be built preferably in a terrain normal elevation c) The foundation schemes, soil test and investigation shall be done and it shall comply with the national building code. d) The health center shall be provided with road access, water supply, electric city and communication facilities. e) The building shall be

parallel to the wind direction, sun glare and heat. f) The surroundings of the health center shall be free from dangers of, landslide, theft, intrusion of stray/wild animals, pollution of any kind (example air, water and sound) and health hazards. g) The health center shall be landscaped, therapeutic, appealing scenery, attractive with green areas/beautiful trees.(Ethiopian Standard, 2012)

Within residential area; near intersection of residential roads; far from noisy activities (for health post only) Health center 1,500 - 2,000 meters far away from activities that have undue noises, smoke, dust or foul odors, Shall not be located adjacent to railroads, freight yards, airports, grinding mill, traffic pools, industrial plants and disposal plants.

200-500 meters far from bars& night clubs, schools, commercial market centers, religious facilities, children's playgrounds Health institutions stationed in the premises of airports or industrial plants shall have 200-500 meters distance 1,500 meters far from a gas depot or cross country petroleum or gas pipelines. The locations of a hospital shall comply with all relevant national and state level regulations.

The hospital shall be built in a flat terrain with a gentle slope; The foundation schemes, soil test and investigation shall be done and it shall comply with the national building code; The hospital shall be located along collector roads within walking distance from mass transport, a need to have water supply, electric city, public phones, etc; The surroundings of the hospital shall be free from dangers of flooding, pollution of any kind (example air, water, noise) and health hazards; From landscape point of view it should be attractive i.e. with green areas and beautiful trees

2.10 Factors Affecting in public hospital site selection

Public hospital site selection is affected by different factors like availability of roads, land cover type, topographic condition, population distribution and mode of transportation used to reach site selection facilities

2.10.1 Road distance

Availability of modern transportation facilities can bring positive impact on health condition by increasing option for commuters, and creating connections to health services. On the other hand, lack of access to affordable transportation facilities is main contributor to health disparities (LCEF, 2011). Availability of roads allows covering an extensive catchment area,

which are located very far from existing health facilities. Its presence increases areal coverage, and number of population served by health facility, and vice versa.

2.10.2 Land use and land cover (LULC) classification

Land use and land cover (LULC) is an important measurement for assessing global change across a range of spatiotemporal scales (Lambin2010). LULC is a widespread, ever-accelerating process largely driven by human actions, and in many cases it also drives changes that affect humans (Agarwaletal. 2011). The increasing scarcity of natural resources is the result of vast agronomic development and demographic pressure. Hence, information on land use/cover and strategies for optimal use are critical for the design, development, and application of land use/cover strategies to meet the growing needs to support basic human and animal health and welfare. This information is also helpful for monitoring the dynamics of LULC arising from the demands of an increasing population (Pande 2014).

An understanding of LULC patterns is essential for the management and development of natural resources (Myers 2013). Changes in land use and land cover patterns must be considered from the perspective of complex factors related to technology, demand, and social relationships affecting both ecological capacity and demand, along with the nature of the environment itself (Verburgetal 2014).

Environmentalists are largely concerned with the effects of LULC as they pertain to biodiversity and water ecology (Turner et al. 2011; Butt et al. 2015). Variation in land use/cover in a watershed can affect groundwater quality and source. For example, LULC due to watershed development and management commonly results in higher surface runoff, decreased groundwater recharge, and application of chemicals (Turner etal. 2001). Thus, the determination of land use/cover patterns and their variations in watershed areas is vital to the development and management of water properties and land use planning.

2.10.3 Topography

Topography is an important barrier to public hospital services. It can influence both positively and negatively, the speed of travel time for land cover types. Its impact is more pronounced if patients are walking or using bike to reach public hospital site selection from their home. The effect of topography will be positive if patient is walking or biking

downward from his home to public hospital facilities. Such type of effect is called anisotropic effect and analysis of such effect is anisotropic analysis (Murad, 2008).

2.10.4 Population Distribution

Population distribution is a central issue on public hospital service delivery. Population is the demand for health care services and any work in health care services (it can be planning, establishment of new health care services etc.) need to consider the spatial distribution as well as spatial separation of population. In this case, populated areas are beneficiaries while less populated are disadvantaged.

This spatial distribution and profiling of population (representing potential demand for public hospital) is major importance for evaluating health care supply in developing countries. Public authorities can use this information to structure healthcare system, in terms of both capacity of facilities and their location (supply) for the attendance of Population (Costa et al., 2011). The type of health facilities for a population is mostly determined by its size. In the case of Ethiopia, 5000 people are needed for a health post, 25,000 are for health center, and 250,000 and above are required for hospital (MoH, 2010).

2.11 Hospital site selection In Geographical information system (GIS)

Some areas that is suitable for hospital. Those are: The hospital should be situated near the major road as the major road is the main communication system of the city the hospital should be situated in the proper land use mainly in the residential areas as the residence is the main user of public hospital. Also there are some qualitative data and analysis that are being used to make the site more authentic for hospital. Those are: Population concentration is a fact as the hospital is needed mostly in the high population concentration areas. Employment concentration can be used as the less employment concentration the area further away from roads is considered less suitable than those closer to roads (Babban, Parry 2001).

Therefore, areas less than 1000-meter from the road are more suitable for urban development Where as the area greater than 3000 meters from main road is least suitable theoretically, a hospital should be located near the roads, especially the main roads then earer the better. However, the noise from motor vehicles passing by influences the patients

in the hospital. Therefore a quiet distance of 100 meters is set. Outside the buffer zone, the nearer the better. Road here means main thoroughfare or trunk road

The Ethiopian government has also stated clearly on the service site selection standard as "the selected site should be adjacent to the road" even if the type of road which should be adjacent is not stated (Ethiopian Standard Agency October 2012,). Some roads like ring roads and highway road have noise from motor vehicles passing by influences the patients in the hospital. Therefore, Distance from the road in 100 meter radius is mandatory. The nearer outside the buffer is, the better

2.12 Empirical Related Literature Review

A study introduced by (Aseel Kmail December 2017). In their study, "GIS-based MCA and AHP techniques for Hospital Site Selection in Jenin governorate" Using GIS for an area of approximately 231km^2 with a population of using ArcGIS Multi-criteria decision making and stake holder's interview as the two approaches with variables considered asslope, land cover, distance to airport facilities, distance to rivers and lagoon, distance toexisting major roads and distance to populated communities. At the end a composite map was arrived at which shows areas that satisfied all the suitability criteria, then final analysis was carried out using the overlay function in Arc Map and total suitable area was found to be 20km^2 in the land north of Jenin governorate Area.

A study was made by the authors in (Maglogiannis I and Hadjiefthy miades S 2007) combined GIS with suitability analysis in order to settle the affairs of emergency medical incidents. On the other hand, other authors employed GIS techniques and methods in selecting the best site for building health care facilities. In order to build constructions that provide health care facilities, various parameters (i.e. factors) can be considered to identify the most suitable sites such as existing health care facilities, population, economic factors and pollution. These parameters can be classified, analyzed and integrated together in different methods. For example, MCA is used to identify factors that affect building new health care objects in (Nobre, F.F, Trotta, L.T.F, and Gomes, L.F.A.M, 1999). While in (H., Minakami, H.,Yamamura, E., 2007), the researchers employed GIS and Multi-criteria decision making to determine the parameters that affect the physical accessibility of neurosurgical emergency hospitals in Sapporo city. At the same time, the authors of

(Huang-Chu, C 2007.) exploited MCA to evaluate the appropriateness of the location selected for Taiwanese hospital.

Different studies have utilized geographic information systems (GIS) to construct a hospital or problems conserving to health care. Some of these studies are very particular, and others are explained the number of issues (Aguayo et.al 2007) revealed that suitability analysis areas are stimulated by distance and density of specific elements which implies proximity and neighborhood are two important driving forces to site selection .It is difficult to develop an area if the road network is not well constructed because roads open many opportunities, especially for business by attracting higher population migration. Resident's desire to live at a location with easy access to other destinations helps to explain not only facilitates residents" daily lives but also reduces construction cost for amenities like shopping malls and hospitals (Li, Zhou &Ouyang, 2013).

The work in (Temesgen2021) geospatial based site suitability analysis of new public Health centres in adama city this author the objectives such as find Suitable place for enhanced efficiency and better service quality utilized as a criterion for determining accessibility of health centre's in adama city As a result, there is overlay analysis technique for assessing healthcare site.

The work (Husain. m 2019) suitability analysis of new urban facilities for healthcentres in jijiga city examines an approach for identifying the site for the construction of a healthcentres. A multi-criteria approach was employed in conjunction with GIS-based overlay analysis to identify the suitable site for healthcenters in the city. This study was based upon a set of 9 criteria, described that suitability analysis areas are stimulated by distance and density of specific area

2.13 Related Literature Gaps

The studies fills this gap by considering the growth of urban aspect by identify major influential factors related to the existing problem of the public hospital site and identify the urban growth stage to build or to locate suitable site selection for public hospital site occurred during the study period (AseelKmail December 2017). Because a better understanding of those factors that are essential to locate new public hospital site. In this regard, researchers carried out a number of studies on the case of site selection for public Hospital site in Ethiopia and the World at large.

From the literature review it is clear that facilities pose a major challenge to Accessibility, geographical features and both the environment and communities around. New partnerships among all relevant stakeholders should be formed and specifically the facilities to undertake joint planning and accelerate projects to mitigate challenges affecting all them. The main challenge here is coming up with means to factors affecting faciites (Husain. m 2019)(Temesgen 2021).

2.14 Conceptual frame work

The basic aim of MCE analysis techniques is 'to investigate a number of choice possibilities in the light of multiple criteria and conflicting objectives' (Voogd2013). In doing so it is possible to generate compromise alternatives and rankings of alternatives according to their attractiveness (Janssen and Rietveld 1990). Given the current emphasis on site location via a process of map overlay, the problem facing decision makers concerns the identification of best compromise sites on the basis of an evaluation of a finite number of choice alternatives by a finite number of attributes, while taking into account conflicting views and objectives. The term 'choice alternative' refers to any available option in the .choice set, here defined as an individual site.

The basic starting point of any MCE analysis is the construction of an evaluation matrix, the elements of which reflect the characteristics of the given set of choiceSome consideration of the MCE and AHP techniques adapted here for use in a GIS framework is required to explain how they work. The information in this section is derived from published sources and so represents nothing new. Since the various factors taken into account in describing each of the choice alternatives are likely to be measured in different units, the evaluation matrix S needs to be transformed onto a normalized scale (i.e. 1= max,O=min). As indicated above, several common standardization techniques are available. These are described by (Voogd 2013) and include methods with an additively constraint (i.e. the standardized scores are based on raw scores divided by the sum of the raw scores), ratio scale properties and interval scale properties. The last method is GIS are often used to identify suitable areas for land development be it for forestation, a new hospital or, as in the example given here, a radioactive waste disposal facility.

As was suggested earlier, however, the functionality of GIS in this context is essentially limited to overlaying deterministic digital map information to define areas simultaneously satisfying two or more sitting criteria Few, if any. GIS provide the user with a

comprehensive set of tools for the evaluation of problems involving multiple criteria and conflicting policy objectives. Overlays are ideal for area screening using site criteria but have certain limitations when dealing with information of a non-deterministic nature. These are summarized by (Janssen and Rietveld 2010) as follows:

- Digital map overlays are difficult to comprehend when more than four or five factors are involved.
- Most overlay procedures in GIS do not allow for the fact that variables may not be equally important.
- When mapping variables for overlay analyses the problem arises of how the hold values used therein are defined (the outcome of area screening depends strongly on the choice of threshold values).
- The use of threshold values to map continuous variables, such as population density, on a nominal basis will inevitably lead to substantial losses of information.

Suitable site selection process considers four parameters such as accessibility, physical, environmental and socio-economic (Javadian et al., 2011; Chakma, 2014). Accessibility analysis encompasses any spatial analysis of the area like proximity to road and railway, different services; dangerousness of the location and natural features. Physical features deal with features and attributes of the land surface. For example, soil type, slope, elevation and topography are important parameters in the suitable site selection process. Environmental is an important parameter for suitability analysis such as distance from water body site, slope, etc. socio-economic is another significant parameter for suitability analysis such as LULC, population density, noise influence and historical and cultural area.

Generally, there are many determinant factors (main factors and sub factors) that affect public hospital development. Main factors are accessibility, physical, environmental and socioeconomic. Sub-factors include road, railway, slope, existing hospital, stream, park, LULC, population density, noise influence and historical and cultural area etc. The conceptual framework illustrated in figure 2.1 demonstrates the main components which determine LULC change, pubic hospital suitable site selection parameters and benefit of public hospital.

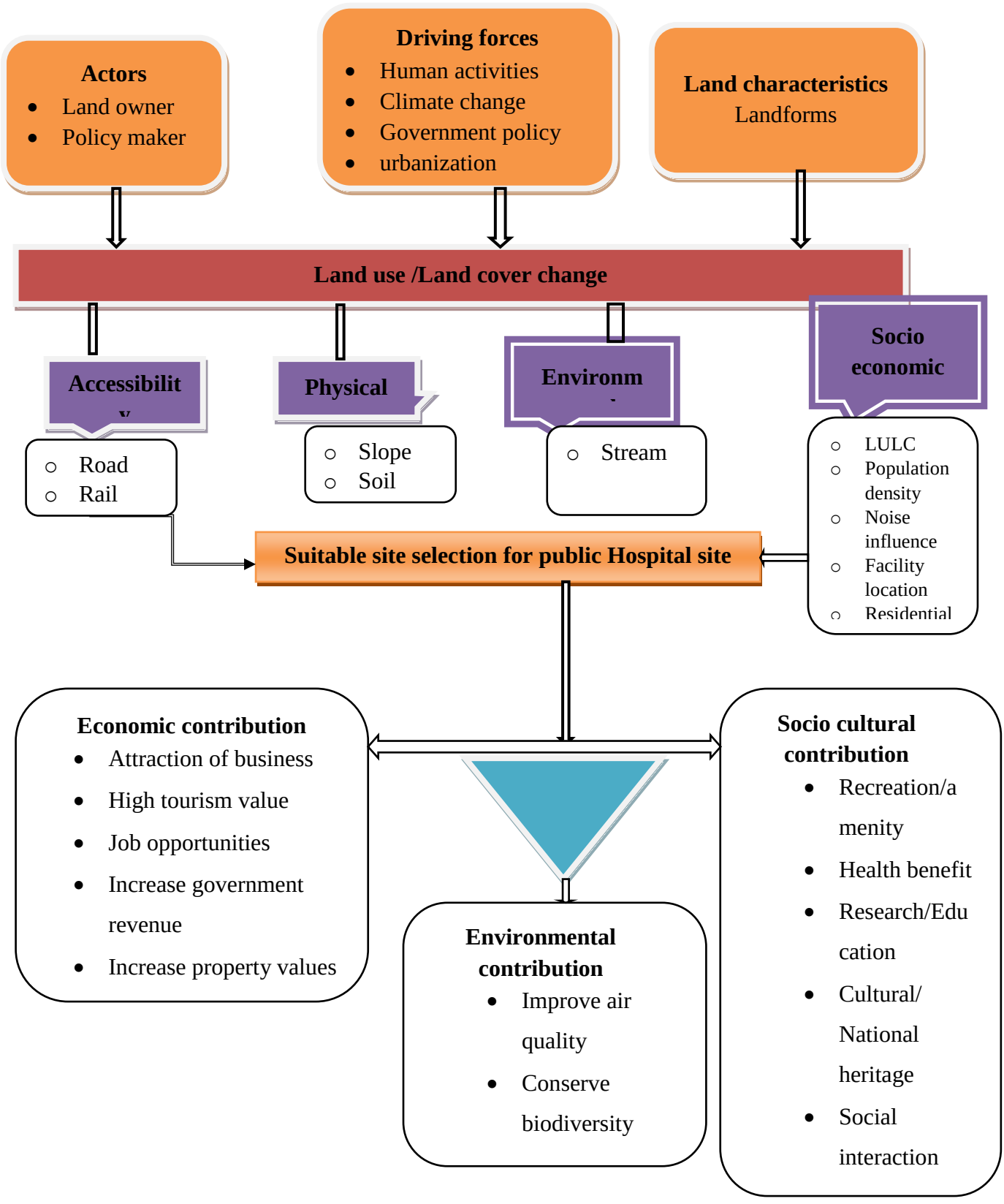

Figure 2.1: Conceptual framework for the study

Source: Hersperger et al., 2010; Mensah, 2014 and modified by the author

CHAPTER III. MATERIALS AND METHODS

3.1 Description of the Study Area

Bishoftu is one of the renowned City in the history of early urbanization process of Ethiopia in general and Oromia in particular. The natural beauty of the town such as attractive lakes, its landscape, and the existence of historical site makes the City to be one of the top tourist attraction sites in the country. Bishoftu City, with a total planning area of 18,577.36hectares, the city is located astronomically between $8^{0}45^{1}$- $8^{0}47^{1}$ North latitudes and $38^{0}56^{1}$-39^{0} East longitudes. It is situated at a distance of 47 km south East of Addis Ababa, and 52 Km from Adama. This has given Bishoftu town to be endowed with physical resources like Lakes and attractive landscapes standing here and there at short distances. (Oromia national regional government oromia urban planning institute may, 2012)

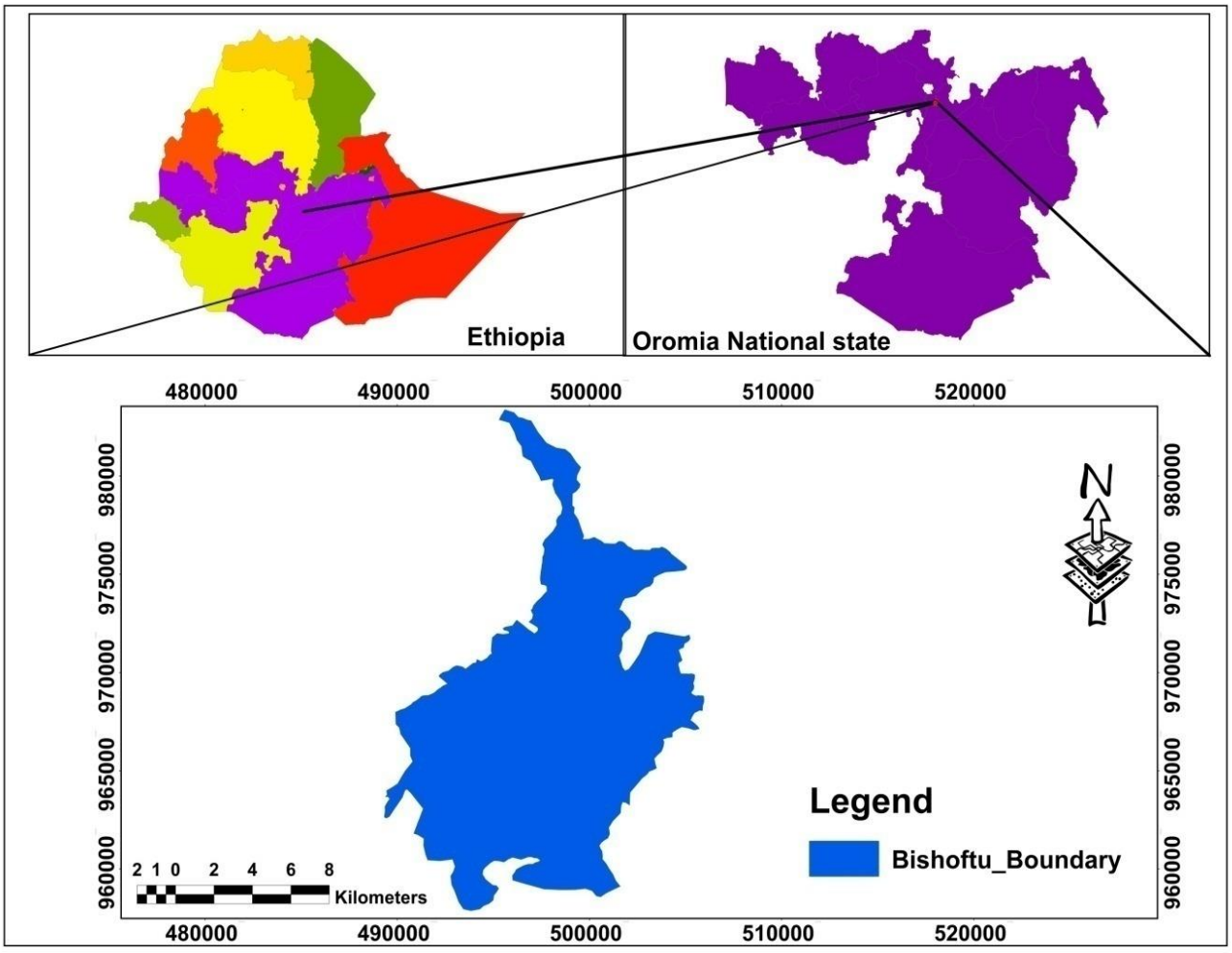

Figure 3.1 Location map of the study area

3.1.1 Elevation

The general elevation of the town ranges from 1746m to 1930m. The altitude is generally higher in the southwestern part of the town and gradually declines to east directions for few distances and then increases again to the same direction. Altitude declines gradually from north to south direction for few distances and then increases elevation again from north to south direction. The greatest proportion of the altitude of the town ranges between 1893 to 1930 meters and almost covers western, northern, and southwestern parts of the city the central part of the city where the lakes are found is surrounded by higher elevations ranging from 1856-1893m with few lower altitudes to access the lakes. Altitude of the water levels of the lakes also varies accordingly. The water level of Lake Kuriftuis located at elevation of 1858m above mean Sea level while the water level of Hora Arsedi Lake is located at elevation of 1844 m above mean Sea level. This shows that the altitudinal difference between the two lakes is 14m and this indicates that siltation is one of the problems of Lake Kuriftu besides diversion of water course from its natural flow. The water level of Lake Babogaya is found at altitude of 1752m above mean sea level. The water level of both Bishoftu and Green lakes is found at similar elevation of 1848m above mean sea level. (oromia national regional government oromia urban planning institute may, 2012)

3.1.2 Population

The population of the city is rapidly mounting from year to year at an average growth rate of more than 2.9 % per annul As the data obtained from the population study made by Bishoftu plan and Economic development office, the city has a total population of213,689 by the year 2017. From the total population 99,201 are males and 114,488 are females. (Source Bishoftucity administration office) including the rural kebeles currently incorporated under the administration of the city. The city administration has an estimated population density of 11 persons per hector. It is grouped under sparsely populated area in the East Shewa zone. Oromo people were predominately live in the area. But nowadays, there are more than five ethnic groups namely Oromo, Amhara, Gurage, Welayita, Tigre and others are living in the city.(CSA 30 years Population census report).

3.1.3 Topography

The topography of Bishoftu town and its environment comprises vast plain areas, swampy and water bodies, soft, rounded hips and hilly mountains, steep and rounded hills and associated undulating dissected areas. The town found at an average altitude of 1971m above sea level According to the study made by (OUPI, 2009) Structure Plan of Bishoftu Town Demographic Profile, Utilities and Social Services Final Report, the city growth has been limited, because of many lakes, vast military camps, many research and educational institutions, industrial establishments and developed urban agriculture within the town, its area is believed to be much larger than implied by its population size.

3.1.4 Climate

Climate is one of the prominent factors that affect the activities of people directly or indirectly. The elements of climate include temperature, humidity, rainfall and wind. All these elements affect the activity of every group of the society, including the urban community. It is mainly the altitude that makes the temperature and rain fall to vary from place to place and it controls other elements of climate. The altitude of the town ranges from 1900-1995m above sea level. Thus, it belongs to Woinadega (climate change), Its average temperature and rainfall are 18^0C and 816mm, respectively. May is the hottest month of the year, while November is the coldest month in the town. December and July are the driest and most rainy months of the year in the town with 2mm and 204mm of rainfall, respectively. (Source Bishoftu city administration office)

3.1.3Land Use Classes of Bishoftu City

Several land use types are recognized in irregularly mixed appearance with one another through the whole study area. Before health facility allocation is made, it is important to identify each and every parts of the area under study and for what purpose it is used because it helps to isolate where the demand (request) for the public Hospital and where there is not, where the demand is high and where it is low etc. According to Bishoftu City Administration Integrated Land Information Center of 2014, there are about a number of land use types identified in Bishoftu City in general.(Source Bishoftu city administration office)

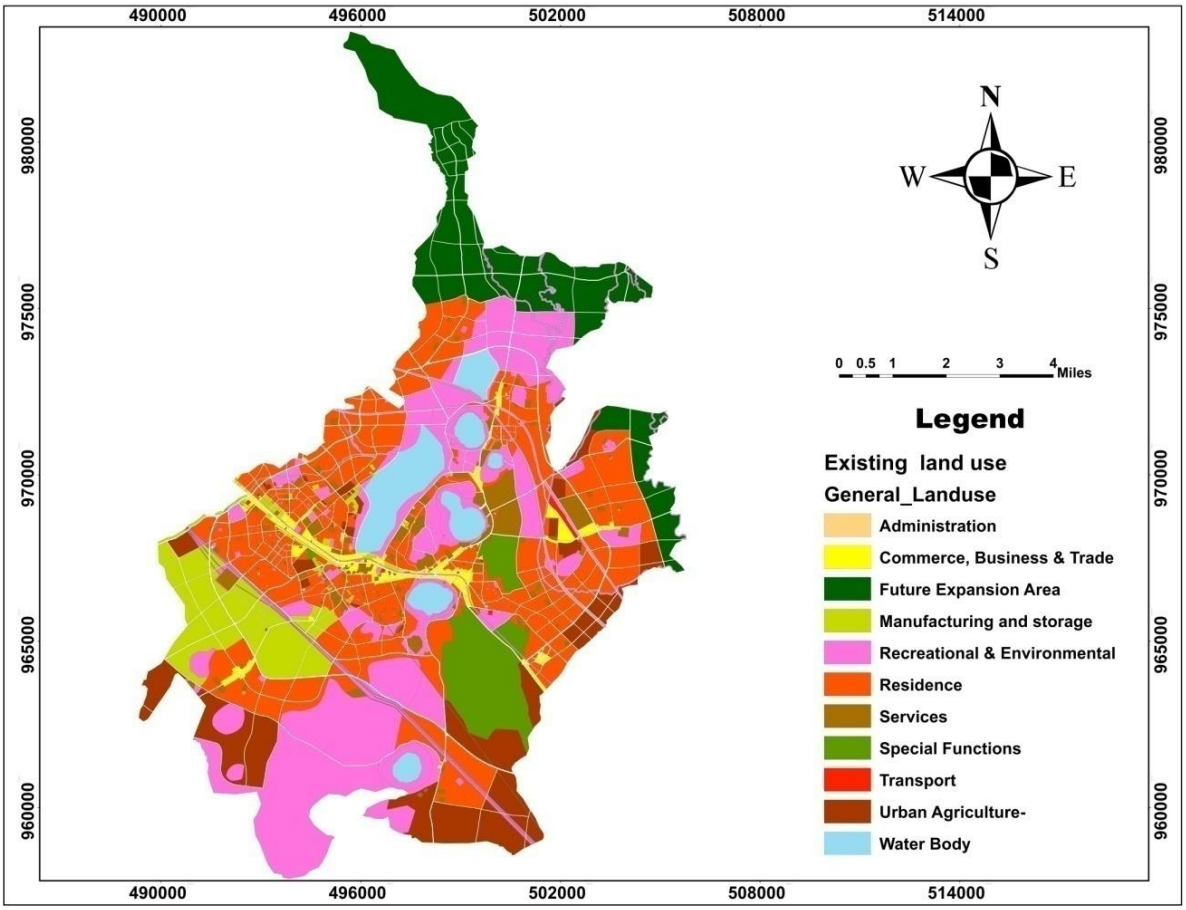

Figure 3.2ExistingLand Use in BishoftuCity

3.2 Distribution of Health Institutions in Bishoftu

Health institutions in Bishoftucomprise the very basic parts of social services. As the distribution of health institutions in the study area is concerned, the outcomes of the data indicate the availability of the compulsory health institutions in the area. Consequently, hospital, health center, clinic and drug vendor are the existing health institutions. To see the number and type of their ownership statuses refer to the following table.

Table 3.1: Distribution of Health Institutions by Type of Ownership

No	Health Institutions	Number			
		Government	NGOs	Private	Total
1	Hospital	1			1

2	Health Center	1			1
3	Clinic			9	9
4	Health Post				
5	Drug Vendor			2	2
Grand Total		**2**		**11**	**13**

Source: Bishoftu Town Health Office, 2009

As can be seen from the above table, there are a total of 13 health institutions that represent four categories. Accordingly, there is one hospital and one health center both owned by government, nine private clinics and two private drug vendors. Though this is the case, the health office further indicated that there is a plan to build one public hospital and two health centers in the coming five planning years. Nevertheless, the table indicates us the presence of hospital in the town that gives regular service for the town residents as well as for the surrounding areas of *Dire, Godino, Hidi, Mojo, Dankaka, Adulala, Dukam, Kajima* and*Kurkura.*

3.3 Data Collection and Software Used

The inputs for the design of a model for service facility site selection decision making are both spatial data and non-spatial data mining to suitability analysis outputs. To achieve our general and some other specific objectives, we use vector data from Bishoftu Aerial image (orthophoto) and Google earth. The vector data which we can't find from the open street will be digitized from the Aerial image and Google earth, boundary of Bishoftu and, extracted from the data sets were spatial in nature, as the present study emphasized on spatial suitability analysis for Hospital site selection.

This study focuses on suitability site selection for public hospital site in BishoftuCity by using GIS technologytechnique. To do this study some data are used. These data are primary and secondary source.

3.3.1 The primary data

The primary data were collected from field surveys and observation. It may be collected on a sample or census basis or from case studies some of the primary data are

- Field observation
- Collecting coordinates using handle GPS
- interview
- Gathered extra data from different agencies of the city

3.3.2 The secondary data

Secondary data are the Second hand information's, The data which have already been collected and processed by some agency or persons and are not used for the first time are termed as secondary data. And some of the secondary data are shown in table 3.2

Table 3.2 secondary data source

No	Data	Type	Sources
1	Administrative Boundary	Spatial	Bishoftu city municipality office
2	Aerial image (Orthophoto) (2018)	Spatial	Bishoftu city municipality office
3	Contour of the town	Spatial	Bishoftu city municipality office
4	master plan of the town	Spatial	Bishoftu city municipality office
5	Topographical map of the town	Spatial	Bishoftu city municipality office
6	DEM	Spatial	Google Earth USGS
7	Land use land cover data	Spatial	Bishoftu city municipality office
8	Population data	Non spatial	Bishoftu city municipality office

3.3.3 Software's and other Instruments Used

As presented their list, version, and purpose in (Table), in order to complete, the study effectively different software packages were operated to help a decision such as ERDAS imagine ARC GIS Google earth and Microsoft word. A number of tools have been used to determine the proper site.

Table: 3.3 software and instrument used

No	software's	Version	Purpose
1	ARC GIS	10.3	• Change raw data to useful information for the study. • Enables to prepare the data convert to raster to Reclassify, and finally weight over lay, and overlay analysis.
2	ERDAS IMAGINE	2015	• Preprocessing mosaic and clip features
3	Google Earth	7.3	A. For Random point collection and accuracy assessment
	Equipment to be used		
4	Hand GPS		uses for collecting coordinates

3.4 GIS Based suitability Analysis methodology

There are different types of GIS operation tools that are used to achieve the objectives of this study. The methods used include geo-referencing, digitizing, rasterizing, buffering and reclassifying. How each of these has been operated was outlined as follows

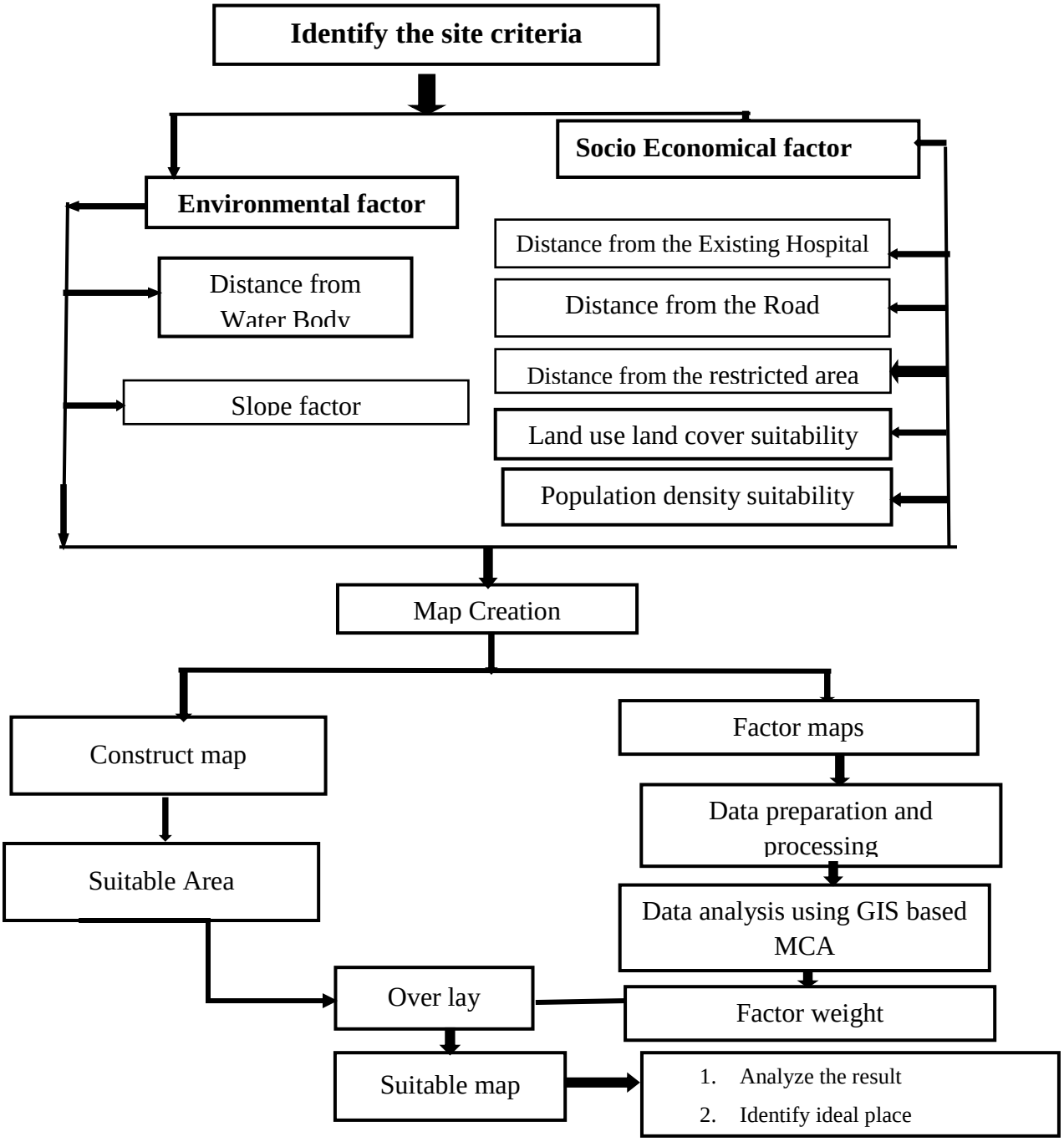

Figure 3.3 Work flowchart of the methodology used in the study

Geo-referencing Geo-referencing is the process of changing the ideal coordinate system of the computer in to real world coordinate system or is the process of aligning geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. it may involve shifting, rotating, scaling, skewing, and some case

warping, rubber, sheeting, or Orto rectifying the data. In geo-referencing process minimum of four points was selected from the master plan.

Digitizing This function of GIS converts the base map of the area into digital map to use in GIS environment. This is done by using on- screen digitizing by encoding the spatial coordinates of the features on the map. It was used to digitize boundaries, land use, roads and drainage that exist in the study area from the master plan

Rasterizing In its simplest form, a raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information. In this project land use map, road network map, distance from the Restricted area map, population map, distance from water body and slope (contour data convert to TIN, TIN to DEM and DEM to slope in GIS tool box) all factors map are rasterized The raster given all maps, ability to perform fast overlays with complex datasets.

Reclassification This process includes recording of attributes in one classification method in to another classification method since it is the way of assigning new value to the old value, and possible only to reclassify from classification method with the large number of categories to another one with small number of categories. The most reasons for classifying data are:

- To replace values based on new information
- To group certain values together.
- To reclassify values to a common scale.

Euclidean distance tools describe each cell's relationship to a source or a set of sources based on the straight-line distance. Euclidean distance is calculated from the center of the source cell to the center of each of the surrounding cells. True Euclidean distance is calculated in each of the distance tools. Conceptually, the Euclidean algorithm works as follows: for each cell, the distance to each source cell is determined by calculating the hypotenuse with *x max* and *y max* as the other two legs of the triangle. There are three Euclidean tools:

- Euclidean Distance gives the distance from each cell in the raster to the closest source.
- Euclidean Direction gives the direction from each cell to the closest source.

- Euclidean Allocation identifies the cells that are to be allocated to a source based on closest proximity.

Reclassify

- Reclassifies (or changes) the values in a raster. The input raster must have valid statistics. Here from old value to new value is assigned and class also selected.
- Old values: The ranges of values of cells in the input raster. Acceptable settings are a single value, a range of values, a string, or No Data. A list of single values can be specified by separating each with a semicolon (;). A range of values can be specified by using a hyphen (-) as the range separator.
- New values: The new value to assign the values or ranges of values. Only integer values are supported.
- Classify: Opens the dialog box allowing the classification Method to be specified. The options are Manual, Equal Interval, Defined Interval, Quintile, Natural Breaks (Jenks), Geometrical Interval and standard deviation.

3.5 Factor for maps criteria setting

At this stage, factor criteria were used to further evaluate these sites according to their suitability in order to indicate the most preferable for locating new public hospital site. This is done through two steps of weighting process. In the first step, each factor was internally weighted based on the minimum and maximum distances and/or requirement. In the second step, each factor was externally weighted based on how critical and important the factor is to the public hospital site problem.

The suitability for locating the public hospital site, the factor should be classified into classes unsuitable for Hospital sitethe suitability of each factor maps was both internally weighted based on their direct distance to features and environmental judgment and externally weighted using GIS, based on the relative importance of the criterion.

This study criteria rating established based on guideline, literature reviews in area of public Hospital land suitability and personal discussion with experts. Table 3.4 shows the criteria for land suitability for public hospital respectively.

Table 3.4 criteria's and classified value

Sub Criteria	Class/ zone	Ranking	Level of suitability	Other studies on hospital site selection used the same criterion
Existing Hospital	>2500 m	5	Highly suitable	(Ali and Ahmad 2020), (Şener et al. 2010,) Kontos et al. (2005)
	2000-2500m	4	Suitable	
	1000-2000m	3	Moderately suitable	
	500-1000m	2	Less Suitable	
	0-500m	1	Very less suitable	
Distance from the road	Class/ zone	Ranking	Level of suitability	(Nachtergaele et al., 2009)
	100-500m	5	Highly suitable	
	500- 1000m	4	Suitable	
	1000-1500m	3	Moderately suitable	
	>2000m	2	Less Suitable	
	0-100m	1	Very less suitable	
Restricted area	Class/ zone	Ranking	Level of suitability	Nachtergaele et al., 2009
	>2000m	5	Highly suitable	
	1500-2500m	4	Suitable	
	500-1500m	3	Moderately suitable	
	100-500m	2	Less Suitable	
	0-100m	1	Very less suitable	
Land use land cover	**Class/ zone**	Ranking	Level of suitability	
	Administration	4	Suitable	(Yohannes and soromesa, 2018) (FAO, 2007).
	Commercial	3	Moderately suitable	
	Future expansion	2	Less Suitable	
	manufacturing and storage	1	Very less suitable	
	Residential	5	Highly suitable	
	Recreational & Environmental	5	Highly Suitable	
	Services	5	Highly Suitable	
	Agriculture-land	2	Less Suitable	
	special functions	RESTRICTED		

	water body	RESTRICTED		
Water Body	**Class/ zone**	Value	Level of suitability	Mandal et al., 2017
	>2000m	5	Highly suitable	
	1000-2000m	4	Suitable	
	500-1000m	3	Moderately suitable	
	100- 500 m	2	Less Suitable	
	0-100m	1	Very less suitable	
Slope	**Class/ zone**	Ranking	Level of suitability	(Mandal et al., 201
	0-5%	5	Highly suitable	
	5-10%	4	Suitable	
	15-20%	3	Moderately suitable	
	20-25%	2	Less Suitable	
	>25%	1	Very less suitable	

3.6 Method of Data analysis

The process of standardizing, classifying and calculating the necessary information of each thematic layer for land suitability and this study comprises the following five steps .The information acquired in one step of process was used as an input for the next step.

- Identification of major factor that affect urban facility a case of public hospital.
- Accessing data from which the major factor can be derived.
- Standardizing and calculating each factor based on the model requirement
- Rating each factor based on their influence for land quality for Hospital use
- Combining each factor by weight overlay and map algebra raster calculator for land suitability.

3.6.1 Method of data Analysis for factor affecting

Both vector and raster analysis has been used in this study. At first, the restricted area has been defined according to the criteria.GIS tool box has mainly been used for this purpose. Also, raster data covering the whole factors Euclidian distance the Feature to Raster and Raster Calculator has been used Euclidian distance have been used for the water body, road distance, restricted area and existing hospital site, then it has been turned before

change into raster data through Feature to Raster. After that, classified tool has been used to make the area unsuitable for the hospital. There are different types of GIS spatial operation tools that are used to achieve the objectives of this study the coordination system is WGS84. The methods used include factors affecting the Hospital site, has been operated was outlined as follows.

3.6.2 Assigning criterion weights

Weight assignment from pair wise comparison for the criteria was based on literature reviews, personal discussion with experts and nature of study area and FAO, 1976 and FAO, 2007 guideline of land suitability evaluation and processed in ARC GIS 10.3 AHP extension tool. The pairwise comparison technique developed (saaty,1987) in the context of decision making process is a ratio (reciprocal matrix) .Where each factor is compared with the other criteria in terms of their importance related to the stated objective scaled: from 1 to 9 (Saaty, 1987). There are three steps for this technique.

Analytical HierarchyProcess (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 and 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 and 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 public hospital development the AHP was carried out in the following three steps:

- Pair-wise comparison of criteria
- Calculating criterion weights
- Calculating consistency ratio(CR)

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 9which is suggested bySaaty(1980)

Table 3.5 the fundamental scale of AHP

absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over other	Experience and judgment strongly favor one activity over another
5	Essential or Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance 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 judgment	When compromise is needed
Rationales	value when compared with i. Ratios arising from the scale	If consistency were forced by obtaining n numerical values to span the matrix

(source: Saaty, 1987)

3.6.3 GIS-based MCA

In this study, the GIS-based MCA can be includes three phase. Phase one is to combine the constraint maps to get a final constraint map. Phase two is to combine the weighted factor maps to get a final weighted factor map. The final result is a combination of final constraint map and final weighted factor map to get a suitability map of public hospital site.As for the final weighted factor map is a weighted linear combination of factor maps, an equation as follows:

1) $S = \Sigma\, wi\, xi$ where,

S = suitability,

wi= weight of factor i and

xi = factor map i.

(1) As for the Boolean overlay operations, the equation for generating the final

Constraint map is shown as equation below:

$$C = \Pi\, cj$$ where, cj= constraint map j, Π = product

(2) The suitability map is derived by multiplying the overall weighted factor map and overall constraint map, as follows equation (3).

$$S = \sum_{i=1}^{N} wixixi\Pi cj$$

Where,

S is the suitability ,

$xi$is the factor map i,

$wi$is the weights assigned to each factor and

N is the number of factors.

After the final factor map and final constraint map are generated, the GIS-based MCA process can produce the final suitability map by overlay final constraint map with final weighted factor map.

Weighted Overlay The weighted overlay tool applies one of the most used approaches for overlay analysis to solve multicriteria problems such as site selection and suitability models. In a weighted overlay analysis, each of the general overlay analysis steps is followed. The Weighted Overlay tool lets you implement several of the steps in the general overlay analysis process within a single tool. The tool combines the following steps:

- Reclassifies values in the input raster's into a common evaluation scale of suitability or preference, risk, or some similarly unifying scale
- Multiplies the cell values of each input raster by the raster's weight of importance
- Adds the resulting cell values together to produce the output raster.

Clip: Extracts input features that overlay the clip features. Use this tool to cut out a piece of one feature class using one or more of the features in another feature class as a cookie cutter. The Clip Features can be points, lines, and polygons, depending on the Input Features type.

- When the Input Features are polygons, the Clip Features must also be polygons.
- When the Input Features are lines, the Clip Features can be lines or polygons. When clipping line features with line features, only the coincident lines or line segments are written to the output, as shown in the graphic below.

When the Input Features are points, the Clip Features can be points, lines, or polygons.

Arc GIS 10.3 software package was used for spatial data processing, analysis, and output generation. Processing a large amount of information at the same time and present the information in a visualized way was one of the advantages of Arc GIS which made an evaluation of spatial distribution and accessibility the on the figure shows the model To produce map for the final suitable hospital sites.

CHAPTER IV. DATA ANALYSIS, RESULTS AND DISCUSSION

This chapter tries to analyze the main findings of the field survey and the major factors determining the performance of public hospital data collection in Bishoftu City The purpose of the site selection is finding the optimum site resulting from a series of pre-determined criteria. According to the pre-determined criteria here all maps are given the next pages which are created.

The problem is to locate hospital site to emergency ambulance services, a possible criterion would be to minimize the average distance (or time) an ambulance must travel in order to reach a random incident. Another appropriate criterion could be to minimize the maximum distance that the ambulance must travel to reach an accident.

4.1 Socio Economical criteria suitability analysis

Socio-economic criteria like Distance from the Existing hospital, Proximity to the Road, distance from the restricted area, population density and Land use land cover of the site are the determinant criteria used to evaluate public hospital site so as to choose the following factors were deeply discussed

4.1.1Distance from the Existing hospital

Distance to existing hospitals means to keep distance as far as possible between the location of new hospitals and existing hospitals (Erlien et al. 2006).to increase the effective service for various regions especially those without hospital facility In examining the service radius of the health facilities, it was ascertained according to (Shankland Cox 1980) in his general report on the Greater Planer (Jos Master 1973) that the maximum distance to health facility is Far from 500m. Therefore, new hospital constructions should take this criterion seriously. Keeping the distance from other existing hospitals as well as anticipating impact from each other, is not only relevance to rational resource allocation, but also does matter to the fair competition in the market economy. There is an oral agreement that normally the distance is far from 500 meters." said by the deputy chief of the Medical Affairs Section in Haidian Health Bureau (Ji-Shun 2011). Hence, in this study, the new hospital is also wished to keep a distance of 500 m from the existing hospitals, the further away the better.

Table 4.1Distances from Existing hospital reclassified value

Class/ zone	Ranking	Level of suitability	Area (ha)	Area(%)
>2500 m	5	Highly suitable	16614.15	89.43
2000-2500m	4	Suitable	706.92	3.80
1000-2000m	3	Moderately suitable	942.12	5.07
500-1000m	2	Less Suitable	235.72	1.26
0-500m	1	Very less suitable	78.45	0.42

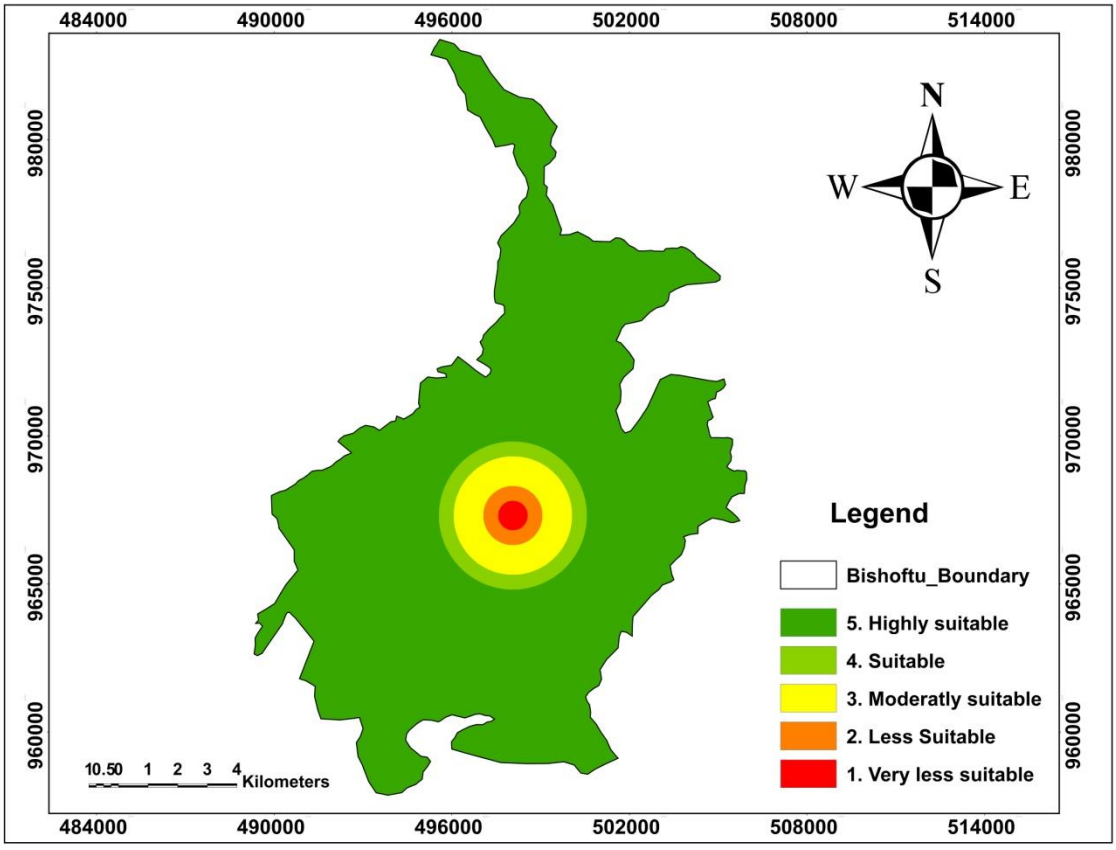

Figure 4.1: Reclassified map of existing hospital site

4.1.2 Proximity to the Road

Road accessibility is one of the important parameters for urban land suitability analysis as it provides linkage between the settlements. The distance to existing urban areas is important because the significantly impact moving costs and time, so the roads are an important factor in housing development because their presence indicates human activity (Seid, 2007).This study is concerned with the distance from the road network. The road network in the city consists of major roads and other roads the road network layer of the study area was digitized from the study area of Topographical map and Aerial image of the city. Roads should be designed and constructed to provide for the safe, convenient,

effective and efficient movement of people and goods. There is no specific rule of what should be the best distance to place the public hospital site. Most studies suggested that the public hospital site should be located within a hospital should be located near the roads, especially the main roads. The nearer is better. However, the noise from motor vehicles passing by influences the patients in the hospital. Therefore a quiet distance of 100 meters is set. (Ali &Ebrahim, 2011)

Table 4.2 Reclassified distance to the Road value

Class/ zone	Ranking	Level of suitability	Area(ha)	Area(%)
100-500m	5	Highly suitable	8275.59	45.37
500- 1000m	4	Suitable	1664.26	9.12
1000-1500m	3	Moderately suitable	493.88	2.70
>2000m	2	Less Suitable	186.56	1.02
0-100m	1	Very less suitable	7617.64	41.76
Sum			18237.93	100

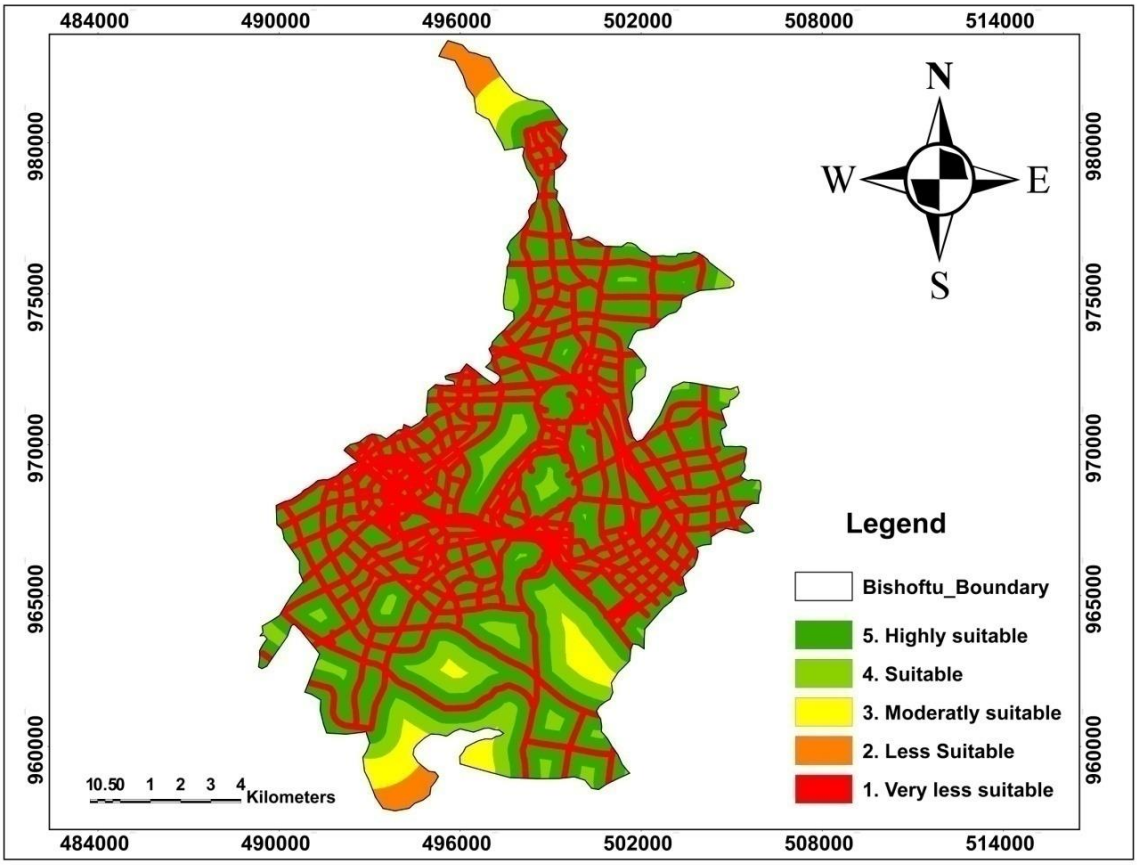

Figure 4.2 Reclassified Road distance Map

4.1.3 Distance from the Restricted Area

Military camps (Ethiopian air force), Religious church ordinance depots, missile sites, National Guard and Reserve armories are included in this category. Boundaries of major military installations are identified by fence lines and roads along their perimeter. Military facilities have a wide variety of conditions including training camps, missile sites, etc. Auxiliary land uses, particularly residential, commercial and other supporting uses located on a military base should be included in this category the hospital must not be in Religious places. The Religious places area is noisy and has extra traffic concentration, which can be a problem for the hospital.

Table 4.3 Reclassified distance to the restricted area value

Class/zone	Level of suitability	Ranking	Area	Area (%)
>3000	Highly suitable	5	9061.32	48.78
1500-2500m	Suitable	4	3295.49	17.74
500-1500m	Moderately suitable	3	3816.17	20.54
100-500m	Less Suitable	2	1348.76	7.26
0-100m	Very less suitable	1	1055.62	5.68
Sum			18577.36	100

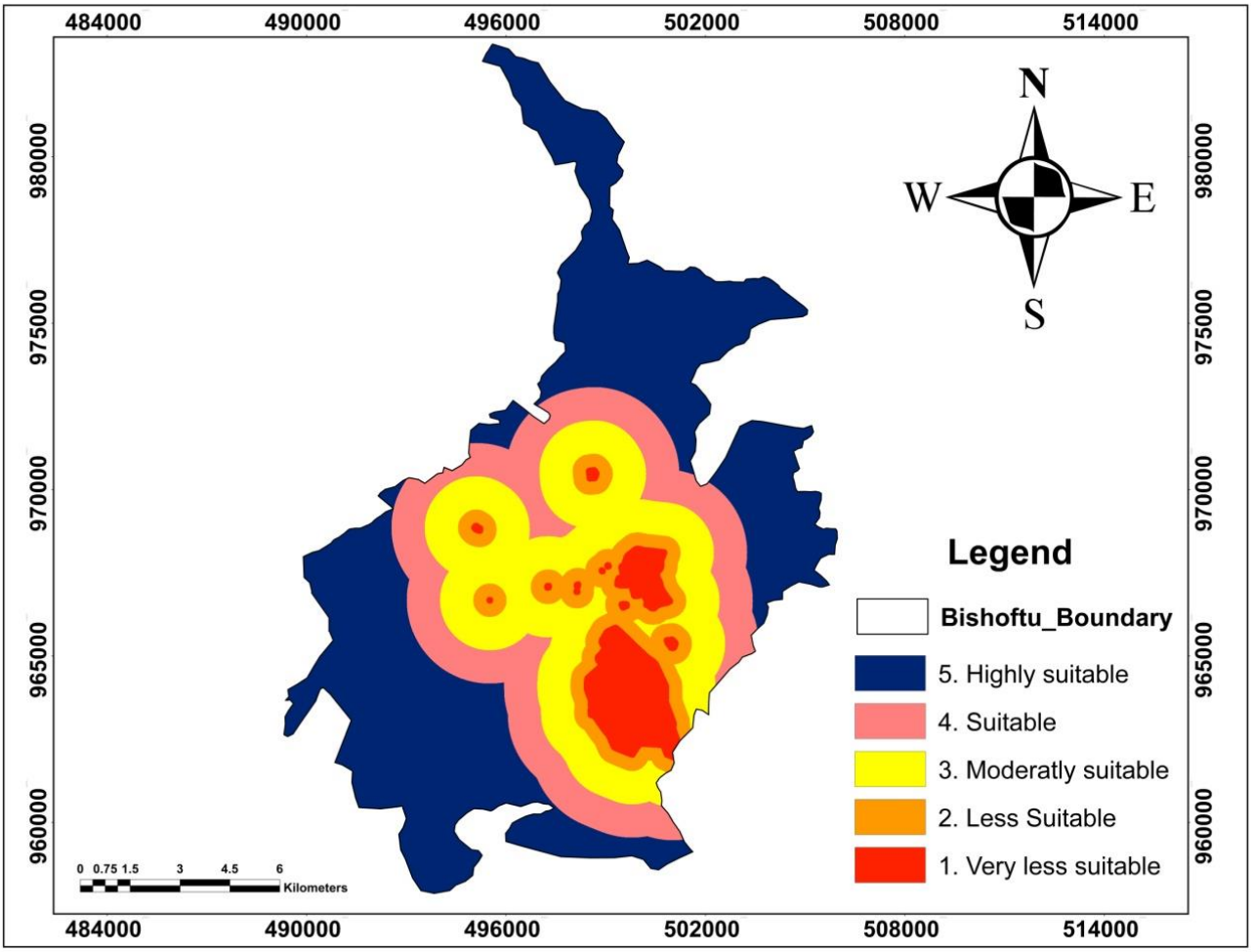

Figure 4.3 Reclassified Distance from the Restricted Area map

4.1.4 Suitability of Land use land cover

The land use is considered an environmental factor in construction new public hospital site in this study restricted areas such as water body (lakes and Rivers), military camps (air force, and Defense University and Police Station) and Religious Churches were left out in computation. Spatial extent of net area used for land use land cover was computed in hectare (ha). There are eightmajor land uses such as included.

- Administration:- Government Institutions
- Commerce: -Business & Trade,
- Recreational & Environmental such as green space, open space and sport centers
- Residential
- Services like Religious institutions centers, and health centers Utility Services &Infrastructure
- Transport:- parking and terminals
- Agriculture-land area

- manufacturing and storage

Land use land cover based hospital site suitability. According (AmitbJohar 2013), water bodies, manufacturing storage and forest coverage are not suitable for hospital establishment. Whereas areas like open spaces, Services area and residential area are high suitable for hospital site location.

By reviewing different literature it was advisable to select land, which was occupied by Services; Recreational & Environmental and Residential places sites are Highly suitable for public hospital site (Sener et al. 2011). Land use types were grouped and ranked according to their suitability for public hospital site as Very less suitable, less suitable, Moderately suitable, Suitable and Highly suitable for public hospital site location by assigned a ranking values of 1, 2,3, 4 and 5 respectively,

Table 4.4 land use land cover classification

General Land use	**Ranking**	**Level of suitability**	**Area(ha)**	**Area%**
Administration	4	Suitable	18.81	0.12
Commercial	3	Moderately suitable	342.75	2.26
Future expansion	2	Suitable	2111.66	13.95
manufacturing and storage	1	Very less suitable	1092.59	7.22
Residential	5	Highly suitable	4779.4	31.60
Recreational & Environmental	5	Highly suitable	4476.5	29.58
Services	5	Highly suitable	675.35	4.46
Agriculture-land	2	Less Suitable	1631.94	10.78
Sum…….			…..15129	100
special functions	RESTRICTED			
water body	RESTRICTED			

Table 4.5 land use land cover classification suitability value

Level of suitability	**Ranking**	**Area**	**Area(%)**
Highly suitable	5	9931.25	65.64
Suitable	4	18.81	0.12
Moderately suitable	3	2454.41	16.22

Less Suitable	2	1631.94	10.79
Very less suitable	1	1092.59	7.22
Sum		15129	100

From the total area, the reclassified map of LULC in the table 4.5 shows that 1092.59(7.22%) is Very less suitable, 1631.94ha (10.79%) leveled as Less suitable, 2454.41ha (16.22%) Moderately suitable18.81ha (0.12%) isSuitable9931.25ha (65.64%) Highly suitable for hospital locations are water bodies and special functions were assigned zero weights (restricted), hence these sites are not considered for hospital establishment.

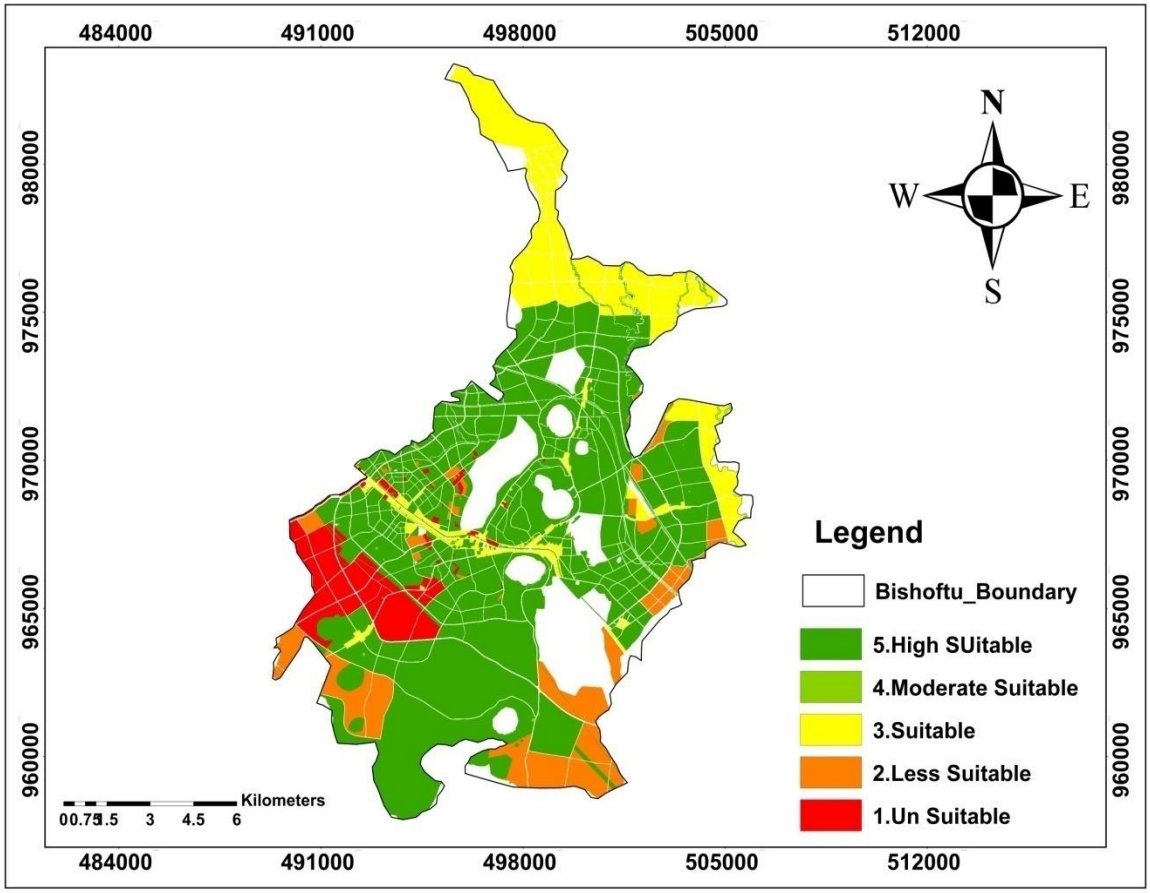

Figure 4.4 Reclassified LULC map in terms of suitability level

4.1.5 Population density

Population density is associated with potential demand and performance effectiveness of a hospital site. The higher the score is for an alternative. However, in rural areas proportionally more patients attend the nearest practice reflecting the lack of alternative options. The study also demonstrated the importance of travel time on choice of GP surgery attended and highlighted the need to incorporate consumer behavior as well as travel times into potential accessibility models.

The hospital should be situated in the proper land use, mainly in the residential areas, as the residence is the main user of the public hospital. The special criteria are: Population concentration is a fact as the hospital is needed most in the high population concentration areas. Employment concentration map has been used as less employment concentration means the area has more impoverished people who use a public hospital.

Table 4.6 population density reclassified value

Population density	**Ranking**	**Level of suitability**
>50	5	Highly suitable
30-50	4	Suitable
20-30	3	Moderately suitable
10-20	2	Less Suitable
1-10	1	Very less suitable

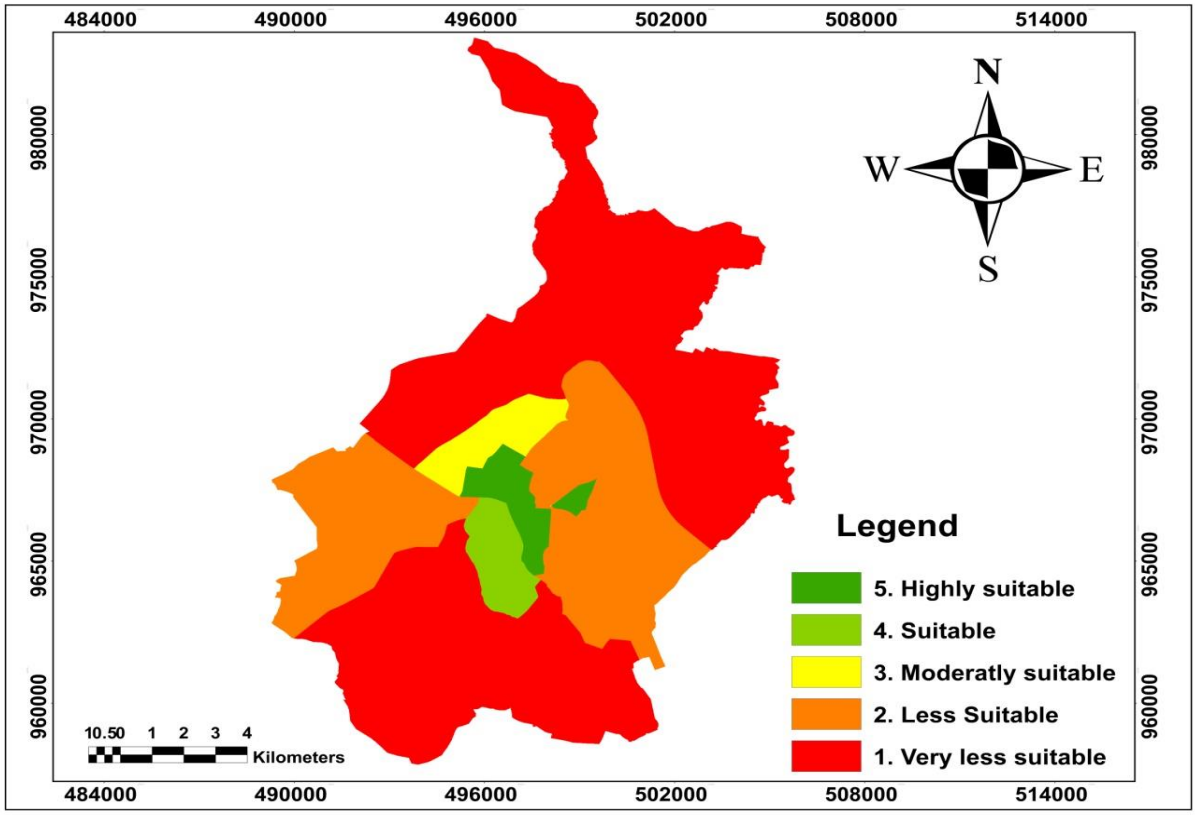

Figure 4.5 population density reclassified map

4.2 Environmental criteria suitability analysis

Criteria land use land cover, water body (river/streams & lake), the assigned criteria in environmental factors in the study area based the hospital should away from, water body. Can be flexible, but some parts of land use land cover provided by City Corporation became permanent and sited as a physical feature in the detailed area plan. Water body can be harmful to patients and also have the possibility of creating an environmental hazard. A Hospital must not be located in close proximity to sensitive areas such as lakes and Rivers areas. Therefore, a 3,000 m distance is necessary to surround an environmentally sensitive area. EPA (1998) recommends a distance of at least 500 m. For this study, at least a 2000 m distance was considered appropriate for a Hospital site.

4.2.1Distance from Water body site

Distance from water body is one of the environmental factors in construction new public hospital site in this study, keep the distance from water body area is important for public hospital keep air and water pollution.

In some other cities, service facilities should away from the river because drainage discharge and some other factors could contaminate the river, but the rivers in Bishoftu are badly contaminated and became a source of bad odor and a health problem by itself so 300 meters far away is the better. Water body is one of the main affecting factors for hospital site selections. Hospital must be located at some safe distance from water bodies. Water body's areas within 1000 meter are considered unsuitable for an establishment hospital. Water body for hospital is one of the major sources of environmental challenge in river/streams & lake, distance of at least 1000m (Jain, 2008). According to Ebrahim et al (2015), land suitability for Hospital location within proximity to lake as follows.

Table 4.7Distance from Water body site value

Class / zone	Level of suitability	Value	Area	Area%
>2000m	Highly suitable	5	4777.07	25.92
1000-2000m	Suitable	4	4067.98	22.07
500-1000m	Moderately suitable	3	3734.92	20.26
100-500m	Less Suitable	2	3791.75	20.57
0-100m	Very less suitable	1	2061.5	11.18

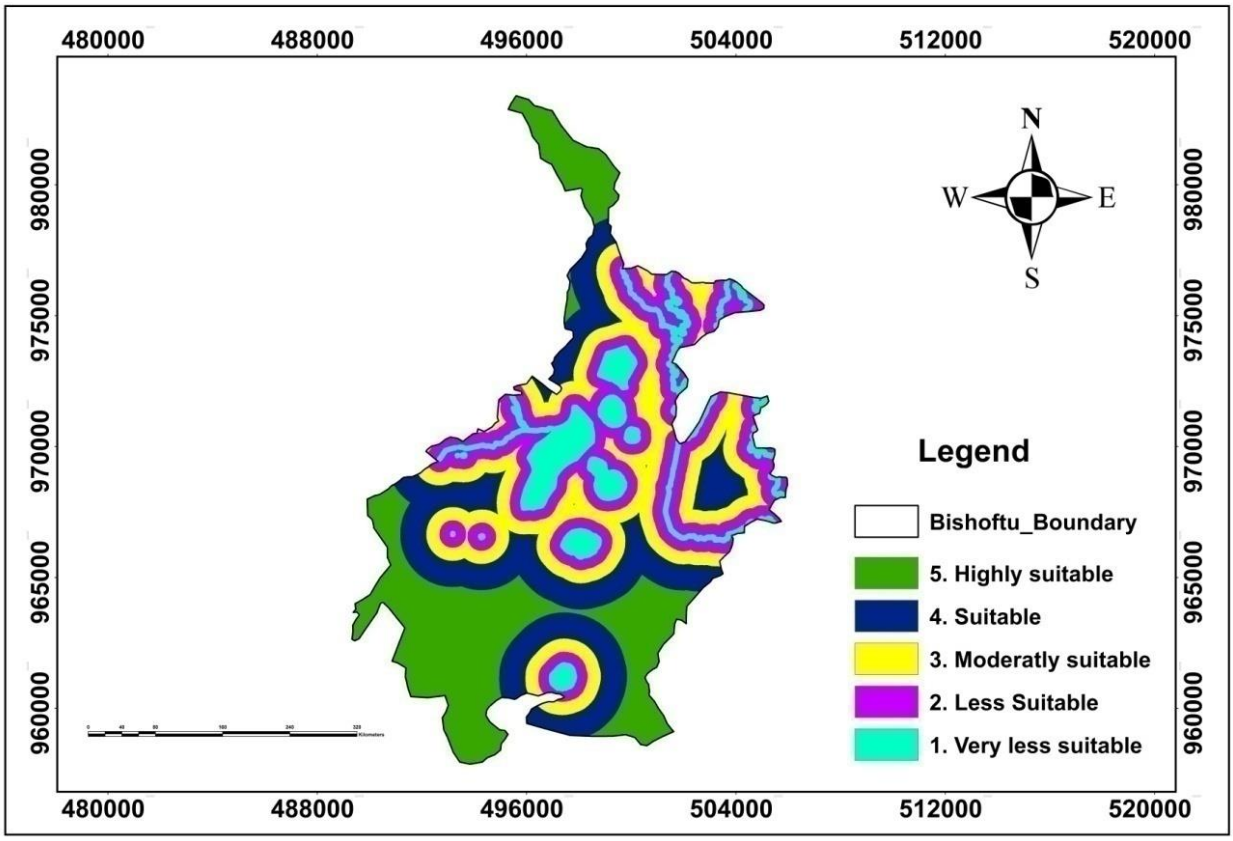

Figure 4.6 Distance from water body Reclassified map in terms of suitability level

4.2.2 Slope factor analysis

Slope is major topographic element related to erosion hazard, land management practice, Workability of the area and climatic factor. Slope of the study area was derived from the digital elevation model (DEM) Slope is one of the key criteria to be considered in hospital site selection. Different research shows that areas with high slopes will have high risk and not a good to build new public hospital site. According to (Seneretal 2011) and (Leaoetal 2011), the land with a slope less than 10% is highly suitable for public hospital. Land with slopes greater than 15% should be considered as decreasing suitability value for public hospital sites (Al-Hanbali et al. 2011). There for to generate slope first generate TIN from contour or elevation and then generate DEM from TIN using 3D analysis and finally slope is calculated from DEM and then reclassifying the slope by giving weight

Table 4.8 Slope reclassified value

Class/ zone	Ranking	Level of suitability	Area(ha)	Area %
0-5%	5	Highly suitable	12649.25	68.59
5-10%	4	Suitable	2317.76	12.56
15-20%	3	Moderately suitable	1637.52	8.88
20-25%	2	Less Suitable	446.12	2.41
>25%	1	Very less suitable	1389.01	7.53

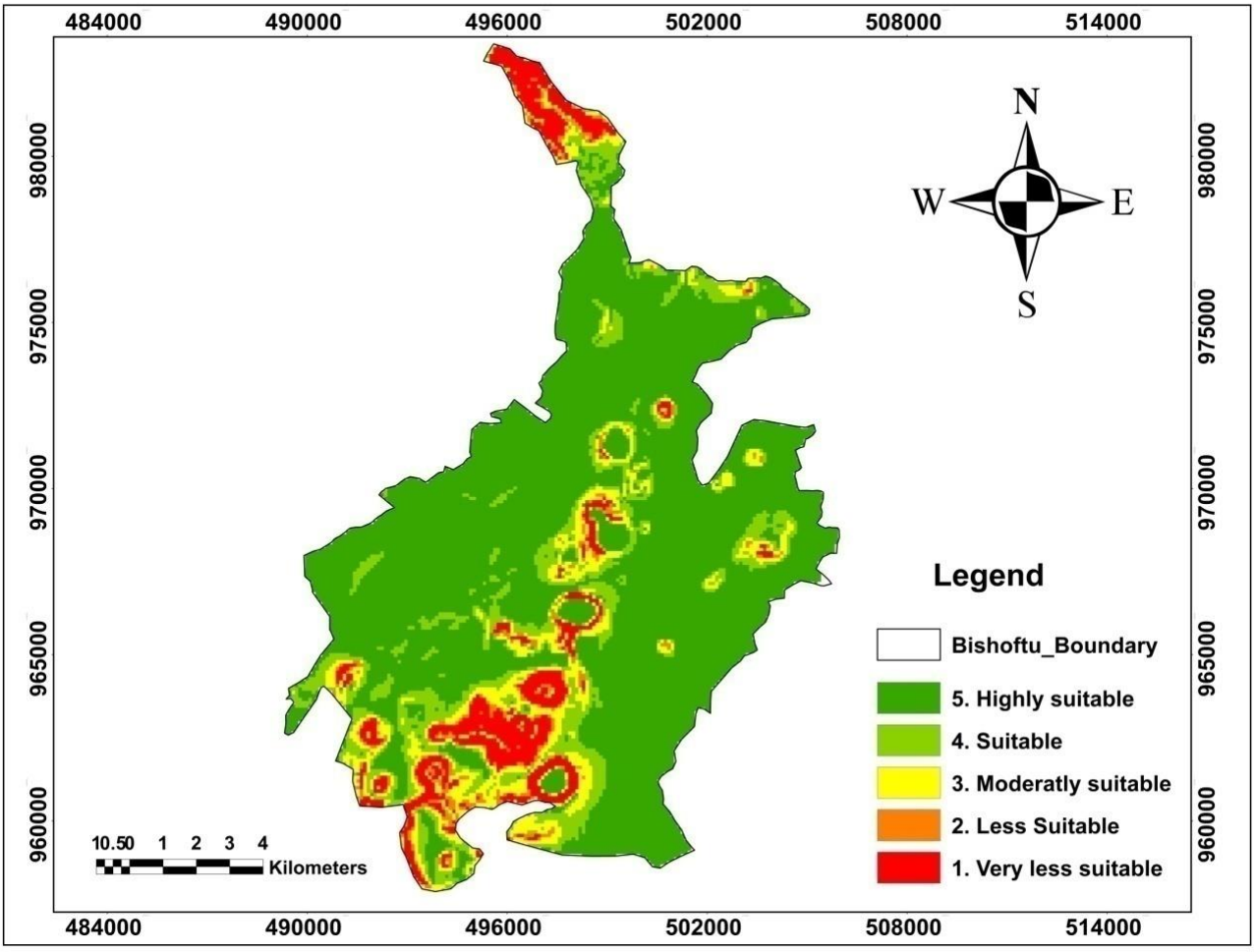

Figure 4.7 slope Reclassified map

4.3 The Final Selected Suitable Areas

These are areas that are free from the limiting factors listed above (i.e. slope is safe for constructing houses, land use type is the most preferable for Public hospital, distance from water body, from restricted area (distance from religious institution, military campus and police stations,) distance from main road, distance from existing public hospital, High population concentration and slope from suggested sites is the highly suitable).This is

achieved after each raster output is further Reclassified into common measurement scale values in order to let each participant factor have equal influence in creating the most suitable areas For this study case, as can be observed from the consecutive figured maps displayed above a common measurement scale of 5 is assigned for all participating inputs. Combination of the factors by means of overlay analysis result the final output aimed to be acquired. The result is thus affianced or suitable areas for public hospital buildings as displayed below in Fig 4.8. The preparation of land suitability map involves a weighting of relating factor that affect Public hospital capability of the land. The factor is identified by on guideline, literature reviews personal discussion with different experts, nature of the study area, of related study.

4.4 Result of Public Hospital Suitability Map

As explained in the methodology part preparation of criteria maps involves the identification of the factors (criteria) required for land suitability for hospital use. The land suitability factors must be considered when evaluating the suability from highly suitable to very less suitable land for a hospital site. of GIS and multi-criteria decision analysis (MCDM) methods allow combining knowledge derived from different sources to support land use planning and management (Malcyewski 2000). In this study AHP is used to drive the weight factor. The pair-wise comparison was done for factor used to determine the hospital use suitability The preparation of land suitability map involves a weighting of relating factor that affect hospital of the land. The factor is identified by personal discussion with different experts, nature of the study area, literature review of related study. A total of 7 parameters used in this study such as Distance from the Existing hospital, Proximity to the Road, distance from the restricted area, population density and Land use land cover of the site, distance from water body and slope factor are the determinant criteria as shown in figure 4.1up to figure 4.7 respectively Before merging the reclassified image.

weight must be assigned using the Analytical Hierarch process based on (satty, 1987) Analytical Hierarch process (AHP) , which involves creating a pair wise comparison matrix for each map using a nine-point priority scale as shown in table 3.4 in previous chapter . Each factor is compared with the other criteria in terms of their importance related to the stated objective. In this study AHP is used to drive the weight for the factor by using AHP extension tool in Arc GIS 10.3

In order to combine all the layers to process overlay analysis all the parameters were weighted with their respective percent of influence and overlay to produce the suitability map and reclassified/rank in to four classes like highly suitable, suitable and Distance from the restricted area and water body area is very less suitable for public hospital in the study area bishoftu city. The factors, their values and weights are summarized in (Table 4.9). According to the degree of importance, they have the role to selecting suitable public hospital site. After the overlay analysis of the given factors the suitable hospital site map was produced. The areas were highly suitable for public hospital site are selected identified. The area coverage of each suitability class was calculated in GIS environment. The result showed 115.66ha and 60haless moderately suitable and unsuitable for hospital the study area is (restricted) as the areas are environmentally unfriendly, socially unacceptable and/or economically unfeasible for public hospital Overlay of several raster inputs using a common measurement scale and weights of each according to its percentage influence is prepared. The re classed results obtained above are all combined through the weighted overlay toolset from spatial analyst tools

Table 4.9 weight derived from pair wise comparison matrix

No	Criteria's	weighted value
1	Existing Hospital	16.50%
2	proximate from the road	18.50%
3	Land use land cover	20.15%
4	Population density	13.20%
5	Restricted Area	9.15%
6	Distance from water body	11.60%
7	Slope	10.90%
	Sum	100%

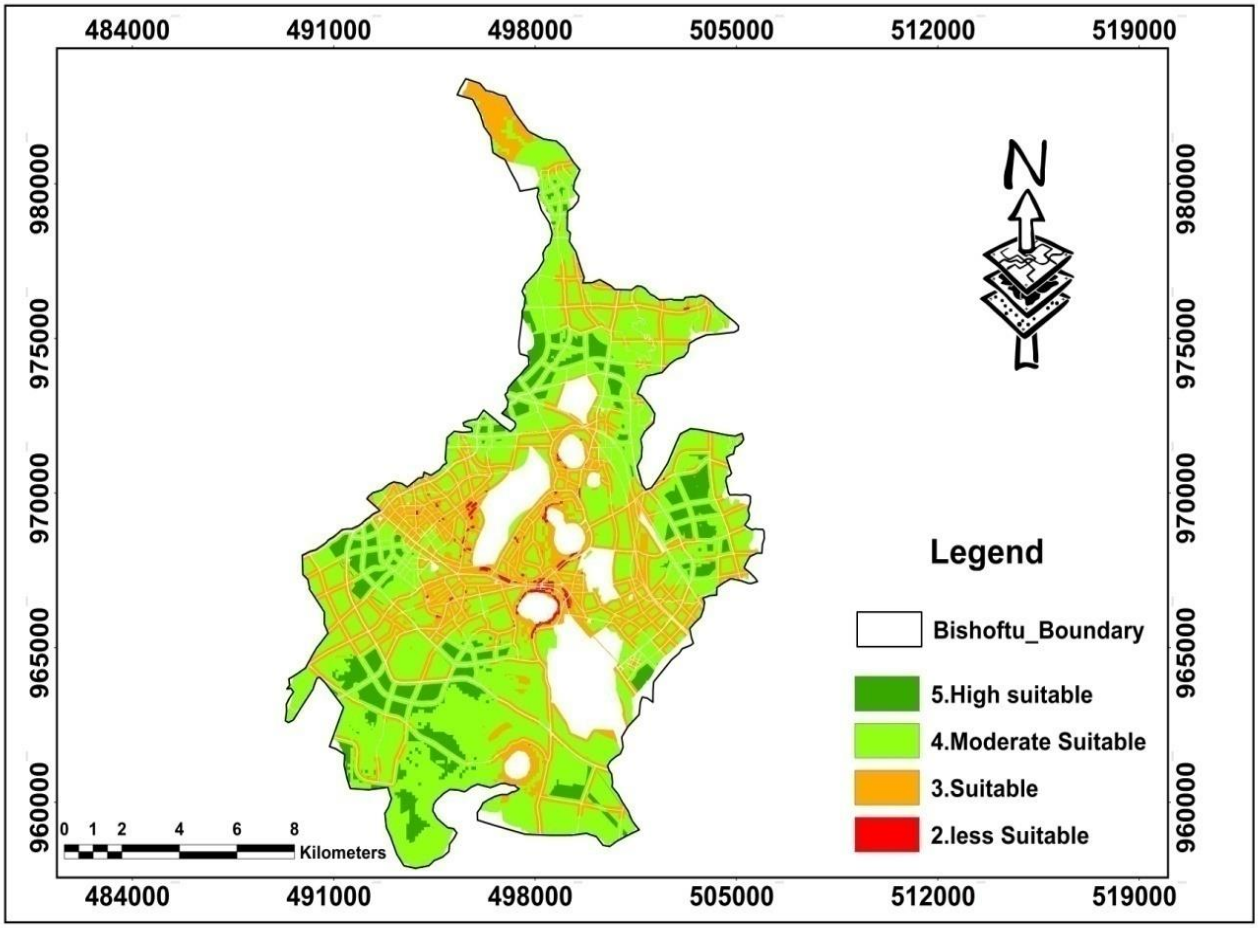

Figure 4.8 Output of the Weighted Overlay for Public Hospital Site Selection

Table 4.10 final weighted area covered and area in percent value table

Level of suitability	**Ranking**	**Area (ha)**	**Area%**
Highly suitable	5	1432.65	9.49
Suitable	4	9059.14	60.03
Moderately suitable	3	4423.73	29.31
Less Suitable	2	115.66	0.77

CHAPTER V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

GIS-based Multi-Criteria Analysis (MCA) provides a more technological, convenient and precise way for hospital site selection than the traditional ways. It combines spatial and non-spatial data to construct visualized information that can be easily understood and analyzed by decision makers. This study aimed to evaluate and mapping public hospital suitability and spatial distribution of hospital suitability analysis in the study area which is necessary for sustainable land use.

The entire analysis suitability index the pixel value is between 10 x10 meter and the highly and very less suitable areas were determined. This study considers seven economic and environment criteria were used to select public hospital site the three candidate sites were suggested in light of the methodology and available data applied in this research. The results; 9.49%, 60.03% and 29.31% have demonstrated that three sites were chosen as highly suitable, suitable and moderately suitable respectively. These places are far from any water body (lakes and rivers); restricted area such as religious church's military camps (Ethiopian air force) and different factors are taken into consideration in the analysis. The High suitable places are located at different parts of the town. The most appropriate site was situated at over Residential and Recreational & Environmental are as the planners and the decision makers can get useful information about the possible locations of public hospital sites using this methodology.

5.2 Recommendation

On the basis of the findings in this study, the researcher makes the following recommendation sare put forth to improve and more effectively in order to manage urban planning and incorporate different factors which are responsible to use public hospital.

This study considered seven social, economic and environment criteria were used to select public hospital site, but other factors influence public hospital site selection should be included as evaluating criteria like cost of construction, aspect, geology and others GIS-based MCA provides a more technological, convenient and precise way for health site selection. MCA are used to locate the candidate public hospital site selection. Data organization of bishoftu Office is hardly strong such that it is

recommendable to pertinent individuals that health data shall be prepared and organized properly and consistently. Health Service Reports, magazines, brochures and booklets such as Health service Coverage, For GIS researchers whose goal is to develop methods of solving real-world problems; their case studies should put those methods to a practical test. This study showed the need to identify not just the required data type for inputs, but also the standards of topological accuracy and attribution necessary to produce a reliable solution. Additional case studies like this one could help to refine the existing models and show new paths for further research. Even though this research has identified new sites for locating Hospital site and methods to locate selection of best site dynamically. Further developments are necessary to improve this method because real time technologies like GPS should be used to take into considerations the congestion level of the road networks.

The road network of Bishoftu in the expansion area, being based on the nature of the existing network, therefore the municipality should design new road network which cover the entire expansion because road network is major driving force of Suitability analysis in the study and most built up expansion follow the existing road network.

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