**Evaluating Spatial Accessibility and Optimal Location of Community Health Center Using GIS Techniques, A Case of Yeka Sub City, Addis Ababa, Ethiopia**


BY

Getu Desalegn


A Thesis Submitted to the department of Geomatics Engineering
School of Civil Engineering & Architecture

Presented in Partial Fulfillment of the Requirements for the Degree of Master of Science in Geo-informatics Engineering Program


Office of Graduate Studies

Adama Science and Technology University


Adama

November, 2020

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# DECLARATION

I, Getu Desalegn with Registration Number: pgr/18031/11, hereby declare that this thesis is my original work and that it has not been submitted partially; or in full, by any other person for an award of a master's degree in any other university or institution.

Name:  Getu Desalegn Mesele

Signature:______________________

This MSc Thesis has been submitted for examination with my approval as thesis advisor.

Name: Tilahun Erduno(Dr.Ir)

Signature:______________________

Date of submission:

# ADVISOR’S APPROVAL SHEET

To: Geomatics Engineering department

Subject: Thesis Submission

This is to certify that the thesis entitled “**Evaluating Spatial Accessibility and Optimal Location of Community Health Center Using GIS Techniques, A Case of Yeka Sub City, Addis Ababa”** submitted in partial fulfillment of the requirements for the degree of Master‘s in “Geoinformatics Engineering” the Graduate program of the department of “Geomatics Engineering” , and has been carried out by “ **Getu Desalegn Mesele**. **Id. No. pgr/18031/11** under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby he can submit the thesis to the department.

Advisor Name: Tilahun Erduno(Dr.Ir)

Signature:____________________

APPROVAL of BOARD of EXAMINARS

Thesis submitted by Getu Desalegn Mesele, Entitled as “Evaluating Spatial Accessibility to Health Center and Optimal Location of Community Health Center Using GIS Techniques: A Case of Yeka Sub City, Addis Ababa, Ethiopia”, In partial fulfillment of the requirements for the award of a Master’s Degree in Geoinformatics Engineering

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| Advisor | Signature | Date |
| Chairperson | Signature | Date |
| Internal Examiner | Signature | Date |
| External Examiner | Signature | Date |
| Department Head | Signature | Date |
| School Dean | Signature | Date |
| Postgraduate Dean | Signature | Date |

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Getu Desalegn

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| | |
|---|---|
| AA | Addis Ababa |
| AACA | Addis Ababa City Administration |
| AACAILIC | Addis Ababa City Administration Integrated Land Information Center |
| AACG | Addis Ababa City Government |
| AACRA | Addis Ababa City Road Authority |
| AAHB | Addis Ababa Health Bureau |
| CHC | Community Health Center |
| CSA | Central Statistics Agency |
| DEM | Digital Elevation Model |
| EGA | Ethiopian Geospatial Agency(EGA), |
| ESRI | Environmental Study Research Institute |
| FDRE | Federal Democratic Republic of Ethiopia |
| GIS | Geographic Information System |
| GPS | Global Positing System |
| HSAA | Health Statistics Annual Abstract |
| HSDP | Health Sector Development Programme |
| HSDP | Health Sector Development Program |
| ILIO | Integrated Land Information Office |
| MoH | Ministry of Health |
| ND | Network Dataset |
| SA | Service Area |

# *ABSTRACT*

*The main topic of this study is entitled as Evaluating Spatial Accessibility to Health Center and Optimal Location of Community Health Center Using GIS Techniques: A Case of Yeka Sub City,Addis Ababa, Ethiopia. Many people who live in the periphery of most cities in the world lack efficient transportation; and in emergencies, time required to reach a health centers becomes a major issue. In study area, Yeka sub city, health facilities are unevenly distributed and they are scarce for peripheral dewellers. As national standard, the existing community health centers are not fully accessible physically, the reason behind is, uneven scattering of the population in fact is the topographical location of the Sub-City. The general objective set to deal with the problem is to make analysis and find results on balancing the distribution of health center and demands of the society for the services in theentire area of Yeka. The study profoundly helps both the government and the society in placements and use of health center in the research area based on scientific reasons. Service area analysis method supported by GIS techniques of network analyst and spatial analyst method (such as euclidean distance, reclassify and weighted overlay analysis) were used. In this study the followind data were used, such as Road network, Existing health center and population for service area analysis in network anlyasis in terms of distance and time, where as DEM, population, existing health center, schools, manufacturing site, religious institution, river, main road, population and land use data were used. In service area anysis, road network converted in to network dataset. In the spatial anlyst, except DEM and Land use, the rest data were analyzed through proximity analysis and reclassified in to suitability mode. To select optimal site weighted overlay method were used. In the result it is identified that health centers are not evenly distributed resulting in densely situated around infrastructures such as transport facility, road network and population. In the anaylsis, in the national standard, about 80%(368,203) population were health center service accessed, where as 20%(87735) people had not accessed. Based on the objectives suitable site selection was analyzed, there were ten criteria's were used. Therefore highly suitable sites were selected. The outputs were mapped spatial accessibility in terms of traveling distance, time, population coverage and the new selected health center site .*

**Key words**: Distance, Health Center, Service Area, Spatial Accessibility, Spatial Analyst, time.

# CHAPTER I. INTRODUCTION

## 1.1. Background of the study

Public policy makers and city planners need to design mechanisms of providing services especially in developing countries. From the present day situation, where world is facing the rapidly growing population contradictory to unalterable size of land to survive on, there must be a special means of resolving the challenges of providing services and facilities such as health institutions (Clinics, healthcare centers, Hospitals, Ambulance stations etc.), schools, water supply, market centers, power supply, infrastructures, fuels etc. in both urban and rural areas. Access to Health care is one of the most important facilities of overall population in the country. Many researches focus on improving access and eliminating the disparity region of health care facilities. Accessibility mainly depends on the availability and affordability of the services. Ensure that all the sectors of the society should have equal and adequate access to primary health care, regardless of socio-economic and geographic factors.(Wondwosen, 2019) Spatial accessibility index represents the degree of fit between the clients and the health care system. (Penchansky and Thomas, 1981, cited in Hanadi, 2014). Service provision for publicly provided facilities with quality services and infrastructure for improved access is better approached through proper planning. The spatial planning of health care services involves aspects of resource allocation. Access to health care facilities is one of the important facets in the health care planning process. Given the spatial perspective of this study, performance is then assessed in terms of geographical access levels of the services by potential users.

Motivations to this topic were the followings, such as limitation of researchs in this topic, manual approaches of measuring spatial accessibility in the study area and the existing community health centers were very crowded during service delivery, so the question was raised, why most of the health centers are very crowded, and the solutions to decrease the crowdness of these health facilities.

The rationale of selection of Yeka sub city as study area were Topographic difficulty, the number of populations, infrastructure and road accessibility.

GIS-based accessibility analysis is a logical method which can be applied to measure the degree to which geographical access is obtained. It has recently been used to approximate the degree of health care need and / or forecast health care demand in a number of studies (e.g. McGrail, 2012; Al-Taiar et al., 2010, Apparicio&Séguin, 2006, Bagheri et al., 2005 & Lin et al., 2005 cited in Hanadai, 2014)). GIS-based accessibility analysis is a relational evaluation of services relative to potential user's demand measured within a specified distance range and using a detailed road network. This type of analysis is therefore not a simple service-to-population ratio, but also the consideration of distance and time. A key advantage of measuring accessibility is that the measurements take into account service sufficiency (capacity) with respect to its location.

In the case of Yeka sub city there are 15 community health centers (Yeka sub city health office, 2018), In Yeka sub city, many people live at the periphery of the sub city, for this reason peoples must walk long distance to get the health center (Yeka Sub city health office, 2018). Then, spatial accessibility analysis to health center is necessary using GIS technique in study area and locating new health center site after evaluation of spatial accessibility to CHC.

The purpose of proceeding with this research is raise mechanisms on levelling accessibility and coverage, so that each health center is accessible to the population in the city at proper space with minimum distance cost particularly of the interest area.

## 1.2. Statement of the problem

The demographic explosion in developing world countries has created a tremendous pressure on resources and public facilities (Ahmed M. W. Abdel-Latif, 2007 cited in Wondwossen, 2016 p. 2). 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. Peters, et'al, 2008, cited in Wondwossen M. and Bedasa A. 2019). There are no such basic grounds based on which these services and other facilities are distributed among population of Ethiopian cities and districts as (Fei Gao, et'al, 2016 cited in Wondwossen M. et'al 2019) indicated in their study as "Health inequalities originate through several factors - including the organization and management of space which could vary between socio-economic groups"). Several facility service area layer methods have been proposed by different scholars that enable governments to fairly reach the demands of their citizens for the services. Ethiopia is poorly experienced in uniformly distributing all amenities and facilities which are believed have to be reached the citizens from the social service sector. (Wondwosen M. et'al, 2019) and also there a problem on selection of suitable site for additional social service facilities. Among these facilities, health facilities are included.

Many people who live in the periphery of most cities in the world lack efficient transportation; and in emergencies, time required to reach a health centers becomes a major issue (Michael B. et 'al, n.d). In study area, Yeka sub city, health facilities are unevenly distributed and they are scarce for peripheral dewellers. As national standard, the existing community health centers are not fully accessible physically, the reason behind is, uneven scattering of the population in fact is the topographical location of the Sub-City. Yeka Sub-City is characterized by vigorous type of topography with noticeable elevation deference and steep landscape especially in the northern part (Atlas of Yeka, 2014, P. 22 cited in Wondwossen M. 2016). More of the Yeka sub city, residents, who live in peripheral must walks long distance to reach to health center), which is very difficult during emergency to reach on time (Yeka sub city health office, 2018). To solve this type of problem GIS based spatial analysis of accessibility preferred, to examine the spatial accessibility of health center. Many researches were done on spatial accessibility health care facilities by different researchers, but in Ethiopia there is limitation on this topic, specially in study area.

In Ethiopia, Abebaw Andarge has done related with health center distribution mapping. The title was "*Health Facilities Distribution Mapping in Addis Ababa, Ethiopia".* The researcher focus on ratio of population to health centers of government and private. The study did not concentrate on distance and time, that has been covered by peoples in the study area.(Abebaw, 2016). But this study was differ from Abebaw studies, that the current study focus on the national standards of that must be covered by peoples to get health service. The other researcher that deal with accessibility of public service in Yeka Sub City. The title was" *Location Allocation Analysis For Urban Public Services Using Gis Techniques: A Case Of Primary Schools ility in Yeka Sub-City, Addis Ababa, Ethiopia*". This study also use GIS to measure spatial accessibility to primay schools in terms of distance and time, and try to select suitable sites to schools. From this study, the current study measures the spatial aceessibility to health center in terms of distance and Time, but this study differs on types of service and number of suitable selection criteria. In addition to this, there is no research done on evaluating spatial accessibility to community health center in Yeka sub city and there is geographical difficulty to adopt directly other countries study on spatial accessibility health to facility, based on this it is necessary to evaluate spatial accessibility to community health center in the study area standalone using traveling distance and time. (Yeka sub city health office, 2018). In Yeka Sub city there are 15 community health centers (Yeka Sub City Health Office, 2018) for 455,998 people (CSA, 2019). Theses health centers are very crowded for service delivery.

This paper work particularly aimed at the emphasis on how the formerly constructed community health centers in Yeka Sub-City of Addis Ababa City are seen after service area analysis indemand and service setup; where and how many new health centers shall be established to achieve the objectives anticipated in the study; what maximum distance shall be covered by patient to get to the health center nearest to him or her etc.

Service areas for the health facilities are generated to identify populations that are accessible to the facilities from the others based on the limited distance and time taken to reach the health center destinations. A technique of finding suitable areas for health center using spatial analyst extension tools from ArcGIS is also applied to determine the most optimal location of the new community health centers to be established as a supplemental part of the site selection analysis.

## 1.3. Objectives of the study

The *general objective* of this study is to evaluate spatial accessibility and optimal location of community health centers in the study area.

**The *specific objectives* are to:**

- examine spatial accessibility of exisiting community health centers (CHC) using service area analysis interms of distance
- examine spatial accessibility of exisiting community health centers (CHC) using service area analysis interms of time
- select new community health center site in the study using suitability analysis in Spatial Analyst Tools of ArcGIS extension using muluti criteria

## 1.4. Research Questions

- How to examine spatial accessibility of community health centers (CHC) in the study area using distance and time?
- What are the criterias to select suitable site for new community health centers using GIS ?

## 1.5. Scope of the Study

The spatial area coverage of this study is limited with Yeka sub city administration boundary. The thematic scope of this study is focused on evaluating the spatial accessibility and optimal location of new community health centers site using service area analysis and spatial analyst tool respectively in the study area using GIS techniques.

The study is commenced by collecting the spatial locations of all community health centers in the area. Based on these spatial locations, additional locations are designated for further health centers to manage distance and time cost disproportion. Locational Judgments of the chosen sites are made through spatial analysis in terms of distance and time from existing health centers, river, road and residential parcels(population) and relevance of the selected sites are observed.

It also covers its analysis on examining the pre, ongoing and upcoming construction of health centers facilities in terms of suitability. It deals with extracting general information about how to locate the health centers through spatial analysis in the ArcGIS environment.

## 1.6. Significance of the Study

The result of this study profoundly helps both the Yeka Sub City administration and the society in placements and use of community health centers in the research area based on scientific reasons.

Therefore, this thesis work result after completion is believed to contribute to solve the various emerging problems on the subject matter of demand and facility relationships in the district of Yeka Sub City. It can be used for relevant urban land management stakeholders such as planners, surveyors, engineers, and other municipal personnels as a reference to make concrete locational decisions related with spatial accessibility that have in scientific basis.

### 1.6.1. Benefit for The Community

Making researches like this primarily benefit the society that are affected by the distributions of the service centers among their residence areas in Yeka Sub City. After solving the problems, the time and distance consumed for getting the service will be reduced. The most important among the implications of this research are averaging time and transportation cost for the patients who specially take long distances from their home to health center and forth daily. Different problems that encounter patients due to long distance coverage such as traffic accidents and criminal acts will also be minimized. Increasing health service on the other hand considerably increases peoples healthy.

### 1.6.2. Benefit for The Government

It is significant to the government to go through such kinds of studies for several applications. Public-sector facilities, such as hospitals, schools, libraries, fire stations, and Emergency Response Services (ERS) centers, can provide high-quality service to the community at a low cost when a good location is chosen.

As sub city level, it transcends the measurement of facility sufficiency or quantity with respect to its location within the administrative unit in which it is located. This improves current service access at overburdened focal points where previously not realized. In addition, the actual distance travelled by the residential are analyzed to serve as input and give support to the attainment of more equitable access standards to a range of services in a sub city and to apply optimal facility location, in conjunction with movement patterns.

## 1.7. Limitations

The researcher has been encountered different hindering problems and that could not be resolved. Road network of the Sub-City is not properly structured so that this intern affected the analyses of spatial accessibility interms of distance and time made based on the network analyst in GIS. The land use land cover data also not properly organized, this affected the final optimal site selection for new community health center. One third Health Centers office fail to cooperate. Managers associates when meet researcher I want to know the health center situation, are biased because of fear for government actions like service giving and their performance etc. They are suspicious and most of them are not volunteers to state and show the reality of their health center situation even with officially supported letters of cooperation. The researcher because of such reasons in turn deprived of additional detail information from health centers apart from health bureaus, this problem affected the discusstion part of the thesis.

# CHAPTER II. LITERATURE REVIEW

## 2.1. Introduction

*Accessibility* often refers to spatial or physical accessibility and is concerned with the complex relationship between the spatial separation of the population and the supply of health care facilities. Accessibility is influenced by both spatial factors (geographical location and travel distance) and non-spatial parameters (socio-economic status, populations health status, financial status, perception about health and health care system and traditional customs. (Aday and Andersen,1974; khan 1992). However, the two most significant factors influencing access to health care are health centers supply and population demand (Luo, 2004 cited In Shalini, 2014).

*Spatial accessibility* refers to the relationship between the locations of the supply of and the locations of demand for specific services, taking into account existing transportation infrastructure and travel impedance. In the literature, spatial accessibility and geographical accessibility (McLafferty, 1982; Pooler, 1987; Brabyn and Skelly, 2002; Apparicio et al., 2008) are often used in an interchangeable manner, in the sense that both concepts are location-based and spatially constrained, as Khan (1992) has noted that spatial accessibility is specifically conditioned by the spatial or distance variable (as a barrier or a facilitator of access) and the pattern generated has the most direct geographic manifestation.

**Common Terminologies**

The following terminologies are of special concentration throughout the location allocation of the primary schools. They are described by Arifin (2011) as follows:

**I. 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 uncapacitated considering how much demand it can meet. If facility can supply an infinite demand then it is uncapacitated and when facility's capacity is limited then it is capacitated. Facility can also be classified depending on the number of service it is providing. A facility can provide only one type of service or a group of services. Example of a single service facility is food shop which only provide food and example of multiple services is general hospital that provides multiple health supports.

Cost is another property of facility though which service area models can be differentiated. Facility cost can be two types. One is fixed cost and another is variable cost. Fixed type of cost depends on the establishment expense of facility. Variable cost has a relation with service delivery.

**II. Demand or Customer:** - the second essential component of service area algorithm is demand which is also known as customer. A demand or customer is a person who needs accessibility to a service or to a supply of a good. Since service area  problem is connected with satisfying demand, it is important to know their distribution, quantity and behavior. If we consider demand distribution in space, it can be assigned uniformly over the area or network. It can be assigned to specific point (geocoded) over the area. It can be assigned on the centroid of the area. However it can also be assigned randomly to simulate the problem over the area if there is no real data. Another hindrance of depicting reality into the research is using demand I the location allocation model. In the classical location allocation, demand is used as weighted value in the nod or in the smallest unit of continuous space. Weighted demand means the aggregation of some customers on one point.

if the size of the demand decreases, it makes the descrement of computational complexity. When the quantity of the customer is very large, for example a million, then it is better to use weighted demand. The demand of the customer can also be either deterministic or stochastic.

In case of deterministic, there is prior knowledge of demand while it is used into the model. In other case, demand will vary depend on the type or service of facility.

**III. Location or space: -** the third essential component of service problems is space or location. There are three types of representation of space in sevice area problem. These are discrete, continuous and network based. In discrete space model, it is assumed that there is a prior knowledge of the candidate or potential sites. Since some best locations are selected from pre-selected potential locations, it is also referred as selected location model. Decision makers make the choice of candidate sites due to geographical or economical factor. Examples of these factors are zoning regulation, presence of structure and land availability etc. some of the location allocation problems deal space as continuous. One or more continuously varying co-ordinates determine all the possible site locations. These continuous site locations are normally considered in Euclidean space. It is also known as site generation model. Because there is no presumption of potential sites for the model, rather appropriate site generation is done as an output by the model.  Another type of representation of space network based. Network space depends on graph-theoretic approach. Model using these approach can solve problem with much larger size. A network with either continuous or discrete space is considered in this type of space or location. Continuous network considers links of network for a continuous set of candidate locations.

In discrete network, new facilities are only placed in the nodes. In space there can be some forbidden area where site selection or site generation should not be done in the model. Similarly some areas cannot be used due to some restrictions. For example new facilities may not be built over water body or park. Site selection or generation over these areas should be avoided due to ineligibility (PP. 11-13).

**Determining factors in the distribution of urban public services**

The following factors explain the distributional patterns for public services as to Jones and Kaufman cited in (Feyzan (Beler) Erkip, 1997):

A. the amount of resources available (this affects the overall service level, which may explain the allocation pattern rather than the distribution);

B. the composition and distribution of population, especially the geographical concentration of socio-economic characteristics of users, may explain some of the service distribution patterns;

C. the number and intensity of political demands may affect service distribution, particularly to higher income groups; thus, these politically powerful groups are expected to be more effective in affecting the distributional patterns;

D. the needs of citizens must be reflected by the demand to be effective in the distributional patterns; even when the needs of citizens are considered in service distribution, they are mostly defined by its providers (P. 354).

## 2.2. Use of Geographic Information Systems (GIS) for Spatial Acessibility

The use of Geographic Information Systems (GIS) for the measurement of spatial accessibility is well established and has been applied in many areas including retail site analysis, transport, emergency service and health care planning. GIS are well suited to measuring spatial accessibility to health care as they contain the core components needed for such analysis namely: data capture storage, management and manipulation tools for both spatial and attribute (textual) data, core analysis algorithms such as buffering, overlay, proximity analysis, shortest path and raster cost-distance analysis, and mapping and visualization tools to communicate the results of analysis.

The traditional approach to measuring access, for years, has been the number of facilities to population ratio as a measure of availability by the distance or time travelled to the nearest or by the number of facilities in a geographic area. These measures, however, do not handle properly such peculiarities as the use of services in other communities, the failure to use the nearest facility, overlapping coverages, redundant services (Rosero-Bixby, 2004). In addition, measuring accessibility using GIS is generally based on the assumption of rational behavior that users will minimize travel distances to access services and that people will not choose to use overburdened and distant health center facilities. However, depending on the type of service analyzed, people's choice of facility may not be guided by proximity alone. It can, for example, be guided by the capacity available at the facility and / or their perception regarding the quality of service they will receive.

## 2.3. ArcGIS Network Analyst

ArcGIS Network Analyst is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis (ESRI, 2005, cited in Wondwosen 2016). ArcGIS and its network analyst tool is the main software that is going to be employed in this study. ArcGIS for Desktop and Network Analyst will help the county make more informed decisions (Monica Pratt et al, 2014, P. 56, cited in Wondwosen 2016).

### 2.3.1. Service Area Analysis

***Network Analyst*** tool is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis. Using a sophisticated network data model, users can easily build networks from their geographic information system (GIS) data. ArcGIS Network Analyst solves a variety of problems pertaining to spatial networks. Capabilities include finding the most efficient travel route, generating travel directions, locating the closest facility, and defining service areas based on travel time and distance. (Shaliniet'al, 2014)

***A network service* area** is a region that encompasses all accessible streets (that is, streets that are within specified impedance). Service areas created by Network Analyst also help evaluate spatial accessibility. Concentric service areas show how accessibility varies with impedance. It is used to identify how many people, how much land, or quantities of anything else within the neighborhood or region. Service area on the basis of time and distance is also helpful to predict the travelling time and traveling distance from demand points to service or Health Centers. In the present study the service area has been generated by from Community Health Centers as service points on the basis of distance and time. From the literatures, during spatial accessibility analysis the necessary inputs are roads that have been converted to road network, health center data for destination point and population data for coverage area, how much is covered land. After the necessary executed mapping spatial accessibility in terms of traveling distance, time and population coverage.

### 2.3.2. Criteria's for Spatial accessibility to Community Health Center Using Service Area Analysis

Table 2. 1.Criteria's for Spatial accessibility to Community Health Center

| No | Data Type | Format | Purpose |
|---|---|---|---|
| 1 | Road Network Data | Shapefile | To build network dataset and to know the travel time and distance |
| 2 | Health facility data | Shapefile | Used for the accessibility source |
| 3 | Parcel Data | Shapefile | To the know the distribution of Heath centers and access coverage |
| 4 | Access Standard | Number | To calculate distance and time |

## 2.4. Optimal Site Selection of New Hospital in 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 Lakhoua (2011) 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 et al., 2000) or Index Overlay operations (Nikolakaki, 2004; Alesheikh et al., 2008; Alesheikh and Sadeghi, 2007; Kallali et al., 2007 cited in Lina Zhou and Jie Wu, 2012),). 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.

**Street:** street here means the main street, which is also very important for the hospital site. Most big hospitals in Beijing are allocated along side with the main streets.

**Sub-street**: sub-street here means path or alley, which is countless and not so vital compared with road and street. That is why this study deals with road, street, sub-street separately.

**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 on the new hospital. Residential area is corresponding to the population density and 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. The specific buffer requirements for these factor criteria are shown in the Table 3 below.

Table 2. 2. Factor a for new hospital site selection

| Factor | 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 |
| Street | The nearer away from the street (>=100m), the better |
| Sub-street | The nearer away from the sub-street (>=100m), the better |
| Metro | The nearer away from the metro station (>=100m), the better |
| River | The further away from the river (>=300m), the better |
| Public toilet | The further away from the public toilet (>=200m), the better |

**Constraint criteria contain:**

**University area:** the Haidian District is an area with high-density universities. Those universities have their own subsidiary hospitals or big clinics. Hence, it is unnecessary to build new hospitals there.

**Ring road:** there are six rings in the traffic system of Beijing. The government declared that there is no need for new hospitals anymore inside the Fourth ring road where hospitals or clinics are already saturated.

**Highway:** the landuse around highway is usually open area. There is no need to have a hospital there, from the view of economy and resource, both are waste.

**Restaurant**: hospital is the source of infection, to protect the general public, keep a distance from the restaurants around is necessary. On the other hand, most hospitals in Beijing have their own canteen for patients. Therefore, to make hospitals near restaurants on purpose is also meaningless.

**Greenbelt:** hospitals are rarely built inside the greenbelt such as parks, it is better to protect those areas which are grown much green from the pollution of hospital.

**Reservoir**: a hospital cannot be built around a reservoir, in case the reservoir is polluted by construction or drainage discharged by the hospital in the future.

**Altitude**: most areas of Haidian District are located in the flat region. While in the northwest of Haidian District, there are mountainous areas, which is not suitable for building a hospital.( Lina Zhou, Jie Wu, 2012)

## 2.5. New Health Center Site selection in Ethiopian context

**Site Selection Requirements**

1. The entry point to the health center shall be clearly defined from all major exterior circulation modes (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 with a gentle slop

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)

Table 2. 3. New Health Center Site selection in Ethiopian Standard

<table>
<tr><th>Level</th><th>Space Requirement</th><th>Served Population</th><th>Location</th></tr>
<tr><td>Health post</td><td>300 m²</td><td>3,000 - 5,000</td><td rowspan="6">➢Within residential area; near intersection of residential roads; far from noisy activities (for health post only)<br>➢1,500 - 2,000 meters far away from activities that have undue noises, smoke, dust or foul odors,<br>➢Shall not be located adjacent to railroads, freight yards, airports, grinding mill, traffic pools, industrial plants and disposal plants.<br>➢200-500 meters far from bars& night clubs, schools, commercial market centers, religious facilities, children's playgrounds<br>➢Health institutions stationed in the premises of airports or industrial plants shall have 200-500 meters distance<br>➢1,500 meters far from a gas depot or cross-country petroleum or gas pipelines.<br>➢The locations of a hospital shall comply with all relevant national and state level regulations.<br>➢The hospital shall be built in a flat terrain with a gentle slope;<br>➢The foundation schemes, soil test and investigation shall be done and it shall comply with the national building code;<br>➢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;<br>➢The building shall be parallel to the wind direction, sun glare and heat;<br>➢The surroundings of the hospital shall be free from dangers of flooding, pollution of any kind (example air, water, noise) and health hazards;<br>➢From landscape point of view it should be attractive i.e. with green areas and beautiful trees.</td></tr>
<tr><td>Health Center</td><td>2,000 – 5,000 m²</td><td>15,000-25,000</td></tr>
<tr><td>Primary Hospitals</td><td>5,000 – 10,000 m²</td><td>60,000-100,000</td></tr>
<tr><td>Primary Hospitals</td><td>5,000 – 10,000 m²</td><td>40,000</td></tr>
<tr><td>General Hospital</td><td></td><td>1,000,000-1,500,000</td></tr>
<tr><td>Specialized Hospital</td><td>30, 000 m²</td><td>3,500,000 – 5,000,000</td></tr>
</table>

Source: MOFA (2005) and ORAAMP (2002)*Small and Medium towns, **Large towns cited in MUDC, 2012

# CHAPTER III. MATERIALS AND METHODS

## 3.1. Introduction

The chapter discusses the way the research is conducted from how literatures are reviewed to the final data discussion stage. The four main points provided in detail in this chapter are the physical and socio economic background of the study area, research design, data and methodology. Brief image of the research design is presented through which the structural flow of the research can be understood. Data types used in the research and their sources, methods through which they are collected are clearly described. Finally the GIS methodology and techniques that is service area analysis and spatial analysis on how to find the optimum health Center sites are presented.

## 3.2. Physical and socio economic background of the study area

### 3.2.1. Historical Backgrounds

Addis Ababa was founded during the reign of Emperor Menelik II in 1886. A centrally located palace, encircled by a camp of different military officials and the ruling elites, characterized the structure and layout of early Addis Ababa (Atlas of Yeka, 2014, P.6). It is the capital of federal government and a chartered city. It is where the African Union and its predecessor, the OAU are based. It also hosts the headquarters of the United Nations Economic Commission for Africa (UNECA) and numerous other continental and international organizations. It is the largest city in Ethiopia (Ashenafi Aimro, 2015, P. 5).

Even though there is no more observed history written about Yeka separating it from Addis Ababa, the researcher could identify few unique things that are pertinent to Yeka. One of these is Adewa Road that historically tell that the troops of the Emperor Minillik II passed through to fight the Italian Fascist invaders. Another historically known place is named Locally Washa Mikael which is recognized by the Ministry of Tourism and Culture as place of Tourist attraction and found on the highest point in Yeka. Another historical road known as Asmara Road also passes in the Sub-City serving in connecting the City with the Northern Society.

### 3.2.2. Geographical and administrative division of Yeka

Yeka is one of the 10 sub cities in Addis Ababa City Administration Units. It is located in the Northern Part of Addis Ababa, bounded from South by Bole, from West by Gulele, Arada and Kirkos sub cities and from North and East by Oromia regional State. At present, the sub city is divided into 13 woredas, 124 subworedas, 394 sefers, and 1344 blocks (Atlas of Yeka, 2014, P.21).

### 3.2.3. Topography or Relief Patterns

Elevation is an indicator that enables a simple understanding of Topography (relief) for a given area. Conversion of vector contour map in to raster creates an elevation surface data providing the altitude value of any space measured on small size square or pixels. From the Elevation map we can see that Yeka Sub City is characterized by a dynamic type of topography with noticeable elevation difference and steep landscape especially in the northern part. Generally speaking in the Sub City, the altitude ranges from 2314m to 3025m above sea level which range of 711 meters (Atlas of Yeka, 2014, P. 22).

### 3.2.4. Descrption of Study Area

Yeka sub-city is located in the north east part of Addis Ababa city. It borders with the districts of Gullele, Arada, Kirkos and Bole. The total area of the sub-city is 8212.52 hectares . Yeka sub-city is located in latitude and longitude of 9°2′14.28″N and 38°50′6″E respectively. The total population of the sub city is 455,998(CSA,2019). In this sub city there are 15 health centers (Yeka Sub City Health Office, 2018).

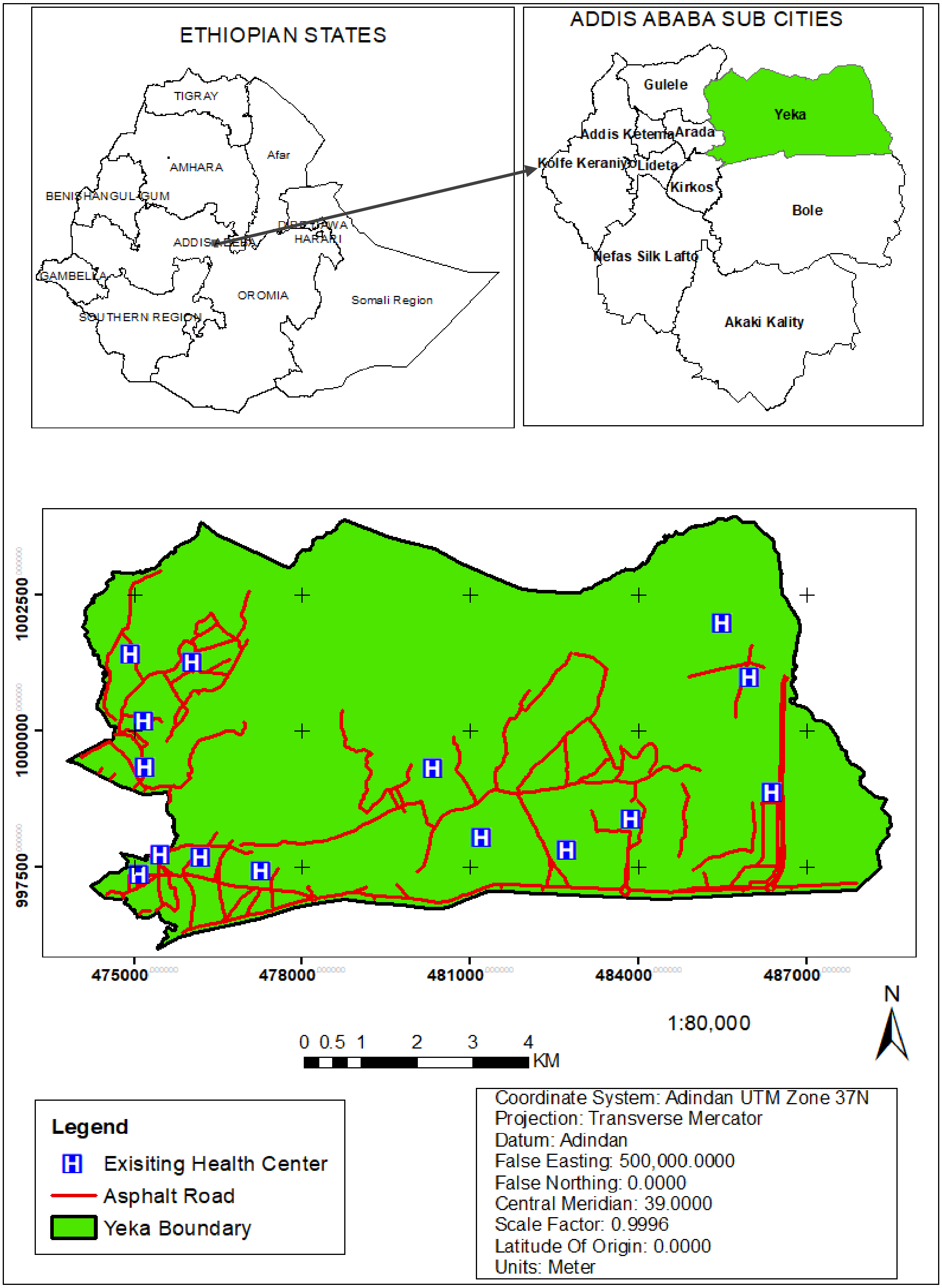


Figure 3. 1: Location Map of Study Area (Yeka Sub City)

### 3.2.5. Land Use Classes of Yeka Sub-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 health center exists and where there is not, where the demand is high and where it is low etc. According to Addis Ababa City Administration Integrated Land Information Center of 2014, there are about 22 number of land use types identified in Yeka Sub-City in general as can be described as follows.

**1. Administration**

Beside the main city administration, the Sub-City has two hierarchically structured administer tions one at sub-city level the second at woreda levels. The first one is Yeka Sub City administration that serves as the center for woreda administration and responsible for the main city government whereas the second one is prepared for each woreda in the Sub-City that closely governs the issues of population under it and responsible for the Sub-City administration.

**2. Commercial**

Market places from the very small retailers to large scale tradings are all grouped under these column of land use type in the entire area. In addition to these organizations such as Fuel stations, Hotels cafeterias, restaurants etc. are included.

**3. Cultural and Social Welfare**

Places for Recreational Centers, Centers for Youth, Sport fields, Entertainments and open spaces for public use are summed up to 35.23ha (0.43%) of the total land.

**4. Education**

Education centers at all academic levels ranging from Kindergarten to University exist in the Sub-City. Based on this there are 111 KG, 123 Primary schools, 4 Primary and Secondary schools, 13 Secondary schools, 18 Colleges, 2 University Colleges, 8 Universities and 279 in Total. The Land use amount that is covered by education is 175.46ha (2.14%).

**5. Field Crop**

Yeka Sub-City partially covers the rural part of the city and thus includes land use for farming purposes. Most northern hilly part of the Sub-City land cover that amounts to 1433.55ha (17.45%) is occupied by inhabitants that live semi-rural lifestyle and thus manage their lives by harvesting and keeping their herds and partially share urban facilities schools, water and electric services. Places on which the peoples sparsely settle their houses are actually reflected in the residential land class.

**6. Health**

The land use covered by health purpose includes, different types of pharmacies, laboratories, 31 clinics, 15 health centers and 6 Hospitals. From the total land use 19.47ha (0.24%) of land is occupied by health.

**7. Infrastructures and Utilities**

Infrastructures are institutes such as water supply services that provide services for the population living in the sub-city at a large scale while utilities are small storehouses and sites such as ground water reservoirs, towers for telecommunications, etc. that give services around the vicinity.

**8. Manufacturing and Storage**

These are industrial areas where different items are produced and are distributed through the entire sub-city. For instance items such as metallic materials for farming, construction HCB, furniture, garments, poultry, dairy, detergents, small and micro enterprises, PLCs, etc.

**9. Mixed Residential**

These land use types are settlements used for commercial purposes besides their usage for residences. Such kinds of houses are built on the ages following specific patterns of asphalt and other roads commonly accessible for population flow. There is no difference between mixed residential and residential types of land use except the former is built mostly following road edges..

**10. Municipal Services**

Places where large water reservoirs, Religious centers, cemeteries, memorial parks exist are considered municipal services. Their land cover size is summed up to 30.35 Ha (0.37%) from the total.

**11. Open Space**

Open space is part of the land use where no kind of economic activity is applied on. Even though it is seen at different locations throughout the area, larger potential of the open space coverage is found in the northern part of the Sub-City where there is sparse population and relatively high altitude.

**12. Plantation**

Plantation takes the third largest area coverage of the total land use next to Residential and Field Crop. Mountainous parts that are not comfortable for residential use are reserved for plantation of mixed Eucalyptus and very few indigenous trees such as Juniper and Acacia etc. 1395.72ha of the area is covered by plantation.

**13. Recreation**

Facilities like open spaces for youth, woreda youth centers, woreda recreational centers, parks, sport fields etc. are grouped under this of land use type. Their expansion follows certain patterns of population density.

**14. Religious Institution**

These are religious centers or institutions that work for spiritual matters. It comprises Churches, Abbeys, Mosques and some religious foundations like Theological colleges and others.

**15. Residential**

This type of land use works for only residential use. Southern, westerns and central most parts of the Sub-City is occupied by the population houses. Residential takes the highest of all other land uses area cover. It is where demand of student population for health facilities is believed to grow. 2469.44ha (30.07%) the land use is enclosed for only residential purpose.

**16. River**

Remarkable amount of area is also concealed by rivers and their tributaries that flow from the Northern mountainous parts down the southern borders of the Sub-City. Some are all weather while some are seasonal flows. Area that is under the river coverage always mistreated in poulated areas especially in cities like Addis Ababa. There is no mode of using the river basins for some educational or scientific studies or recreational purposes like other developed cities in other countries. Instead the rivers in the area are polluted by different kinds of dry and liquid wastes from the residential, Industrial and commercial areas. Kebena River is one of the best example.

**17. Road Network**

One of most important land use type to be studied in this research work is the road network existing in the study area. Road is a transportation route that determines the degree of importance of another land use type by increasing the accessibility of that area. There are five major categories of roads connected to one another in the Sub-City namely asphalt, cobblestone, gravel, paved and unpaved. In general all road coverage in the Sub-City summed up to 715.41ha from the whole land use.

Table 3. 1. Type and lengths of roads existing in Yeka Sub-City

| No | Road Type | Class | Area (hectares) | Length (km) | Percentage (%) |
|---|---|---|---|---|---|
| 1 | Asphalt | 1 | 109.89 | 125.76 | 15.36 |
| 2 | Cobblestone | 2 | 73.19 | 83.73 | 10.23 |
| 3 | Gravel | 4 | 146.44 | 167.53 | 20.47 |
| 4 | Paved | 3 | 93.86 | 107.37 | 13.12 |
| 5 | Unpaved | 5 | 292.03 | 334.11 | 40.82 |
| | | Total | 715.41 | 818.50 | 100 |

**Source:** Yeka Sub-City Integrated Land Information Office and aerial photograph of the area under study captured in 2011

**18. Special Use**

As the name indicates the land areas preserved for special purposes such as Military defense camps, radio transmission station some other undefined areas etc.

**19. Transport Terminal**

There is only one transport terminal in the sub-city known by its local common name Laberet Menehariya (Bus Station) which is designed to serve transportation from Addis Ababa towards East exit of Kara to all Towns and districts at different locations and Vice versa.

**20. Under Construction**

It is very difficult to describe this land use type because it is fluctuating from time to time due to increasing demand of housing and commercial use of construction. Two big factors that affects construction in the Sub-City are Government plan for condominium and real estate industry of private sectors. According to Addis Ababa City Administration Integrated Land Information Center of 2014, the area under construction amounts 189.42ha of the total land.

**21. Vegetable Farm**

Few plots of lands are used by government Ministry of Agriculture for some Agricultural and Scientific studies as well as raising both important indigenous and exogenous plants for city greening purposes.

**22. Mixed Forest**

An area covered by mixed forests of Acacia, Juniper, Eucalyptus, Cupressaceae (Yeferenj Tid), Cordia Africana (Wanza), and White Thorn acacia etc. Such kinds of mixed forests are seen mostly on areas where only some artificial plantation activities are applied and naturally occurring plants are protected, beside religious centers particularly around Orthodox Churches, along river basins and where knowingly varieties of flora are planted etc. 358.20ha of land is coated by mixed forest.

Table 3. 2. The Land Use Land Cover Types and Their Respective area coverage

| No | Land Use Type | Area(Hectares) | Area(%) |
|---|---|---|---|
| 1 | Administration | 277.59 | 3.38 |
| 2 | Commercial | 72.72 | 0.89 |
| 3 | Cultural and Welfare | 35.23 | 0.43 |
| 4 | Education | 175.46 | 2.14 |
| 5 | Field Crop | 1433.54 | 17.45 |
| 6 | Health | 19.47 | 0.24 |
| 7 | Infrastructure and Utilities | 4.33 | 0.05 |
| 8 | Manufacturing and Storage | 134.10 | 1.63 |
| 9 | Mixed Residential | 93.82 | 1.14 |
| 10 | Municipal Services | 30.35 | 0.37 |
| 11 | Open Space | 461.66 | 5.62 |
| 12 | Plantation | 1395.72 | 16.99 |
| 13 | Recreation | 9.16 | 0.11 |
| 14 | Religious Institution | 133.52 | 1.63 |
| 15 | Residential | 2469.44 | 30.07 |
| 16 | River | 161.58 | 1.97 |
| 17 | Road Network | 715.41 | 8.71 |
| 18 | Special Use | 31.32 | 0.38 |
| 19 | Transport Terminal | 2.47 | 0.03 |
| 20 | Under Construction | 189.42 | 2.31 |
| 21 | Vegtable Farm | 8.55 | 0.10 |
| 22 | Mixed Forest | 358.20 | 4.36 |
| | Total | 8212.52 | 100 |

**Source:** Yeka Sub-City Integrated Land Information Office (ILIO)

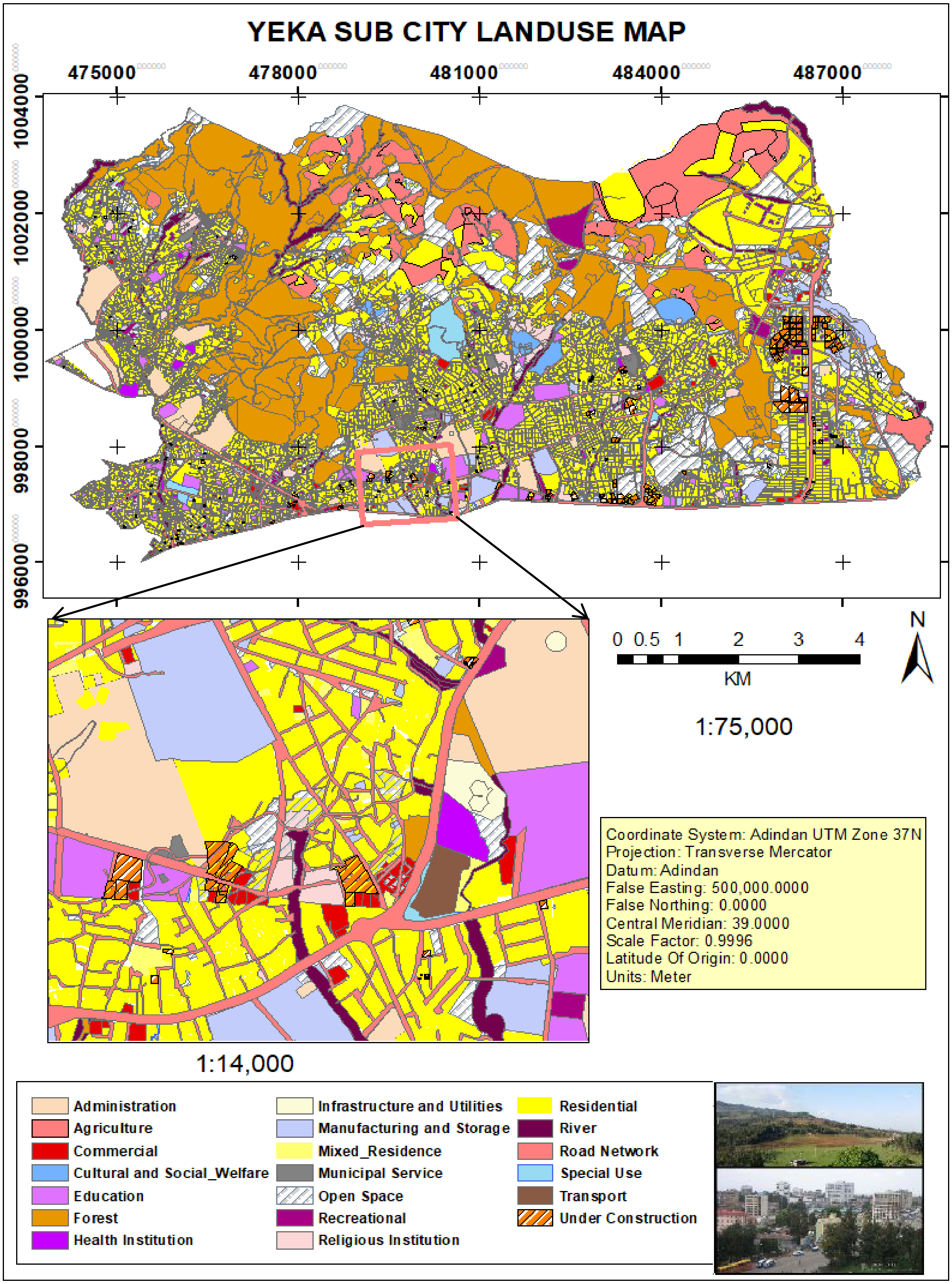


Figure 3. 2: Land Use Type of Yeka Sub City

### 3.3. Research Design

The conceptual structure or the design of the research project that the researcher followed to conduct the research became important issue to be clearly defined to visualize the whole image of the work. Preparing research design highly contributes by showing over all highlights of methods towards result findings. Therefore, before commencement of the research tec niques it is decided to prepare tracks of the research by assembling all the requirements for the problem solving objective (Fig. 3.3).

#### 3.3.1. Approaches to the Research

Both Quantitative and Qualitative research approaches are implemented to produce the I spired information or result which when combined known as Mixed Approach. Even though the qualitative side has more weightage to the final result of the analysis, it is not manageable without involvement of the quantitative side.

#### 3.3.2. Research Type

It is known that there are different types of researches to be employed on the basis of the goal (purpose), Type of data, Field of study or the aim (objective) of the research. Applied research type is used and therefore after conducting the research project, the researcher's strive for locational problems of health center services in Yeka Sub-City will be practically resolved. The inspiring purpose of the research is to see that health in Yeka Sub-City are fully accessible by the demand population of the sub-city at minimum distance.

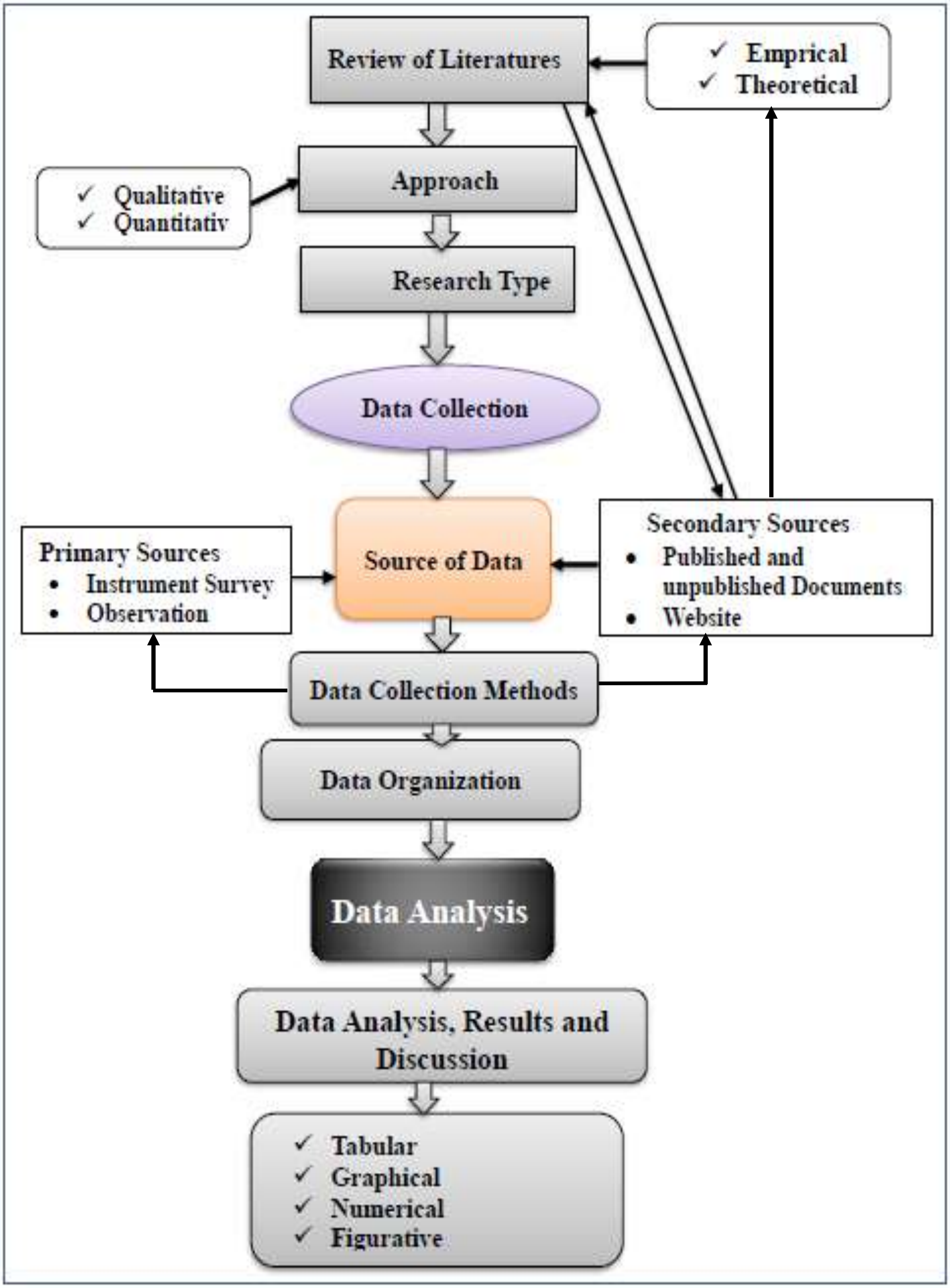


Figure 3.3: Thechnological Scheme of the research/work

## 3.4. Materials and Data Collection

### 3.4.1. Softwares

It is ArcGIS software and its extensions (ArcGIS Network Analyst and Spatial Analyst extensions) is used mainly in addition to some others that are used rarely for minor purposes such as DNR Garmin for uploading spatial information and conversion purposes, Google Earth Notepad (MS excel) for further viewing, editing and arranging the spatial data of GPS whenever needed etc.

### 3.4.2. Equipments and Tools

Laptop computer is the main equipment that is most commonly used for data processing and the final output preparation. The handheld type of GPS is used for collecting X, Y coordinates of Community Health Center in the study area. It is more comfortable, portable and accessible for use and thus is preferred to be used by the researcher. Digital Camera is used for photography data.

### 3.4.3. Sources of Data

Two identified sources of data were Primary data sources and Secondary data sources. Primary data sources were Yeka CHC, Health Center community, Aerial Photograph of Yeka. Published literatures from the web and unpublished documents both qualitative and quantitative were secondary data sources in addition to different organizations.

### 3.4.4. Data Collection Methods

Data gathering procedure includes different techniques that are applied formally and informally in order to achieve all documents for the study. Data of the CHC were collected by the researcher by going to the desired CHC. It was done by means some equipments. The data are as can be displayed in the following table.

Table 3. 3. Primary  and Secondary data, their source and uses in the study

| Data | Source | Format | Uses | Year |
|---|---|---|---|---|
| GPS Coordinates of CHC | CHC understudy | .dxf | Identifying the Sub-City Locations of CHC | 2019 |
| Road network | Aerial Photograph of Yeka (2011) | GRID | Modify existing road Network | 2018 |
| Residential Area | Aerial Photograph of Yeka (2011) | GRID | Modify existing residential area | 2018 |
| Administrative maps of AA & Yeka | AACA ILIC | .shp | For defining the study location | 2013 |
| Parcel Maps Of Yeka Sub-City | Yeka ILIO | .shp | Distinguish residential parcels from the others | 2018 |
| Demographic data | CSA | .dbf | Know Subject population | 2019 |
| Existing CHC | AACA, Yeka ILIO & CSA | .shp | After assessment of their existence on the ground directly taken for use | 2019 |
| Land use Map of Yeka | Yeka Sub-City ILIO | .shp | Yeka Sub-City Separate residential areas and further details | 2014 |
| Yeka Sub-City ATLAS | AACA ILIC | Print out | Get some written evidences of study area | 2014 |

After data collection, a **geodatabase** comprising the input data is developed from which analyses are made. Different data and methods are used for processing inputs. Data used for processing are described as follows.

**I. Maps**

Most of the maps used in this study are based on the AACA Integrated Land Information Center 2014. Maps for the study area are obtained from both from the City and the Sub-City land Information centers. They are prepared hierarchically from the smallest buildings in each parcel up to the largest City Administration Boundary.

**II. Demography**

It tells us population of the city particularly of the study area, number of existing Community Health Center  in it and all sorts of indices indicating number of spopulation they are ser ving,where the demand points are more dense or crowded and less. But, it can be determined also from the entire study area parcels that are in polygon shapefiles by converting to point shapefiles. This implies both the population distribution map and parcel map showing neigh-borhood of the sub-city are required.

**III. GPS Data**

GPS data are collected in the form of X, Y and Z through the entire area whenever there is no information or alternative about each parcel and service locations , location of the demand nodes and other significant features.

**IV. Spatial Location of Existing Health Centers**

Existing Community Health Centers are the ones whose reference locations are recognized by government organizations from which the evidences are taken. As is indicated in chapter three, the main sources are AACG Integrated Land information center, Yeka Sub-City Integrated Land Information Office and CSA.

**V. Road Data**

Spatial data for the road network existing in Yeka Sub-City are also received mainly from Yeka Sub-City ILIO. Road networks at the sub-city office are identified into two kinds, one as local roads and the second as the Structural roads. This subdivision is assigned by the whole city government Municipal from which sub-city roads are distributed. Local roads covered 90% of network used by the network analyst of Arc-GIS. Unlike the former two sources, CSA has prepared the network for the sub-city with less accuracy and quality naming the road types as All-weather Roads, Dry weather Roads and Trails.

**VI. Land Use Data**

Land use datum is the one explained in depth in this chapter. It is prepared in Yeka ILIO in ArcView shapefile format. Identifying the land use classes are significant for the achievement of the objectives set because it is the land use that potentially determines where to locate and where to allocate the existing Community health centers and where to suggest the newly proposed Community health centers. As per the ATLAS of Yeka Sub-City, this land use map is prepared a year before in 2014 which tells us that there is no remarkable difference with the current condition of land use.

**VII. Yeka Sub-City ATLAS**

AACA in collaboration with the ten sub-cities under it has prepared atlas partially for each subcity and partially about backgrounds of the whole City in common in one bound for each subcity. So major physical and socio-economic aspects of the sub-city such as Relief (Topography), education, land use, Road network, land Area and Population, Land Development Plan (LDPs) etc. are roughly indicated. As explained in it, preparation of the ATLAS started with data gathering in the Year 2003 E.C (2010/11) and completed its 1st Edition in year 2006 E.C (2014).

**VIII. Health Statistics Annual Abstract**

One of the publications and reports prepared by Addis Ababa City Bureau of Health is the Health Statistics Annual Abstract (HSAA) on the health institutions under its government especially of the range from small clinic up to specialized Hospital. Therefore this paper work is prepared in part on basis of the information attributed in these published reports-where as in part data and reports from woreda and sub-city health offices are also used in combination.

## 3.5. Methodology

### 3.5.1. Data Adjustments (Preparation) Methods

Two major activities are undertaken in this subtopic. Firstly, adjustments for errors, irregulart-ies and absence. Secondly preparation of the refined data for the requirements (preconditions) of the analysis part. Therefore, data editions like corrections, modifications, deletions, substit tions etc. were made deeply during data preprocessing. These tasks of data preparation is cat gorized into two phases as follows.

***Stage One:*** Comprehensive effort is made in comparing and crosschecking information and evidences on health data from the three origins AACA, Yeka ILIO and CSA. Health Centers common in both attribute and spatal reference from all of the sources are selected and re-served and those with no spatial reference frame particularly that are observed from CSA data are omitted. Some Health Centers are still existing at data levels but they are not practically seen on the ground. In addition to these sources of data, lastly both spatial and socio economic information are gathered physically going to where the health centers are located in the whole study area. The outcomes of the effort came up with missing health centers on the data sources because of their newly introduction to the health market and services which is real-ized mostly on government sector.

***Stage Two:*** This stage works on readjustments and changes of the road network data and the land use of the study area. Raw network data that are originally received from the sources cannot be directly applied as an input for the analysis. Therefore it was obligatory to change from the original file format to the format type supposed to use. ArcGIS Network Analyst us-es the centerline street network to find its analysis result. But Yeka Sub-City local road network data were available in only area shapefiles that bound the areas covered by it. Hence primarily the centerlines of this network data are traced from the existing data by means of editing tools in ArcMap and further modifications and additional road network parts are also added. After all editing activities are finished Yeka Road network Topology (i.e. goedatabase Topology) is built. The topology is controlled by some rules incorporated in it for further refinements of interconnections of all the lines participated in it. If any line in the topology violates one of the rules involved, it is displayed in one of the three errors attributed to any kinds of topological structures and that are; Area errors, Line errors and point errors if the topology is built from the combination of all area, line and point features. Fig. 3.4 and 3.5 shows the work flow of Topology building and the output Yeka street topology respectively.

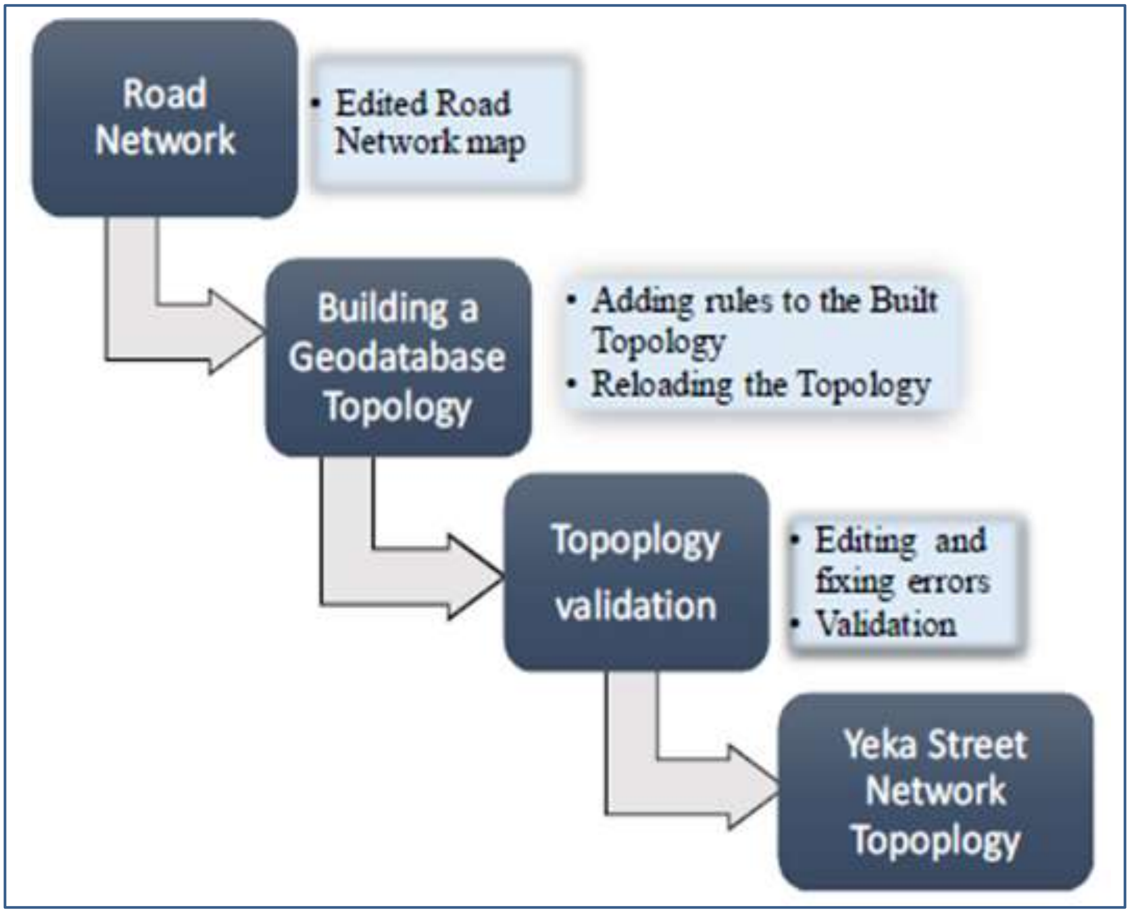


Figure 3. 4: Geodatabase Topology Building Work Flow

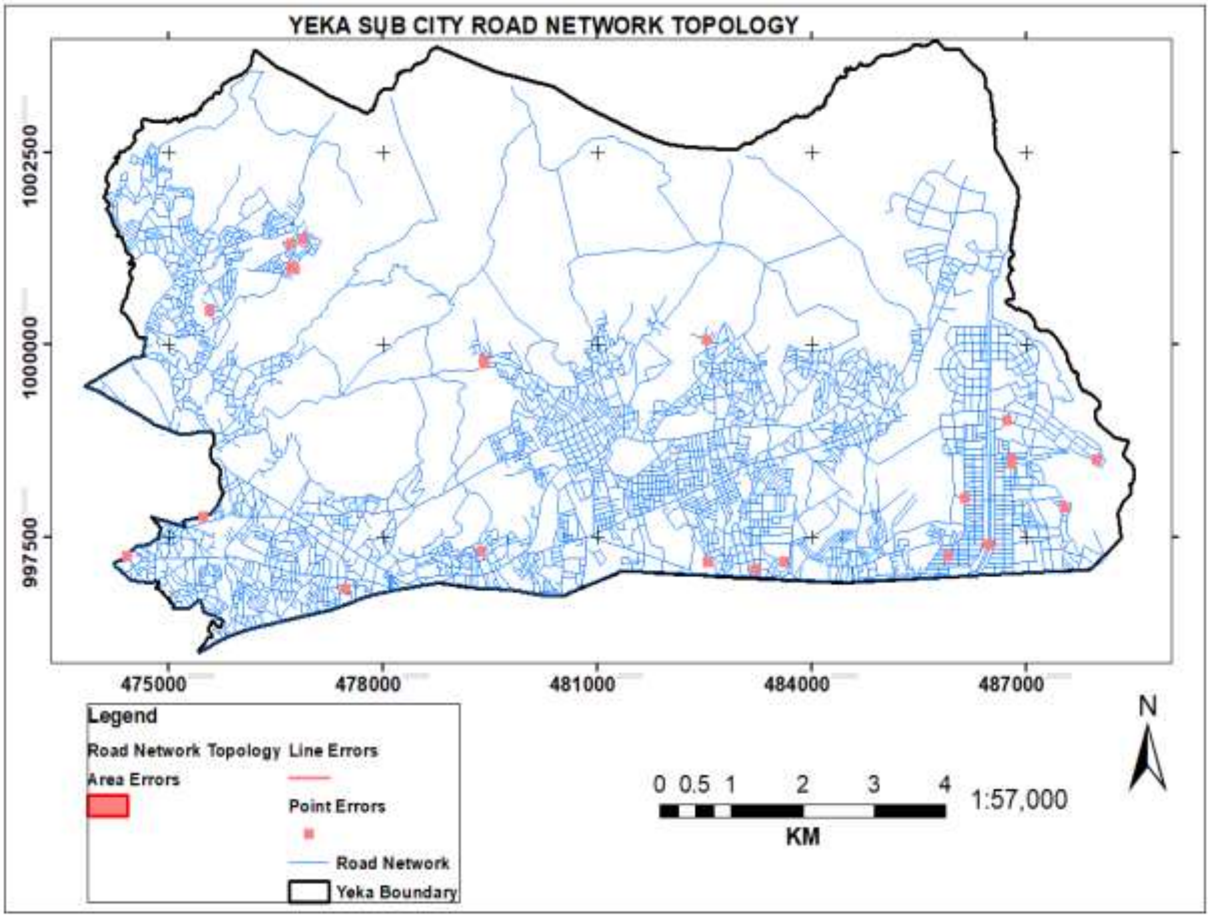


Figure 3. 5: Street Network Topology of Yeka Sub-City

**Note: -** In Fig. 3.5 in the legend content, the three error symbols are not seen in the map because the StreetNet_Topology is free from any type of error. The street Network is topologically pure in its connectivity and the next step is to build a ne twork dataset which is used directly as an input for the analysis part. And the network dataset is the pillar on which the analysis is made. Network can be created either from only involved line features (i.e. street data) or including both points and areas in a similar fashion made in the topology.

There are some elements that are simultaneously created with network dataset. But the importance of the elements depend on many factors such as traffic flow, over passes, tunnels, complexity of the roads and their hierarchy etc. These elements are junctions, edges, turns, restrictions, stops, barriers and centers. But under this study only the former three are dealt (Junctions, Edges and Turns). Fig. 3.6 and Fig. 3.7 show the work flow of Yeka network dataset and the output network dataset respectively.

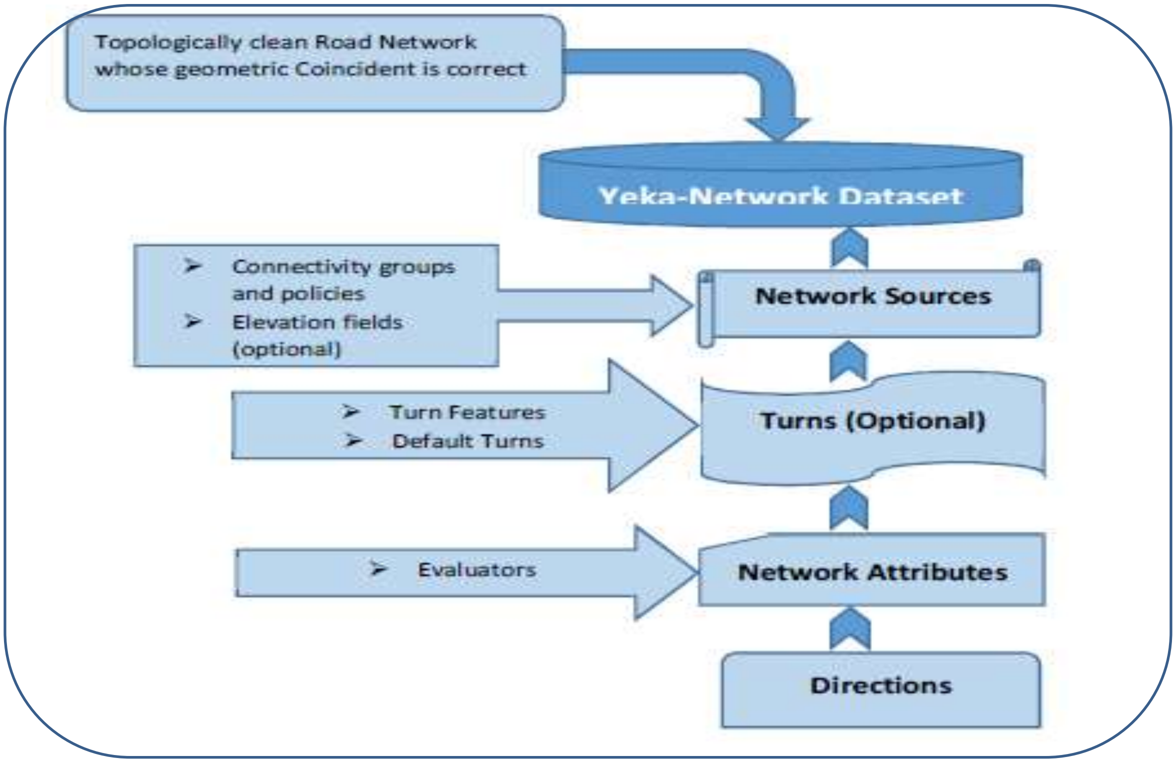


Figure 3. 6: Network Dataset Building Workflow

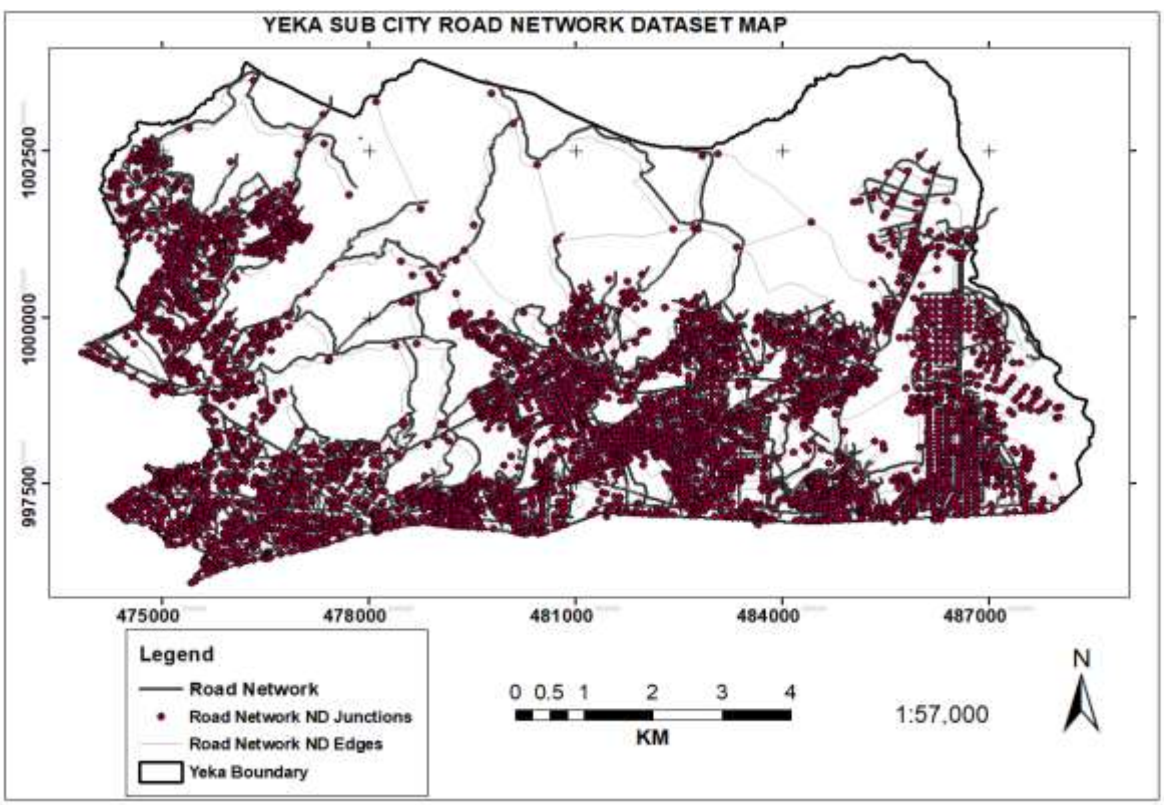


Figure 3. 7: Yeka Sub-City Network Dataset

### 3.5. 2. Methods of Data Analysis

***Service Area Using Network Analysis***. A network service area is a region that encompasses all accessible streets (that is, streets that are within specified impedance). Service areas created by Network Analyst also help evaluate accessibility. Concentric service areas show how accessibility varies with impedance. It is used to identify how many people, how much land, or quantities of anything else within the neighborhood or region. Service area on the basis of time and distance is also helpful to predict the travelling time and traveling distance from demand points to service or Health Centers. In the present study the service area has been generated by from Community Health Centers as service points on the basis of distance and time.

The first step in the analysis is creating file or personal geo-database to data. The next step is built network dataset from road network for creating service area analysis using Network Analyst. After building network dataset creating service area layer that contains (service area, facilities, polygons and difference barriers such as point, line and polygon barriers) is the next task. Then, loading the collected community health center facilities in to service area layer as destination points to dwellers settlements.After loading health facilities, setting access standard traveling distance and time standard. The Next step generate service area polygons to identify spatial accessibility interms of distance and time. Examining spatial accessibility of community health center in the study area is one of the specific objectives in this study, and this step will answer this objective. After, generating service area polygons, calculate the coverage area by population by clipping each parcel by polygons. After this, the suggested or candidate sites for new community health center sites were identified.Two important input datasets are required for service area analysis.

**A. Existing Health Centers**

All the Community health center currently working in the area that are well-known serving for patients have been recognized. The health centers are also attributed by names, reference coordinates, specific woreda in which they relatively exist.

**B. Existing Road Network Dataset**

The road network dataset is developed from both the local and structural roads through the entire Sub-City. First and for most the network dataset is very important for the network analyst tools to work on the problem types under it (i.e. for new route, location allocation. closest facility, OD cost matrix and new vehicle routing problem types including Service Area Analysis.

***Candidate site selection***. It is here where potential sites for introducing new additional health centers facilities are proposed. At this point one can decide where demand nodes are strong and where it is the revers, where are demand points that are beyond the impedance cutoff (Default breaks) so that they are unreachable (hardly reachable). Therefore ones the candidate sites are roughly suggested wherever there are tendencies, the above analyses are revised. The candidate sites that meets all the criteria fully or partially are selected on the basis of the input data and the density of demand points through the study area. But while establishing this new facility sites, already existing facilities of the same purpose (health centers in this case) that are in the area of interest.

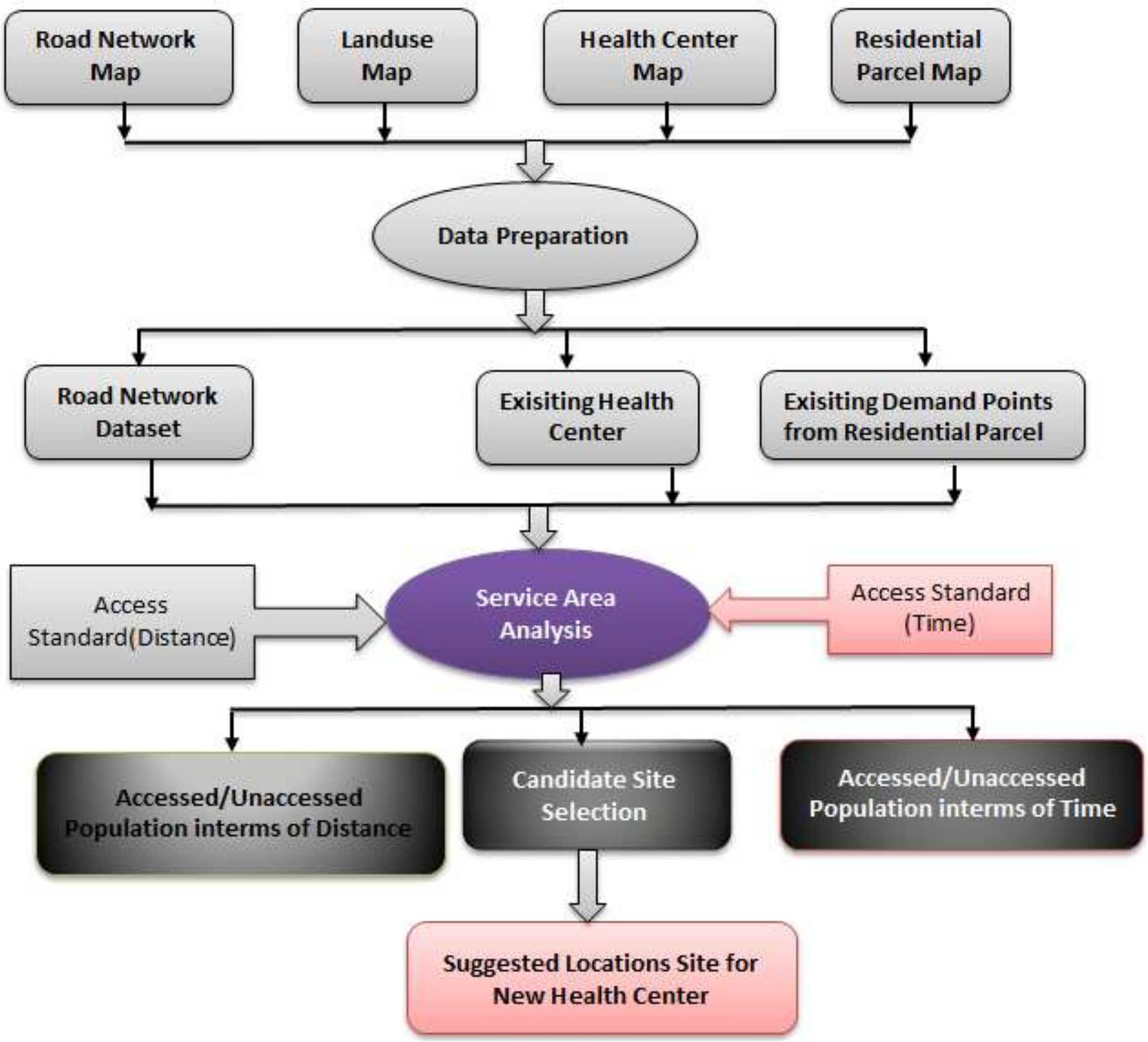


Figure 3. 8: Overview of the methodology Workflow I by Author

## Finding Optimum Community Health Center Locations Using Spatial Analysis

Further analysis is made from the suggested CHC locations result from the service area analysis as input using the ArcGIS Spatial Analyst extension tool.

This is done because in the former methods only rough suggestions are given regarding locations that are recommended to be candidate. In addition to this, the capacity of existing health centers with the population size is also determined from the result obtained before proceeding with this portion. So the main purpose to use spatial analysis is examining the recommended and relocating or validating suitable areas with respect to the existing conditions.

The inputs used in this part of analysis method are different from the ones used for service area analysis except for existing health center and population data used as demand points. But the way these two common inputs are used is different from the above. Therefore five requirements are recognized in order to conduct the analysis as described below.

**A. Elevation Data**

Elevation data is very important to investigate the landscape in terms of slope. Contour data, Tin Surfaces and Spot height data can be source for elevation surfaces for an area. In this case the Digital Elevation Model (DEM) for Yeka Sub-City is used. The area of study is described by varying slope levels from gentle to very steep (hilly). Therefore the elevation data helps to produce changing slope values after it is converted to slope map. The slope is **0-10%** gentle slope.

**B. Existing Health Center**

These are health centers that are working currently and also used in the service area analysis part. The level of interested sites for healthing purpose increases as one go backward from existing health centers. Areas that fulfill another criteria but failed to fit this criterion are supposed not suitable. Thus, locations with farthest Euclidean (straight line) distance from the location of the working health center are well-thought the most suitable. From existing health center the new health center site is **500** metres far away.

**C. Suggested Sites**

These are locations where the service coverage of the existing health center could not reach according to the results obtained from the Service area analysis. These sites and their surroundings can be suitable if they satisfy the other qualities (they must be: - in populated areas, at the right land surface slope, out of noisy region, at suggestible gaps from existing health centers and in barren or vegetation area). Therefore sites very farthest from these locations have lowest probability to be selected. To this reverse, sites that are very nearest to suggested sites have highest tendency for new health center.

**D. River**

In case the new health center drains sewage to river, at least **300** meters distance along the river should be used. Outside the buffer zone, the further away, the better.

**E. Existing Population**

Existing population is the collection of peoples or residents from which population are out-spread. Detailed discussion is made on this part of land use land cover classes in the previous section. In This case because health centers are established to serve best the society at nearest locality, locations far away from population area are not comfortable while the reverse is true where health centers are opened nearest to population are the most preferable.

**F.Schools**

In case the new health center to schools, at least **200- 500** meters distance along the school should be used. Outside the buffer zone, the further away, the better.

**G. Manufacturing and Storage:**

In case the new health center to manufacturing and storage, at least **200-500** meters distance along the manufacturing and storage should be used. Outside the buffer zone, the further away, the better.

**H. Religious Institution:**

In case the new health center to religious institution, at least **200-500** meters distance along the religious institution should be used. Outside the buffer zone, the further away, the better.

**I. Land Use Map**

The land use map used in this analysis is different in format from that used in Fig. 3.2 is re-classified and transformed to raster dataset. The result reduces the number of land cover classes from 22 to only 6 as seen in Fig. 3.7 and 3.8. This is because in the science of remote sensing classes grouped together show almost similar reflectance patterns in imaging process. The reduced land use land cover classes are therefore, Built up (Combines 16 classes) with 4393.80ha of total area, Agricultural land (Combines 2 classes) within 1442.08ha, Barren land which amounts 461.66ha, Vegetation cover of 1395.72ha, Water classes within 161.59ha and Mixed Forest cover of 358.20ha (Table 3.4)

Table 3. 4. Categories of Land Use and Land Cover classes of Yeka Sub City

| Category | No | Classes | Category | No | Classes | Category | No | Classes |
|---|---|---|---|---|---|---|---|---|
| Built Up | 1 | Administration | Built Up | 9 | Municipal Services | Agricultural Land | 17 | Field Crop |
| | 2 | Commercial | | 10 | Recreation | | | |
| | 3 | Cultural and Welfare | | 11 | Religious Institution | Baren land | 18 | Open Space |
| | 4 | Education | | 12 | Residential | Water | 19 | River |
| | 5 | Health | | 13 | Road Network | Forest | 20 | Mixed Forest |
| | 6 | Infrastructure and Utilities | | 14 | Special Use | | | |
| | 7 | Manufacturing and Storage | | 15 | Transport Terminal | | | |
| | 8 | Mixed Residential | | 16 | Under Construction | | | |

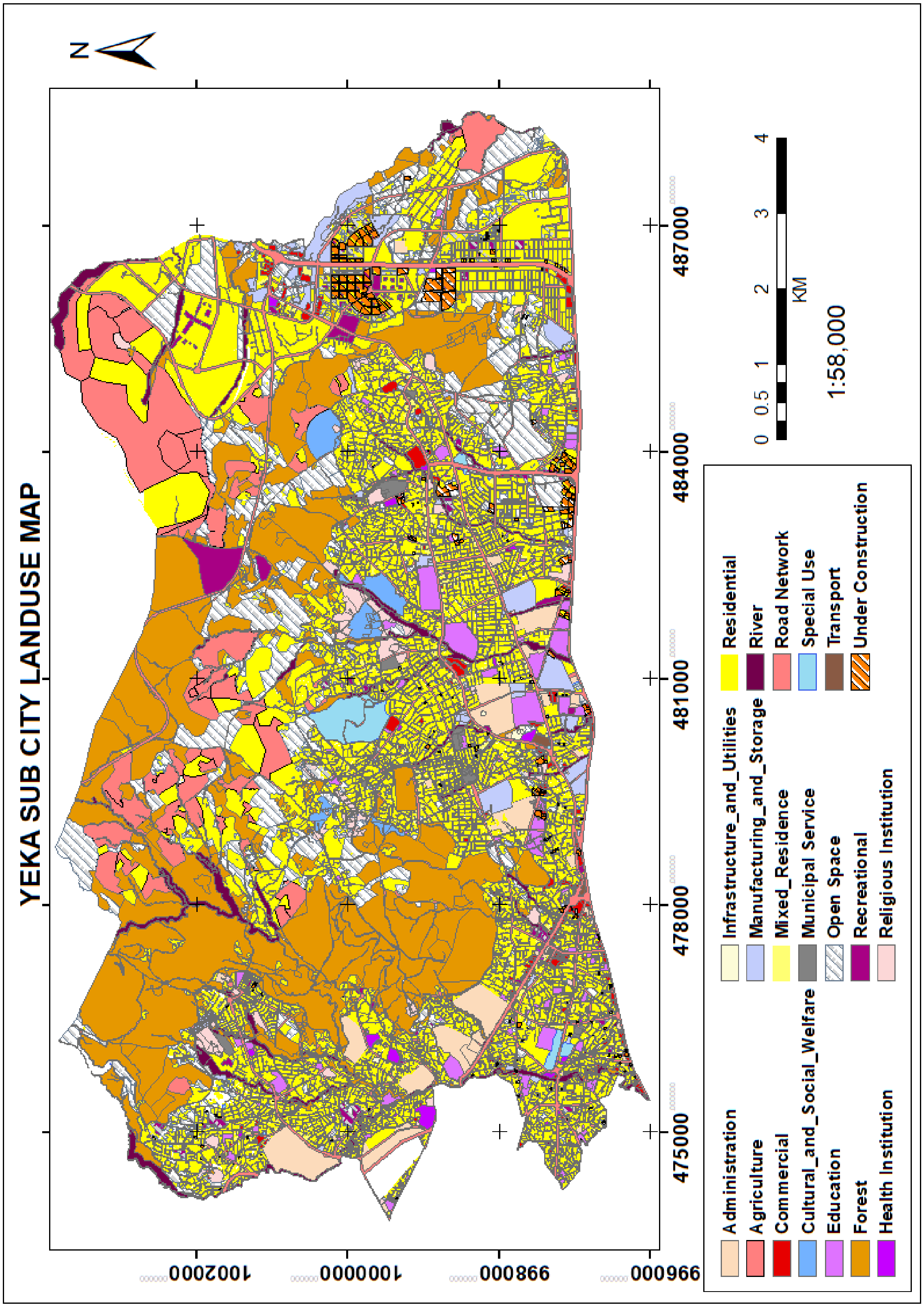


Figure 3. 9: Land Use Map of Yeka Sub City

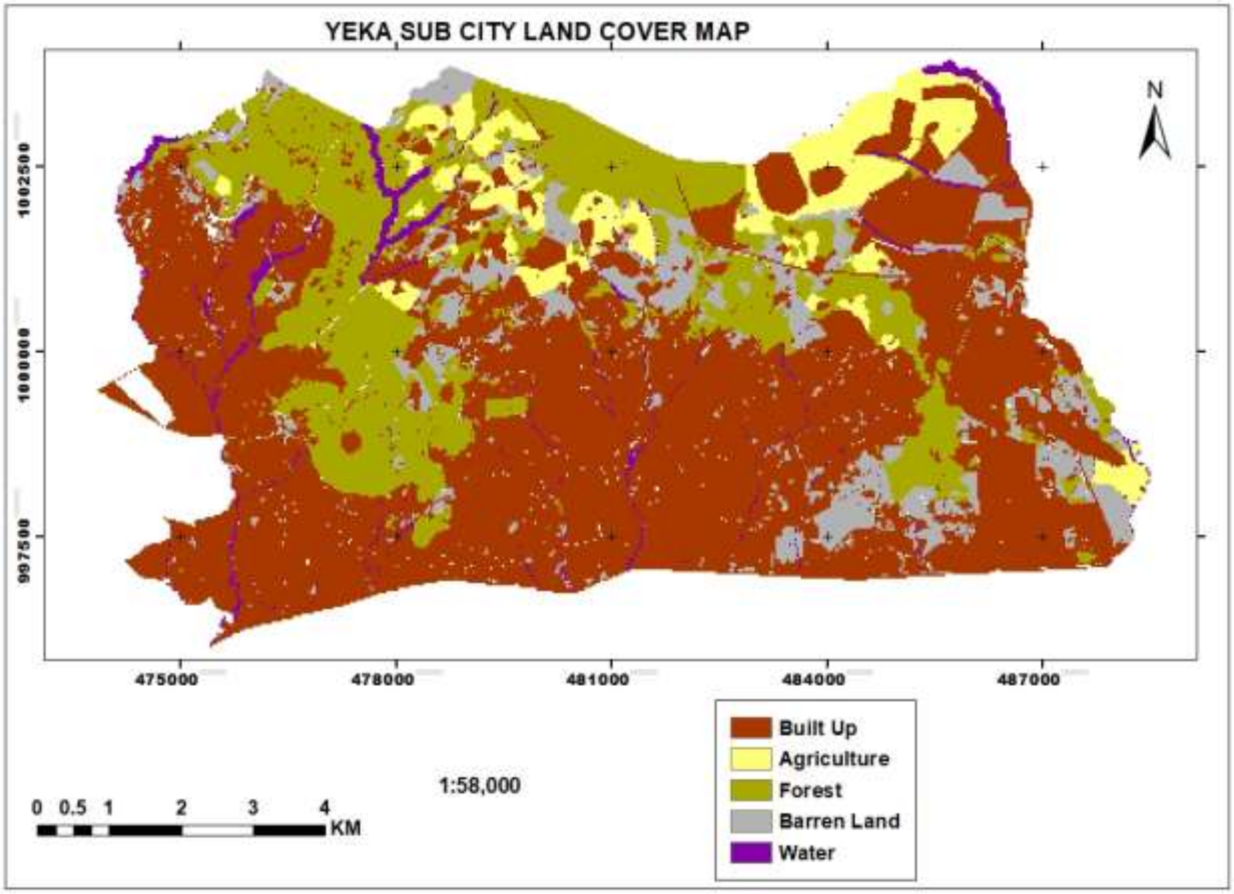


Figure 3. 10:Land Cover Map of Yeka Sub City

Table 3. 5. Summarized Criteria's for Optmal Site Selection for New Health Center

| **Factor** | **Setting** |
|---|---|
| Existing health center | The further away from the existing health center (>=500m), the better |
| Population Parcel | The nearer away from the residential area, the better |
| Road | The nearer away from the road (>=100m), the better |
| Suggested Sites | The nearer away from the Suggested area, with in 500m the better |
| Manufacturing and Storage | The nearer away from the manufacturing and storage (200-500m), the better |
| Religious institution | The nearer away from the Religious Institution(200-500m), the better |
| River | The further away from the river (>=300m), the better |
| Schools | The further away from the Schools (200-500m), the better |
| Elevation | The slope is better, 0-10% |

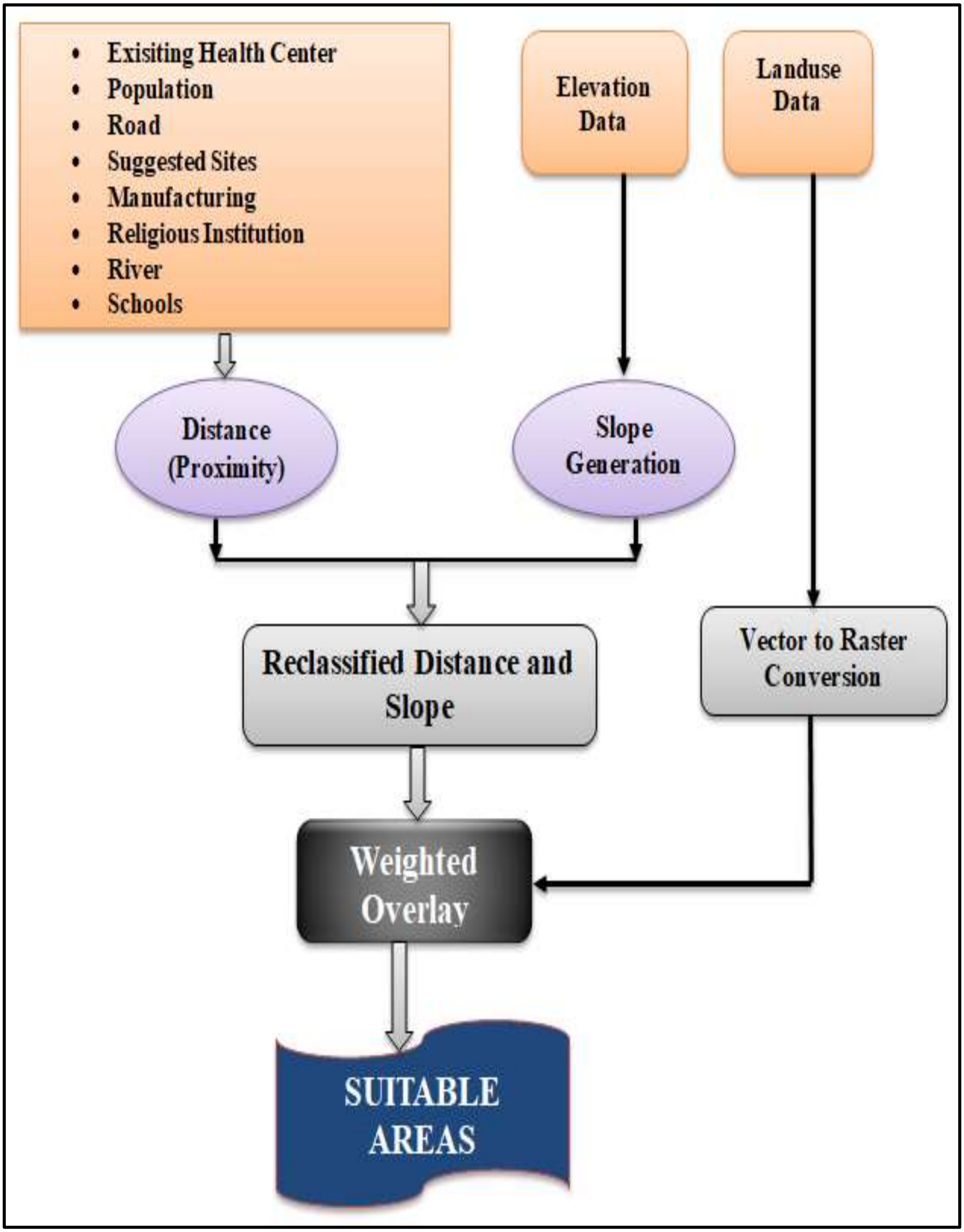

Figure 3. 11: Methodology workflow II by Author

# CHAPTER IV. RESULTS AND DISCUSSION

## 4.1. Accessibility and Coverage of Health Centers in Yeka

The extent to which the existing health center in the locality are serving the surrounding community is important issue to know before further analysis. It is also significant to identify location of each existing health center in terms of infrastructures and population. Computation of access indicators is done to give a rough estimation for the health centers at Sub-City level. These are discussed using the evidences from the spatial and non-spatial evidences collected from different sources in combination with the researcher's works.

The recently implemented Business Process Reengineering (BPR) of the health sector has introduced a three-tier health care delivery system: level one is a Woreda or District health system comprised of a primary hospital (to cover 60,000-100,000 people), health centres (1 for 15,000-25,000 population) and their satellite Health Posts (1 for 3,000-5,000 population) connected to each other by a referral system. The primary hospital, health centre and health posts form a Primary Health Care Unit (PHCU). Level two is a General Hospital covering a population of 1-1.5 million people; and level three is a Specialised Hospital covering a population of 3.5-5 million people.(FDRE Ministry of Health, 2014/2015).

From the above paragraph, on average one health center served for 20,000 people. In Yeka sub city there are 15 health center for about 455,998 people, from this in the current fact 1 health center serves for 30,400 peoples. For this reason peoples must walk long distance to get the service especially, at peripheral location invites for this types of problem.

Fig. 4.1 below shows output of density of health center in Yeka Sub-City based on the search radius of 500m laid by HSDP. From this fact, road network is one of the most influential factor that determined the distribution. In the figure, from the five classes of roads, asphalted portion is sampled to see how the road affects access and coverage of facilities. Therefore, it is clear that all b health centers are densely built where there is ease of access of sufficient road network is available and in reverse the facilities are rarely found at areas where the network is available in low range.

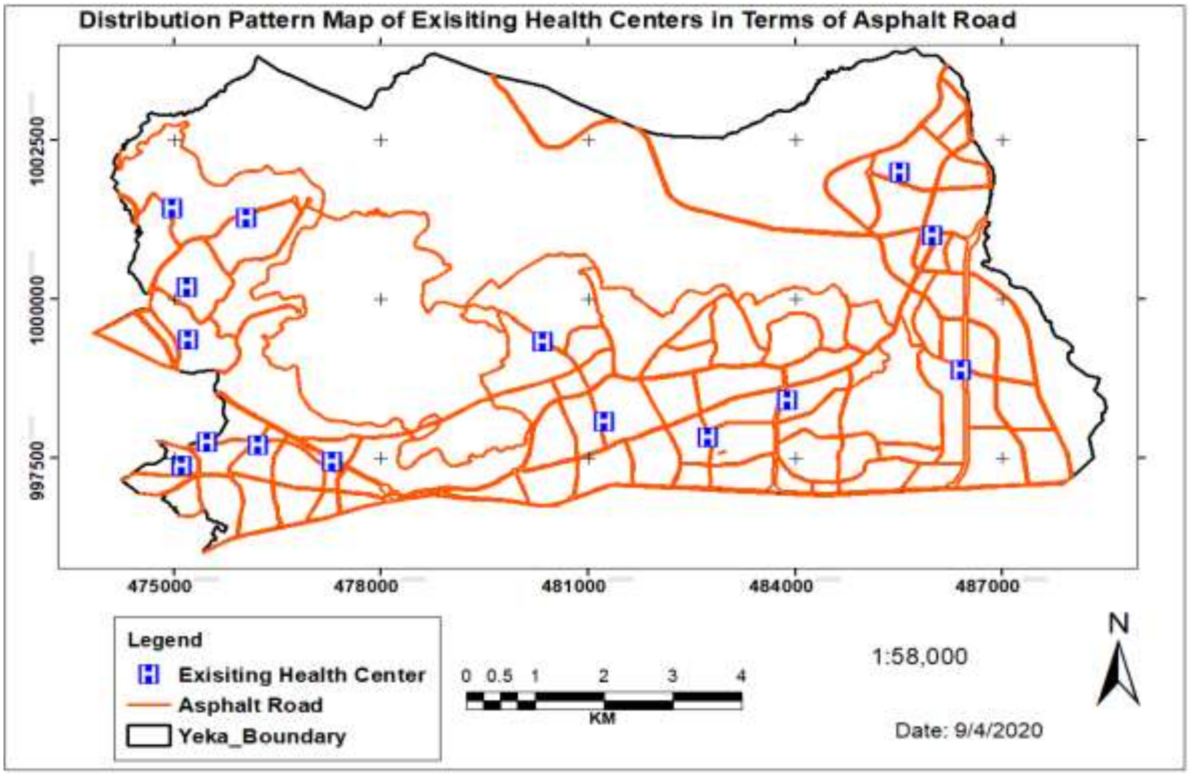


Figure 4. 1: Distribution Pattern Map of Health Centers in Terms of Road

## 4.2. RESULTS

Data analysis in combination with the results are consequently and clearly provided in this section. The predefined methodologies (Fig. 3.8 and Fig.3.11) are followed for service area analysis and finding optimum health center sites in spatial analysis respectively to solve locational problems of community health center in Yeka Sub-City.

### 4.2.1.Service Area Analysis

Service areas creates concentric polygons around the facilities based on the given network. Population nodes that are involved in one of those polygons is known to be accessible to the facility from the result in relation with the network. To identify this coverage amount, the time and distance cost attributes are evaluated in five different magnitudes of intervals known as default breaks. five break values are assigned in both time and distance variables (5, 15, 25, 35 and 45 minutes for time and 0.5, 1.5, 2.5, 3.5 and 4.5 kilometers for distance).

### 1. Distance Based Service Area

In this phase of generating service areas for the facilities, the cost attribute employed is distance. scenarios is laid made for the distance based analysis of in the above by taking the nationally recommended distance of 2.5 km into consideration. Based on this, 0.5 km for the first, 1.5km for the second, 2.5km for the third, 3.5km for the fourth and 4.5km for the fifth break values are selected to generate the results.

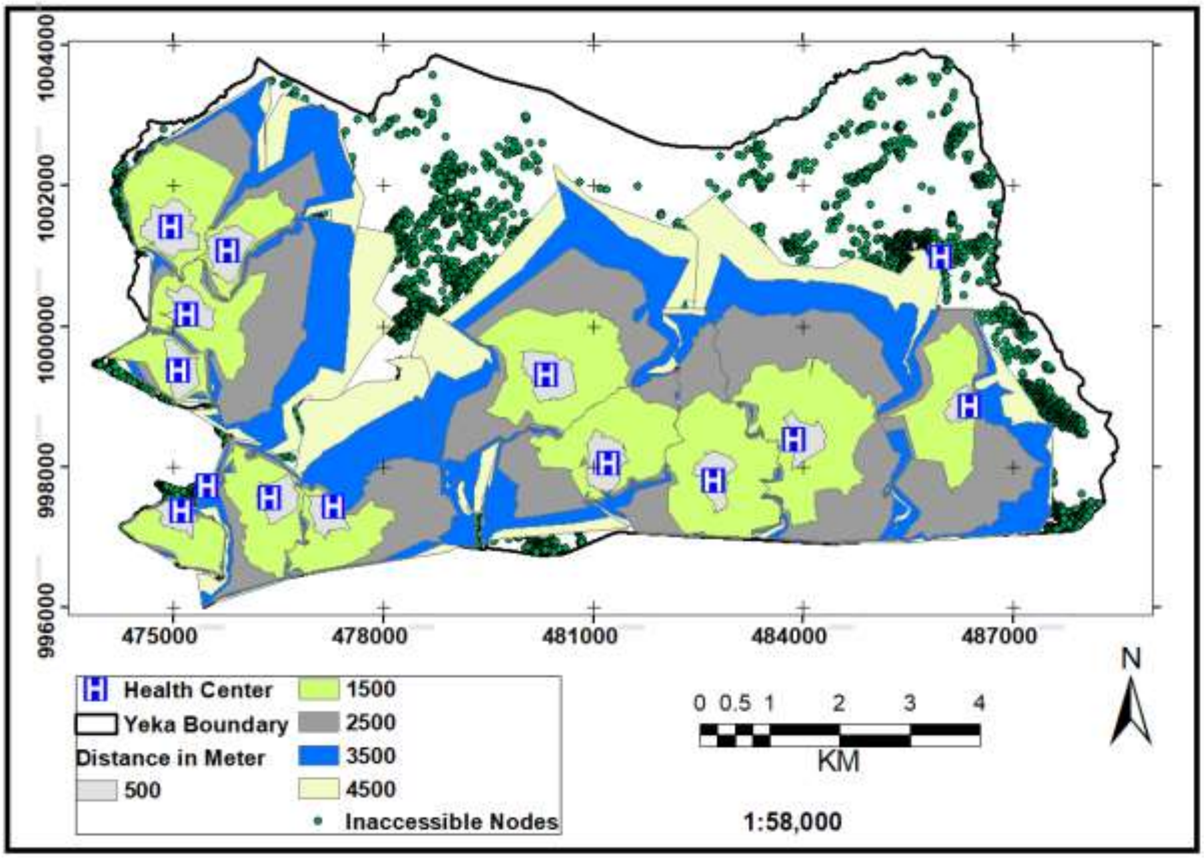


Figure 4. 2: Service Area Map summarized Map in terms of Distance

Table 4. 1. Summary of Service Area Analysis Results in terms of Distance

| Distance in Km | Population Parcels | Population | Percentage of Population |
|---|---|---|---|
| 0.5 | 5277 | 36939 | 8.10 |
| 1.5 | 24427 | 170989 | 37.50 |
| 2.5 | 22310 | 156170 | 34.25 |
| 3.5 | 6860 | 48020 | 10.53 |
| 4.5 | 2598 | 18186 | 3.99 |
| >4.5 | 3671 | 25694 | 5.63 |
| Total | 65143 | 455998 | 100 |

The table 4.1 provides the travelling distance of the people of the Yeka Sub city to reach the closest HC. The data revels that of population (8.1 percent) of 5277 parcels of the sub city have to travel the distance of below 0.5 kilometers to reach the closest HC. Similarly (170989) which is 37.5 percent of population has to travel the distance of 0.5 to 1.5 kilometers to access the closest HC. Within the travelling distance of 1,5 to 2.5 kilometers 156170 per sons (34.25 percent) can reach the closest HC. Within the travelling distance of 2,5 to 3.5 kil-ometers 48020 persons (10.53 percent) can reach the closest HC. (18186) which is 3.99 per-cent of population has to travel the distance of 3.5 to 4.5 kilometers to access the closest HC 5.63 percent of populations of 25694 people have to travel the distance of above 4.5 kilome-ters.

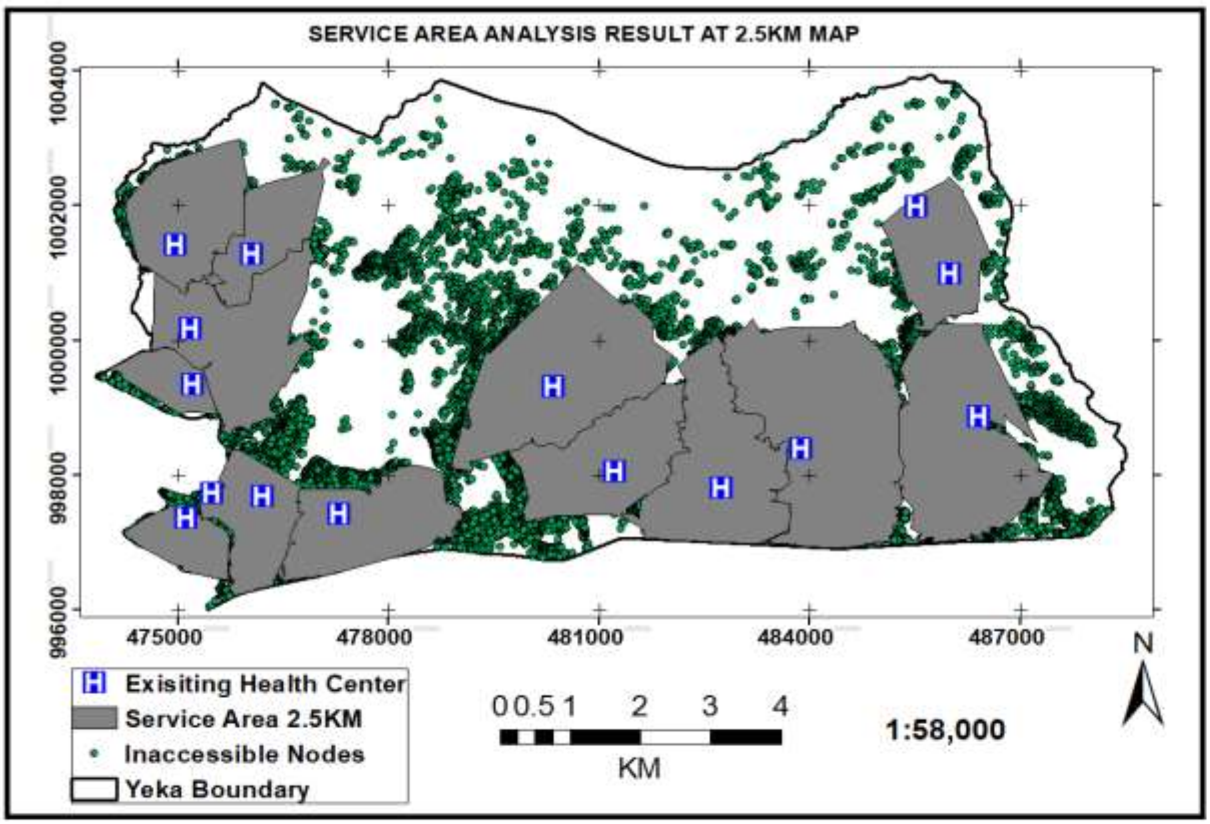


Figure 4. 3: Service Area Analysis Result at 2.5km Break value and Scarcity Area

From the above figure 4.3, 52609 population nodes are accessed in the third distance scenario where the median value 2.5km is used as the defaultbreak (impedance) value. Then solving for 2.5km outstretched service area, 368263 (80.76%) population are bounded and 12534 nodes(87735 people) are not trapped to the service area that expands 2.5km away from the facility along the existing road network. The main objective of analyzing these situations are, to find areas that are left unreachable by nearest health center in Yeka Sub-City and as a result to introduce additional health center in the scarcity area.

Table 4. 2. Service Area Analysis Results 2.5 Km Break value

| Distance in Km | Accesssed Parcels(Nodes) | Population | % Population | Inaccessed Nodes | Population | % Population |
|---|---|---|---|---|---|---|
| 2.5 | 52609 | 368263 | 80.76 | 12534 | 87735 | 19.34 |

2. **Time Based Service Area**

In this phase of generating service areas for the facilities, the cost attribute employed is time. Senario is laid made for the distance based analysis of in the above by taking the nationally recommended distance of 25 minutes into consideration. Based on this, 5 minutes for the first, 15 minutes for the second, 25 minutes for the third, 35 minutes for the fourth and 45 minutes for the fifth are selected to generate the results.

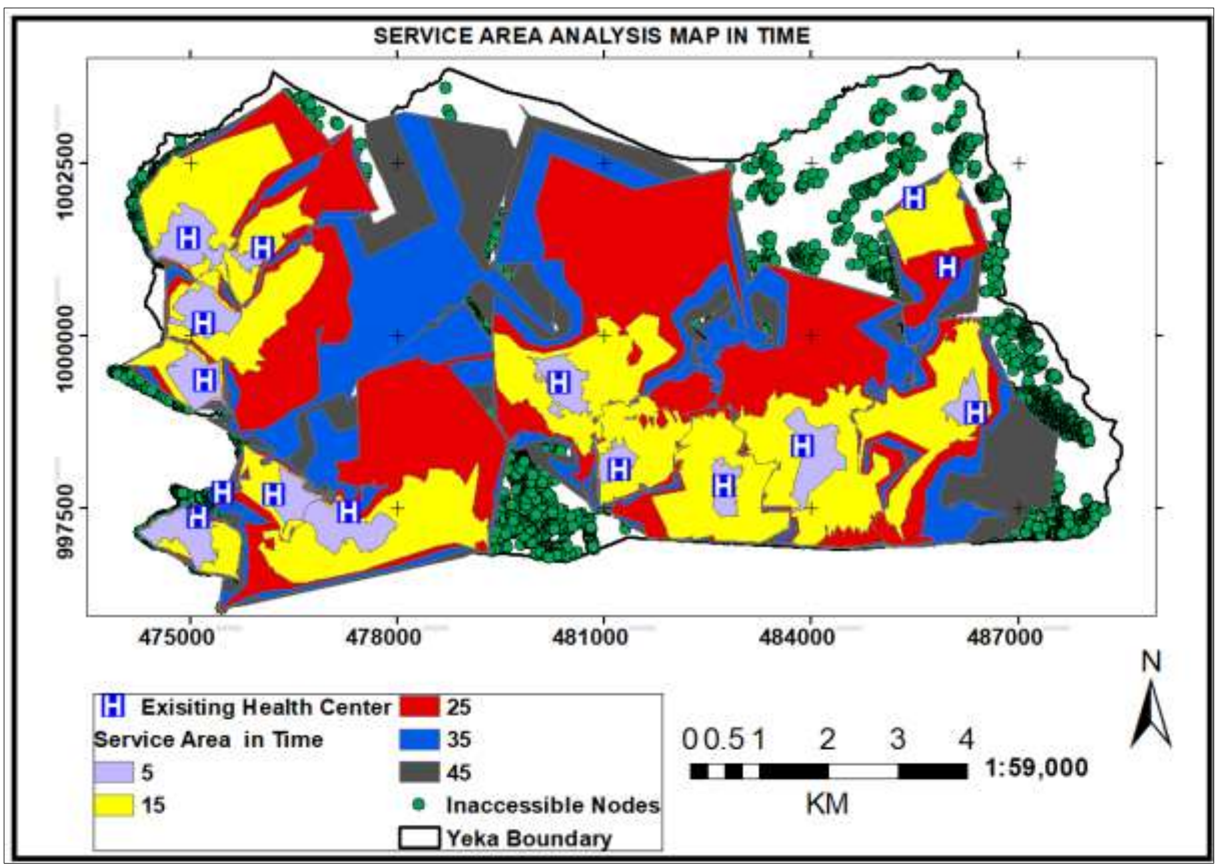


Figure 4. 4. : Service Area Map summarized Map in terms of Time

Table 4. 3 .Summary of Service Area Analysis Results in terms of Time

| Time in Minutes | Population Parcels | Population | Percentage of Population |
|---|---|---|---|
| 5 | 7109 | 49763 | 10.91 |
| 15 | 16454 | 115178 | 25.26 |
| 25 | 19088 | 133616 | 29.30 |
| 35 | 12944 | 90608 | 19.87 |
| 45 | 5247 | 36729 | 8.06 |
| >45 | 4301 | 30104 | 6.60 |
| Total | 65143 | 455998 | 100 |

Table 4.3 provides the travelling time of the people of the Yeka Sub city to reach the closest HC. The data revels that of population (10.91 percent) of 7109 parcels of the sub city have to travel the distance of below 5 minutes to reach the closest HC. Similarly (115178) which is 25.26 percent of population has to travel the time of 5 to 15 minutes to access the closest HC. Within the travelling time of 15 to 25 minutes 133616 persons (29.30 percent) can reach the closest HC. Within the travelling time of 25 to 35 minutes 90608 persons (19.87 percent) can reach the closest HC. (36729) people which are 8.06 percent of population has to travel the time of 35 to 45 minutes to access the closest HC 6.60 percent of populations of 30104 people have to travel the time of above 45 minutes.

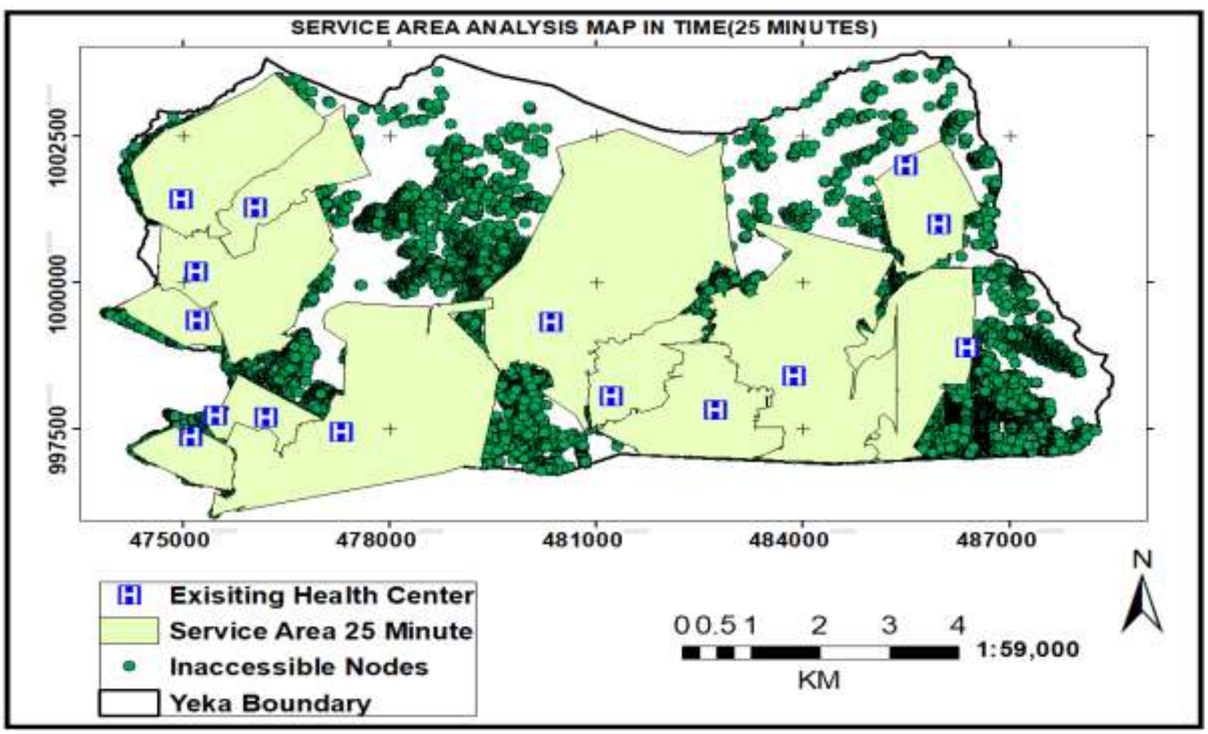

Figure 4. 5: Service Area Analysis Result at 25 minutes Break value and Scarcity Area

From the above figure 4.5, 46548 population nodes are accessed in the third distance scenario where the median value 25 minute is used as the default break (impedance) value. Then solving for 25 minute outstretched service area, 325836 (71.46%) population are bounded and 18595 nodes(130165 people) are not trapped to the service area that expands 25 minutes away from the facility along the existing road network. The main objective of analyzing these situations are, to find areas that are left unreachable by nearest health center in Yeka Sub-City and as a result to introduce additional health center in the scarcity area.

Table 4. 4. Service Area Analysis Results 25 Minute Break value

| Time in Minute | Accesssed Parcels(Nodes) | Population | % Population | Inaccessed Nodes | Population | % Population |
|---|---|---|---|---|---|---|
| **25** | **46548** | **325836** | **71.46** | **18595** | **130165** | **28.54** |

**Candidate Site Selection For New Health Center**

From Service Area analysis in 2.5km impedance value, 12534 population nodes are far from health center (out of range). Because of this, to reach these population by health center access another additional health center must be constructed in their area. So on the basis of scarcity maps shown through Fig. 4.3, and Table 4.2. judgments, candidate locations are proposed for new health center.

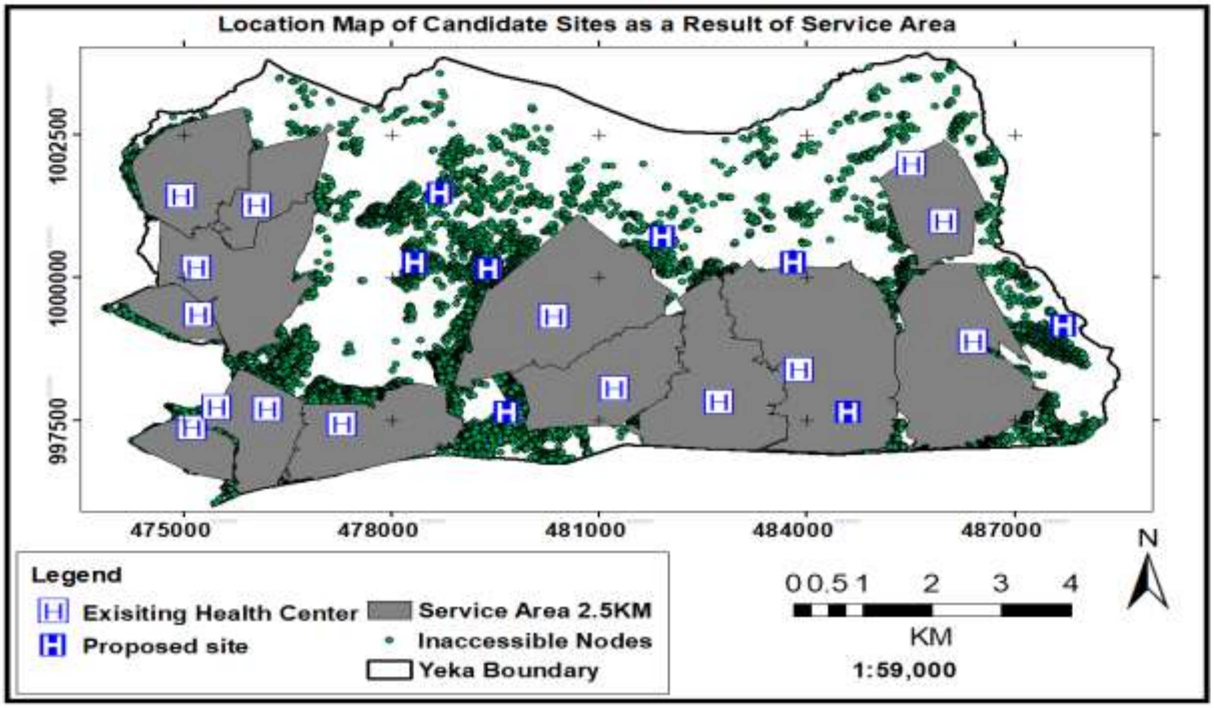


Figure 4. 6: Location Map of Candidate Sites as a Result of Service Area

### 4.2.2. Optimizing Health Center Sites Using Spatial Analysis

The chosen sites as a result of Service Area Analysis might be disallowed if they are evaluated in terms of suitability due to elevation (slope) factors, land use land cover factors, noise factors and population factors etc. Therefore studying from these aspects is compulsory to either validate or relocate the sites. The mechanisms used for solving this problem is provided by spatial analyst extension of ArcGIS. During suitability analysis, suitability 1 is very low, 2 is low, 3 is medium, 4 is high and 5 is very high.

***First Stage***

Spatial analysis methods of decision making requires the input data to be changed in a valid format to come to the desired result. Therefore rasterizing is the process from which participating data are converted from either vector or from raster to a raster form that is required. So the raw elevation data is changed to slope. Existing Health Centers, Road, manufacturing ,religious institution, schools, river, population and suggested sites for new health centres are point data that are originally in the vector format. Euclidean distance toolset from the spatial analyst tools changes these into raster format. It is distance because it calculates the proximity for each pixel in the output raster from the existing source data within an extent of Yeka Border in this case.

***Second Stage***

Surface slope is divided mostly into four common ranges based on the steepness of the surface which are flat ($0^o$-$5^o$), Rolling or gentle ($5^o$-$25^o$), mountainous ($25^o$-$50^o$) and escarpment (>=$50^o$). But for the matter of ease of analysis in this study, terrain slope is reclassified into constant intervals of five 1 ($0^o$ -$17^o$), 2 ($18^o$ -$35^o$), 3 ($36^o$ -$53^o$), 4 ($54^o$ -$71^o$), and 5 ($72^o$ -$90^o$). Intervals that are at high degree values show mountainous or escarpment areas and are not comfortable to build health centers. Because of this, areas of such slope values are not selected. On the other hand areas from zero to gentle slope will be the most suitable. This implies suitability increment is the reverse of slope increment. Straight line distance between the listed input datasets are already prepared. Reclassification is made by giving similar intervals (scale values) of slope for each (Fig.4.7). Existing manufacturing and storage ,river, religious sites and schools are places that negatively influence the course of finding the suitable areas for Health centres. Therefore, areas that will be comfortable for Healthing purpose are pushed away from this sites. Linear straight line distances from these sites that are maximum shall be in line with scale values that are high and very high and vice versa .Therefore the scale values as for slopes shall not be reversed during reclassification. Suggested sites and existing population sites on the other hand positively influence the search work for suitable healthing areas. This is because proposed sites and population attracts Health centre services to be near to them therefore, the reclassed scale values and old values of their respective distances will be opposite to each other (the scale values are reversed in the way it is done for slope) .

Table 4. 5.Reclassified Percent from Slope in terms of Suitability

| S.no | Percent from slope | Suitability | Score value for reclassified raster layer |
|---|---|---|---|
| 1 | $0^o$ -$17^o$ | S5 | 5 |
| 2 | $18^o$ -$35^o$ | S4 | 4 |
| 3 | $36^o$ -$53^o$ | S3 | 3 |
| 4 | $54^o$ -$71^o$ | S2 | 2 |
| 5 | $72^o$ -$90^o$ | S1 | 1 |

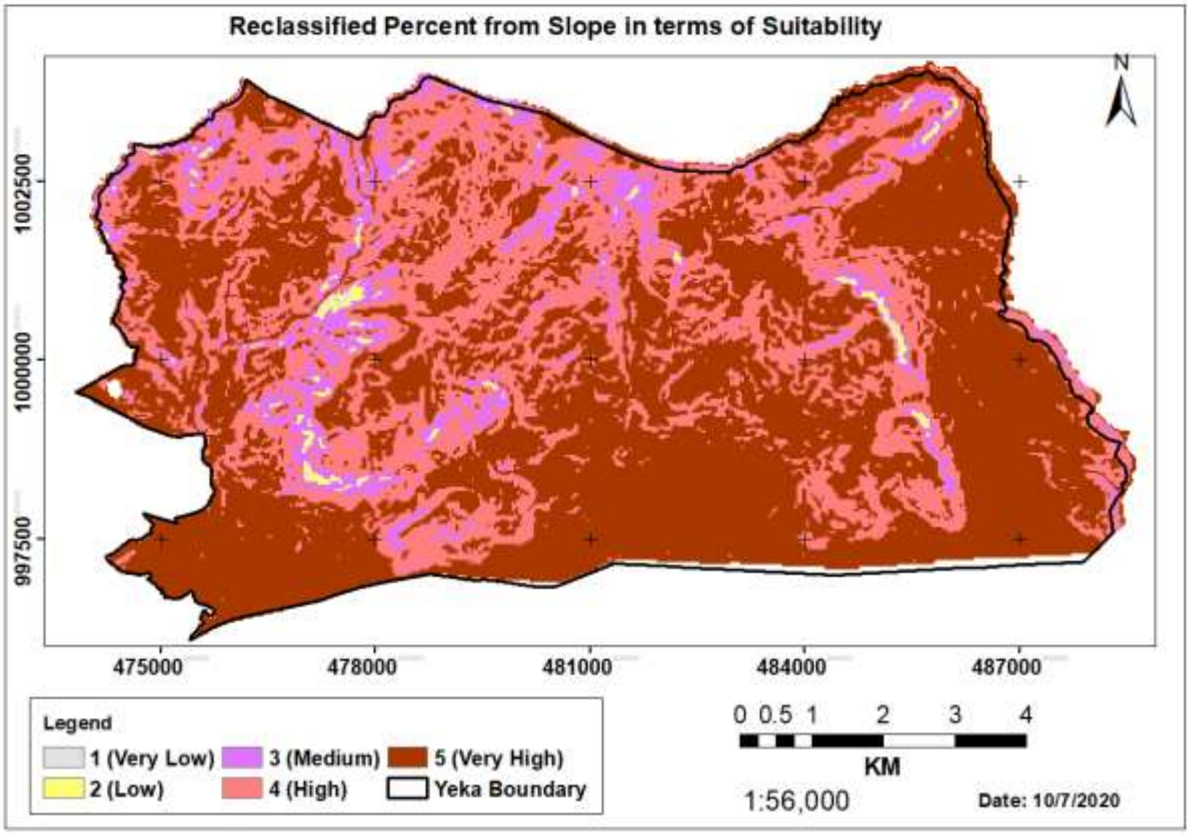


Figure 4. 7: Reclassed Slope in Terms of Suitability

Figure 4.7 indicates that 1 is the suitability was very low, 2 is low suitability, 3 is medium suitability, 4 is high suitability and 5 is very high suitability. From this among the list of suitability the range between 0 and 17 slope is very suitable to select construction.

T+able 4. 6. Reclassified Distance from in Exisiting Health Center terms of Suitability

| S.no | Distance from Exisiting Health Center(In Meter) | Suitability | Score value for re-classified raster layer |
|---|---|---|---|
| 1 | 0-500 | S1 | 1 |
| 2 | 500-1500 | S5 | 5 |
| 3 | 1500-2500 | S4 | 4 |
| 4 | 2500-3500 | S3 | 3 |
| 5 | >3500 | S2 | 2 |

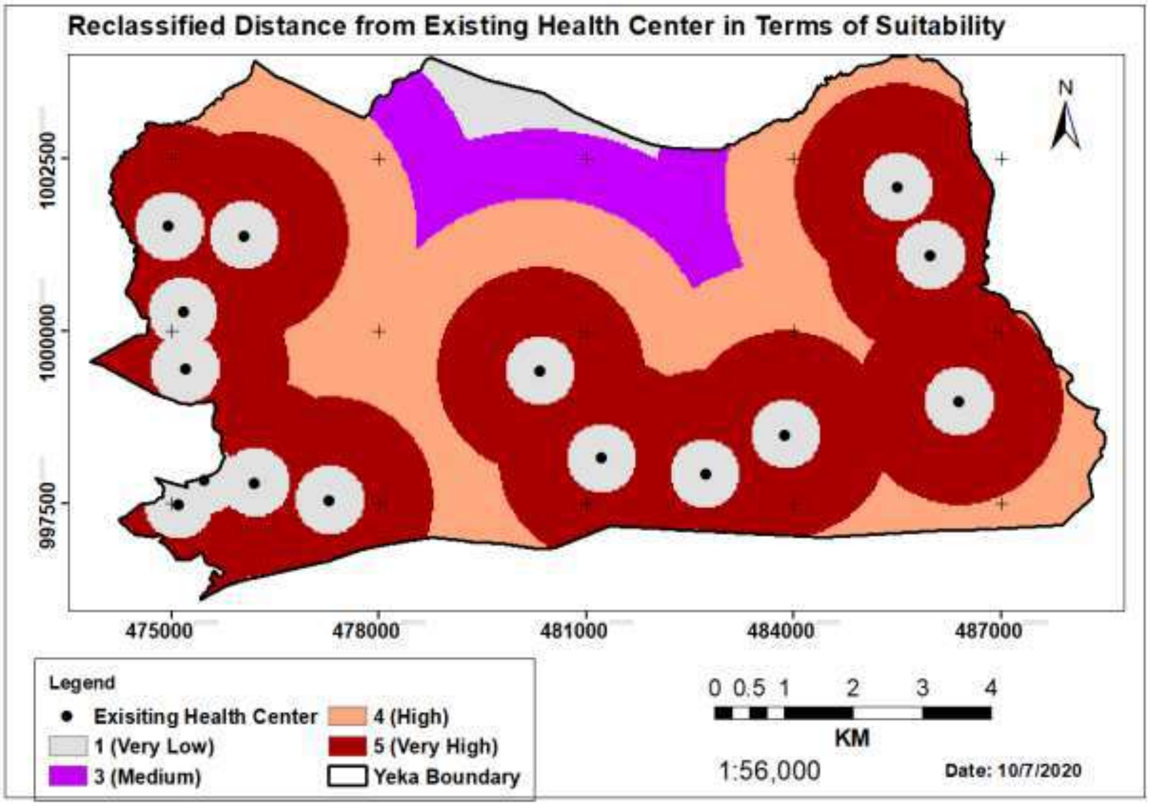

Figure 4. 8: Reclassified Distance from Existing Health Center in Terms of Suitability

Table 4. 7. Reclassified Distance from Proposed sites in Terms of Suitability

| S.no | Distance from Propsed Sites(In Meter) | Suitability | Score value for re-classified raster layer |
|---|---|---|---|
| 1 | 0-500 | S5 | 5 |
| 2 | 500-1500 | S4 | 4 |
| 3 | 1500-2500 | S3 | 3 |
| 4 | 2500-3500 | S2 | 2 |
| 5 | >3500 | S1 | 1 |

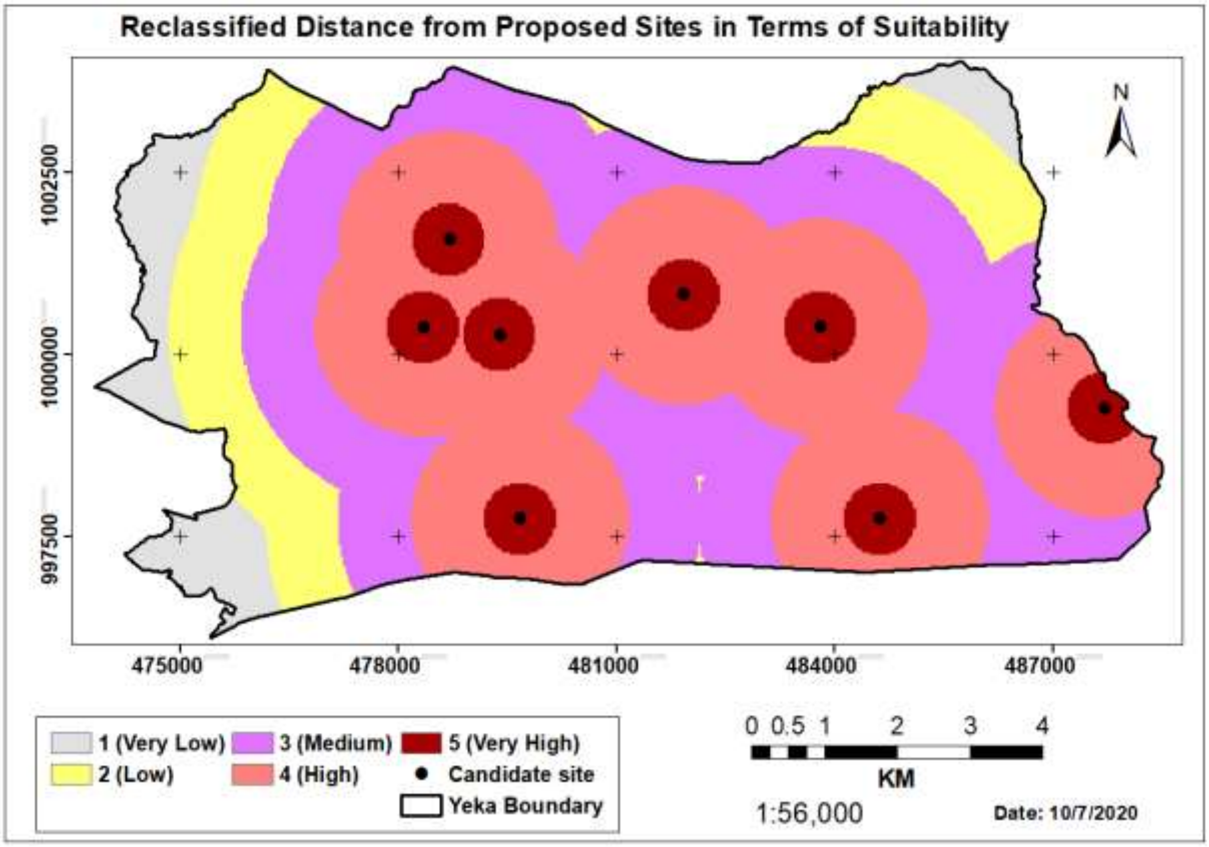


Figure 4. 9: Reclassified Distance from Proposed Sites in Terms of Suitability

Table 4. 8.Reclassified Distance from Population in terms of Suitability

| S.no | Distance from Population(In Meter) | Suitability | Score value for re-classified raster layer |
|---|---|---|---|
| 1 | 0-100 | S4 | 4 |
| 2 | 100-300 | S5 | 5 |
| 3 | 300-500 | S3 | 3 |
| 4 | 500-700 | S2 | 2 |
| 5 | >700 | S1 | 1 |

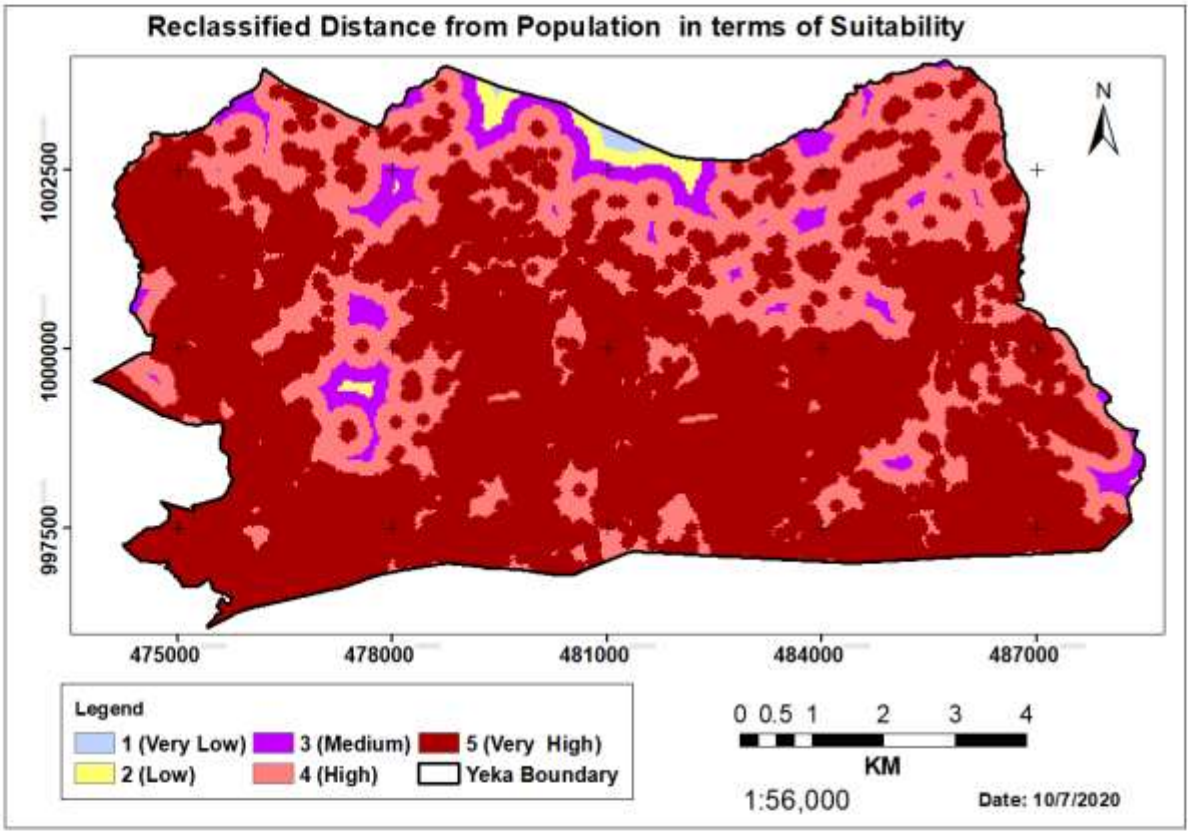


Figure 4. 10: Reclassified Distance from Population in terms of Suitability

Table 4. 9. Reclassified Distance from River in terms of Suitability

| S.no | Distance from river (In Meter) | Suitability | Score value for re-classified raster layer |
|---|---|---|---|
| 1 | 0-300 | S1 | 1 |
| 2 | 300-600 | S5 | 5 |
| 3 | 600-900 | S4 | 4 |
| 4 | 900-1650 | S3 | 3 |
| 5 | >1650 | S2 | 2 |

-

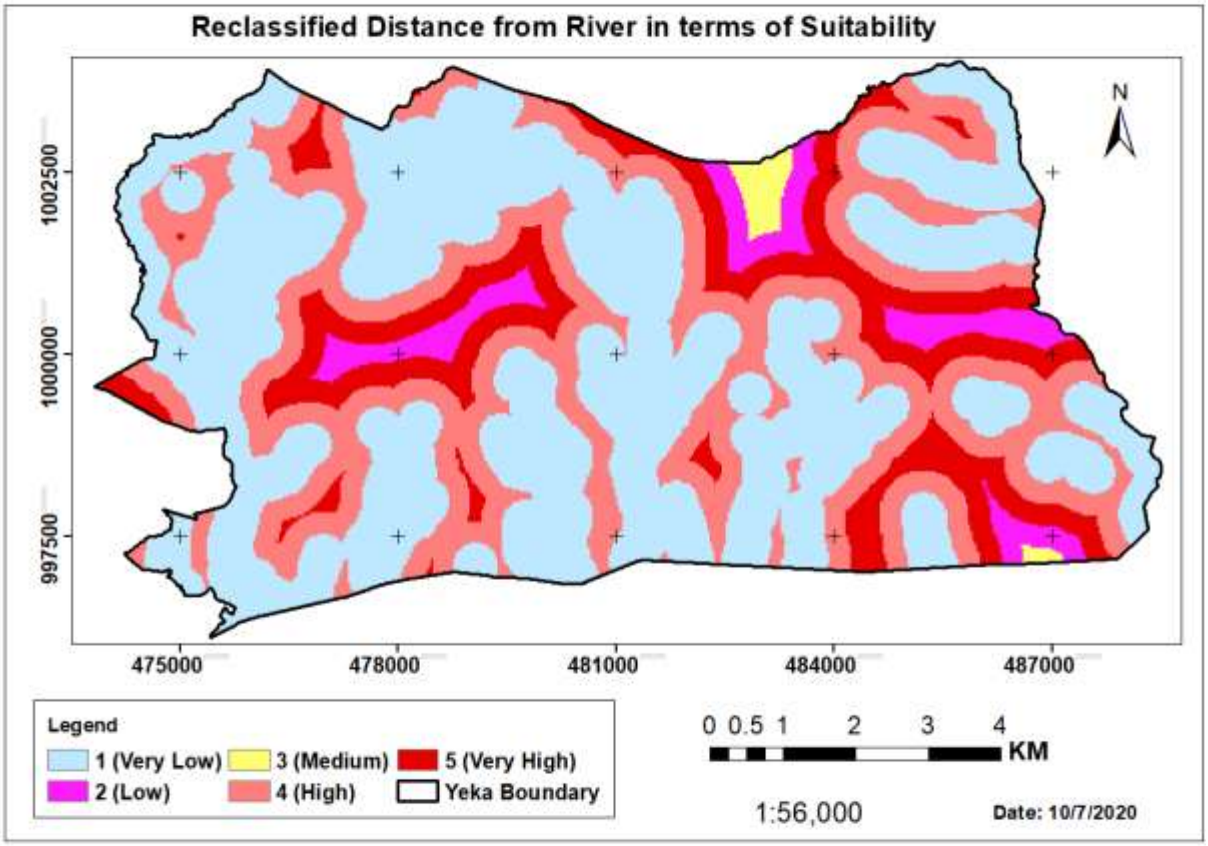


Figure 4. 11: Reclassified Distance from River in terms of Suitability

Table 4. 10. Reclassified Distance from Manufacturing and Storage in terms of Suitability

| S.no | Distance from manufacturing and Storage(In Meter) | Suitability | Score value for re-classified raster layer |
|---|---|---|---|
| 1 | 0-500 | S1 | 1 |
| 2 | 500-1000 | S5 | 5 |
| 3 | 1000-1500 | S4 | 4 |
| 4 | 1500-2500 | S3 | 3 |
| 5 | >2500 | S2 | 2 |

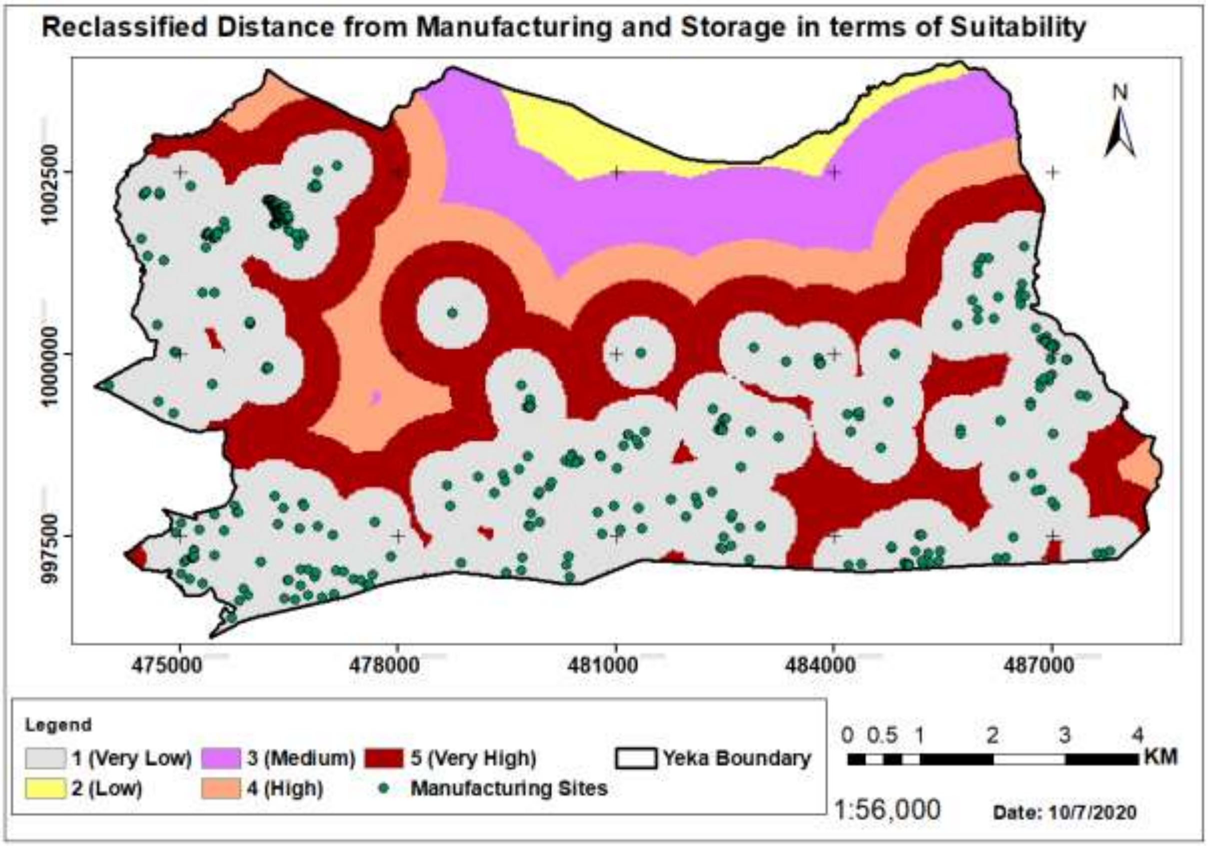


Figure 4. 12: Reclassified Distance from Manufacturing and Storage in terms of Suitability

Table 4. 11 .Reclassified Distance from Religiuous Instutition in terms of Suitability

| S.no | Distance from Religiuous Instutition(In Meter) | Suitability | Score value for re-classified raster layer |
|---|---|---|---|
| 1 | 0-500 | S1 | 1 |
| 2 | 500-1000 | S5 | 5 |
| 3 | 1000-1500 | S4 | 4 |
| 4 | 1500-2500 | S3 | 3 |
| 5 | >2500 | S2 | 2 |

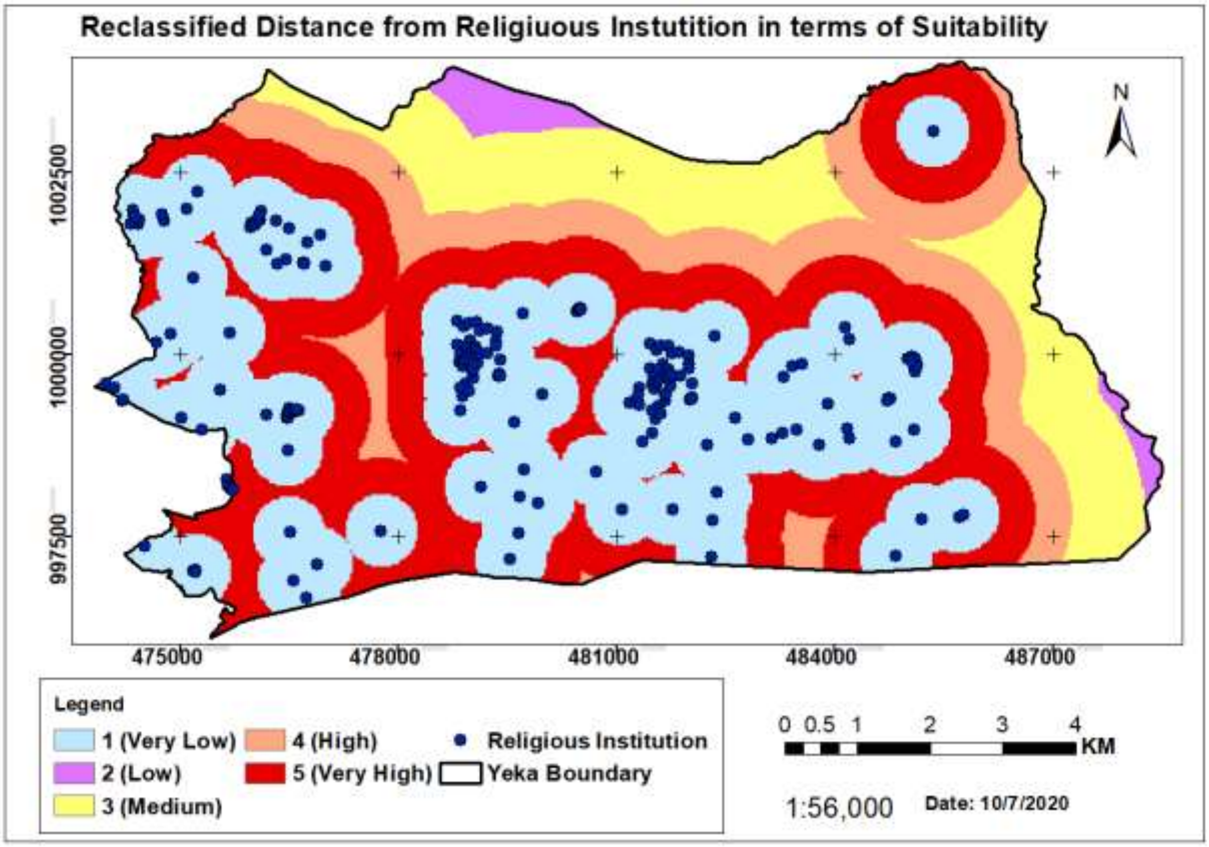


Figure 4. 13: Reclassified Distance from Religiuous Instutition in terms of Suitability

Table 4.12.Reclassified Distance from Main Road in terms of Suitability

| S.no | Distance from Road(In Meter) | Suitability | Score value for reclassified raster layer |
|---|---|---|---|
| 1 | 0-100 | S1 | 1 |
| 2 | 100-200 | S5 | 5 |
| 3 | 200-300 | S4 | 4 |
| 4 | 300-700 | S3 | 3 |
| 5 | >700 | S2 | 2 |

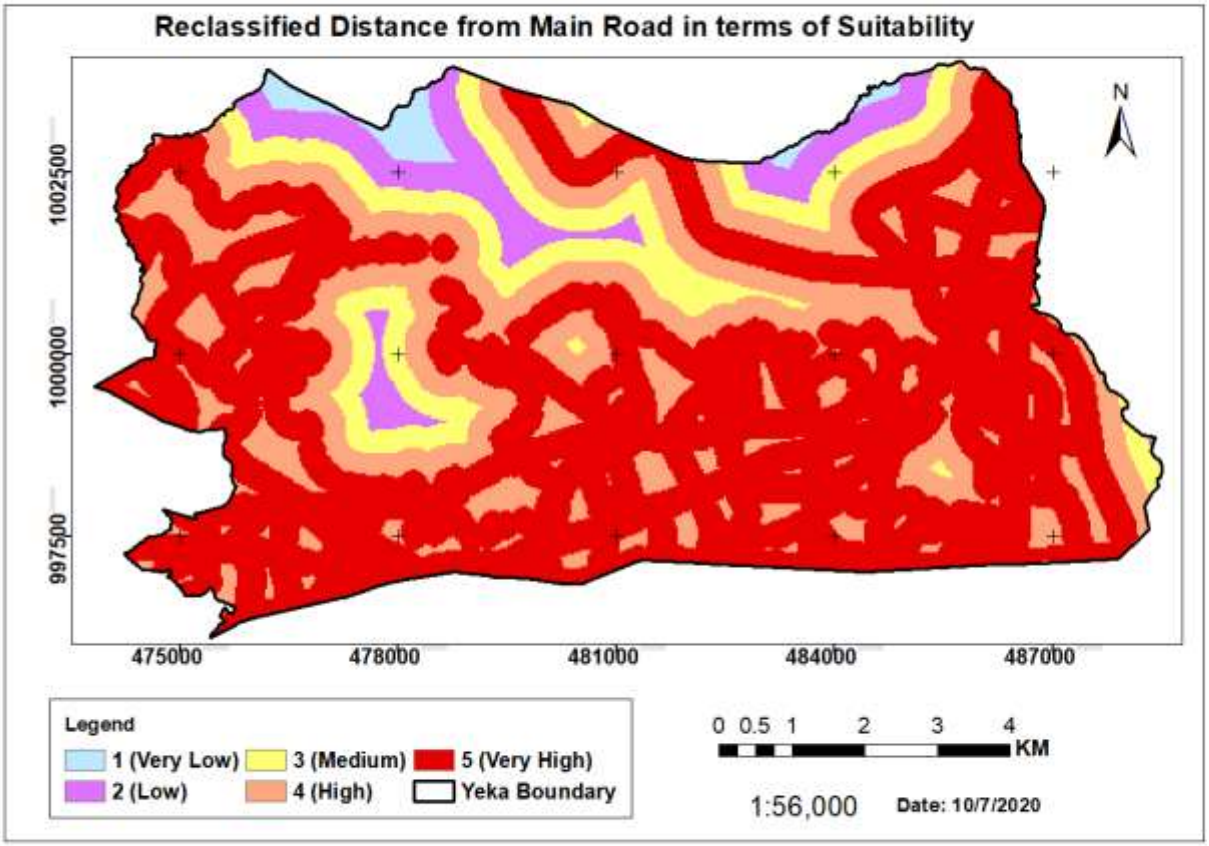


Figure 4. 14: Reclassified Distance from Main Road in terms of Suitability

Table 4. 13.Reclassified Distance from Schools in terms of Suitability

| S.no | Distance from Schools(In Meter) | Suitability | Score value for re-classified raster layer |
|---|---|---|---|
| 1 | 0-500 | S1 | 1 |
| 2 | 500-1000 | S5 | 5 |
| 3 | 1000-1500 | S4 | 4 |
| 4 | 1500-2500 | S3 | 3 |
| 5 | >2500 | S2 | 2 |

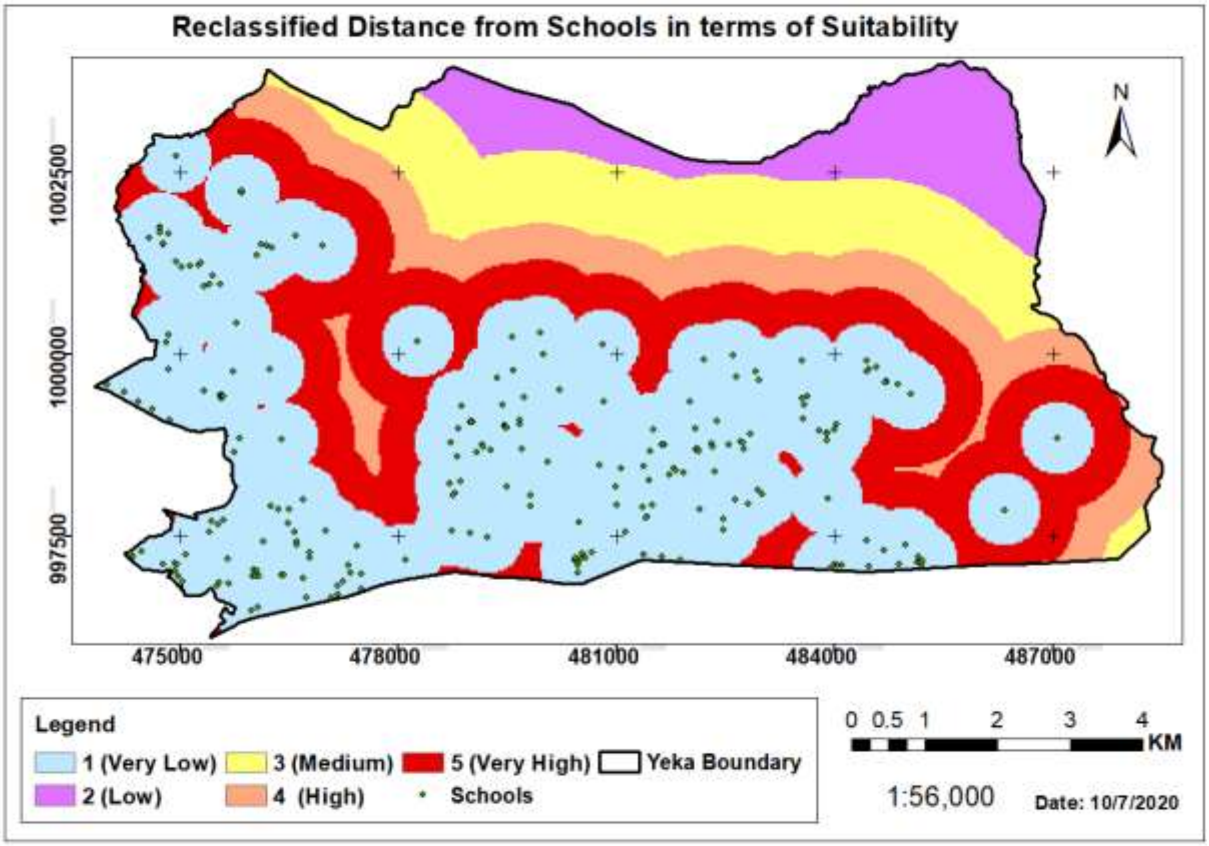


Figure 4. 15: Reclassified Distance from Schools in terms of Suitability

Table 4. 14.Reclassifying Land use/Land cover Map

| s.no | Land use classes (old values) | Suitability | Score value for reclassified raster layer (new values) |
|---|---|---|---|
| 1 | Built Up | S1 | 1 |
| 2 | Mixed Forest | S2 | 2 |
| 3 | Open Spce | S5 | 5 |
| 4 | Urban Agriculture | S4 | 4 |
| 5 | Water | S1 | 1 |

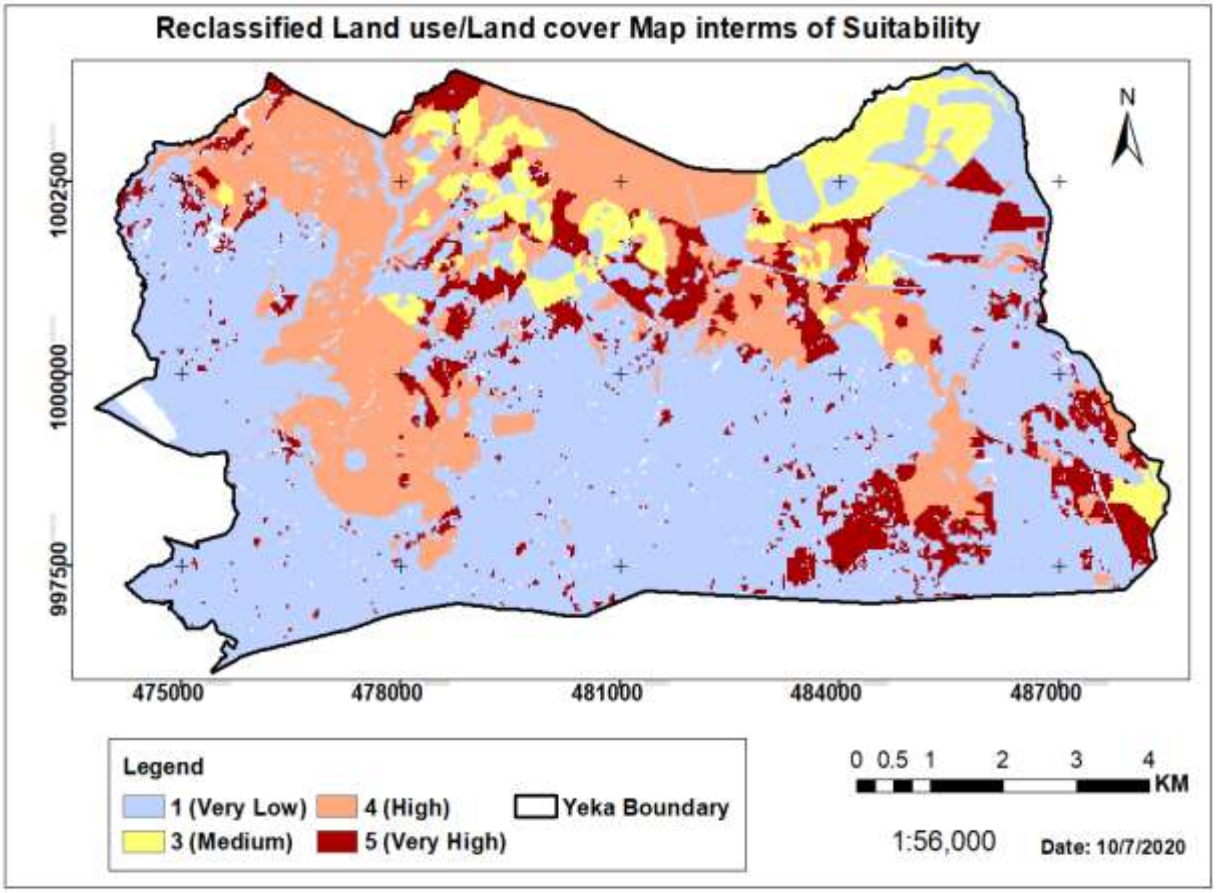

Figure 4. 16:Reclassified Land use/Land cover Map interms of Suitability

### 4.2.3. Weighted Overlay

Overlay of several raster inputs using a common measurement scale and weights of each according to its percentage influence is prepared (Table 4.17). The reclassed results obtained above are all combined through the weighted overlay toolset from spatial analyst tools (Fig. 4.17). The value of each overlay scale as suitability is divided five overlay scale. Such as 1 for very low , 2 for low, 3 for medium, 4 for high and 5 for very high suitable. In this study the reclass scale adjusted for overlay scale. When the reclassified rasters are added to weighted overlay to the value is differ from the reclass scale, then it needs correctly same with the overlay scale to reclass scale.

Table 4. 15. Details of raster datasets in weighted overlay

| Dataset | Weight(%) | Reclass Scale | Overlay Scale | Suitability Level | Remark |
|---|---|---|---|---|---|
| Slope | 5% | 1 | 1 | Very Low | Restricted |
| | | 2 | 2 | Low | Restricted |
| | | 3 | 3 | Medium | Restricted |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Exisiting Health Center | 5% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Proposed Sites | 30% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Population | 25% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Manufacturing and Storage | 5% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Religious Institutions | 5% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| River | 5% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Road | 5% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Schools | 5% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 3 | 3 | Medium | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |
| Land Use | 10% | 1 | 1 | Very Low | |
| | | 2 | 2 | Low | |
| | | 4 | 4 | High | |
| | | 5 | 5 | Very High | |

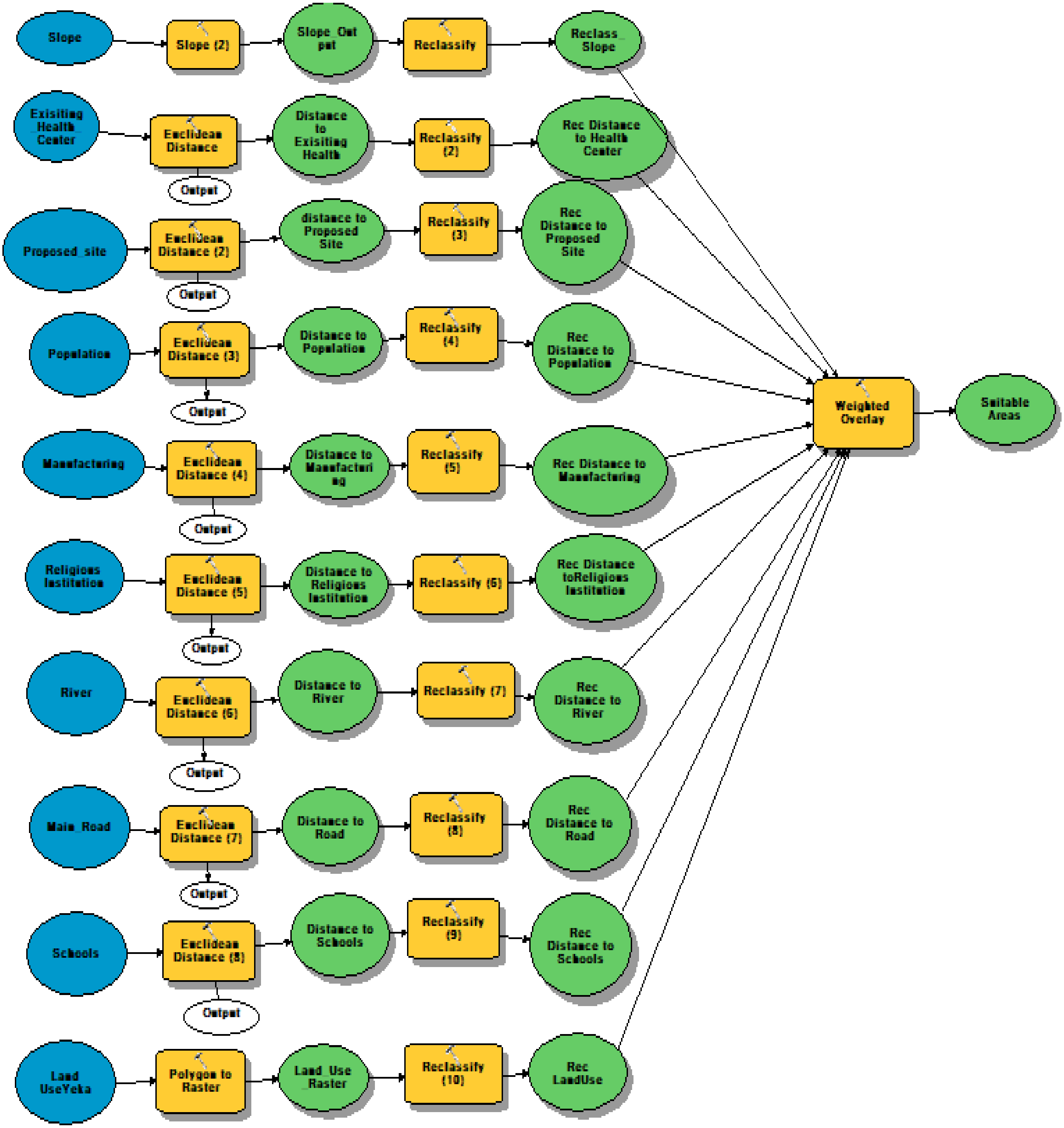


Figure 4. 17: Model Builder Work Flow of The spatial Analysis

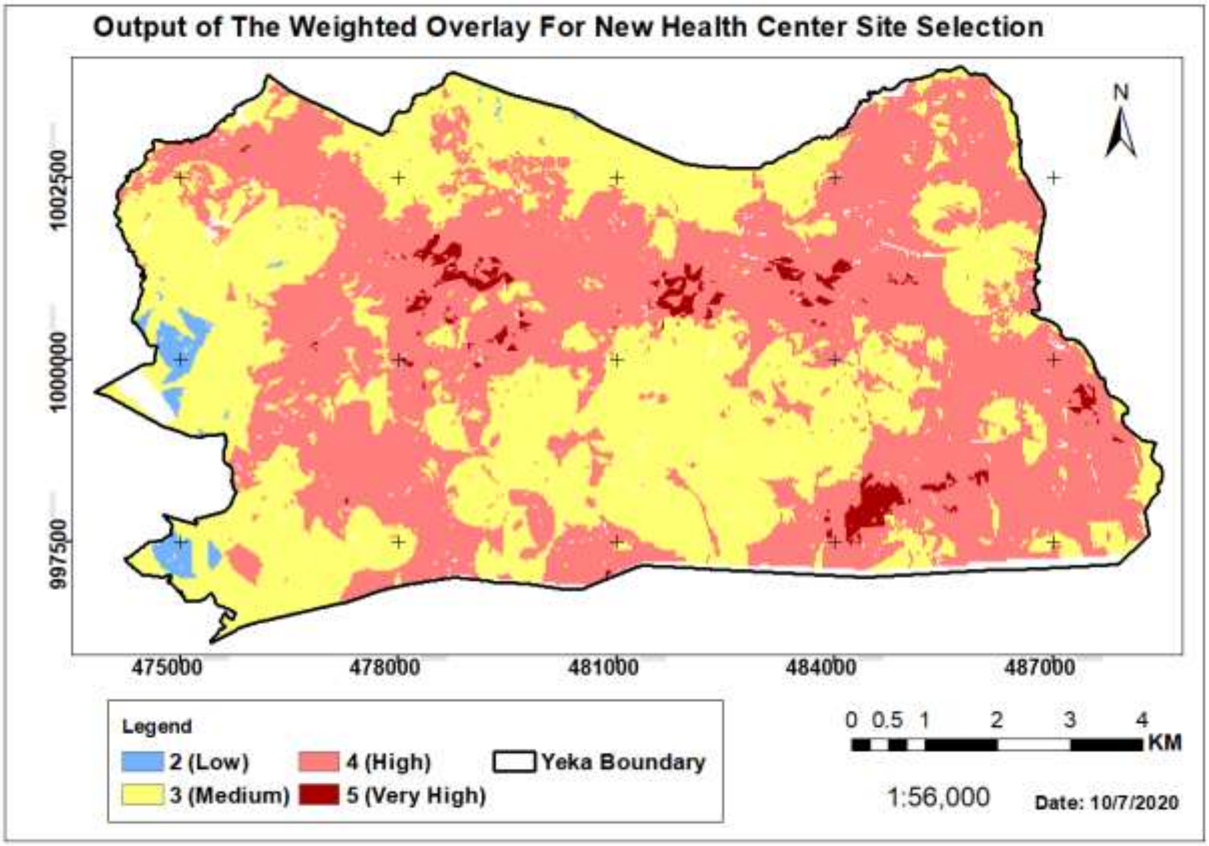


Figure 4. 18: Output of The Weighted Overlay For New Health Center Site Selection

## 4.3. Discussion

### 4.3.1. The Service Area (SA) Analyses

The main objective of conducting the research is to find results on how to balance distribution of the health center and how to establish the health services near to the population (customer) environment. Various factors are investigated in order to achieve the intended goals and objectives set for this study. It is seen through Fig. 4.1 that distribution is not uniform and instead they followed dense patterns of road networks and residential areas. Due to these reasons, on these figures health services are very dense or closely built in southern and western edges of the sub-city while the northern, central and eastern parts where peoples live sparsely are very rare or none. The development of these services should of course follow these dimensions but it does not mean that population groups that are dispersed do not share the service opportunities. Patients from these society are attending their health condition by covering distances that are beyond the customary in the District of Yeka. This distance variation could be observed from the SA analyses results (Fig. 4.2 and Fig. 4.3) so that there are population that are yet moving for more than 2.5km from their home to reach health center destination whereas there are other areas where health centers are established within less than 500 meters apart from each other particularly the Southern and Western edges of the Sub-City. HSDP has set 2.5km distance to be the minimum allowable cost value that is recommended to exist between two health center facilities nearest to each other. But from the current situation where the limit is not currently practical in the Sub-City, schools are unevenly distributed. The first part of analyses compares results drawn from SA of the same basic data set in five distance scenarios that is 0.5km, 1.5km, 2.5km, 3.5km and 4.5km variables between health center services and demand points in Yeka Sub-City. From this, below half (5277 nodes in SA analysis) are allocated to the facilities from the 64143 total demand nodes within 500 meters (Table 4.1.).

The limit value (i.e. 2.5km) is used and the result provided 52609 points are allocated which equals to 82.02%. This implies the services can be taken as enough supply for the demand from the population of the Sub-City. In addition they are found close to one another and demand nodes at high density. But the un-allocated demand nodes 12534 SA are outside this limit. The main intention therefore is to make this population accessible to health center services within this limit or standard distance. The Last 4.5km search radius reduced the un-allocated points to 3671 in SA . This is achieved after increment of the distance approximately by two folds of the limit. Based on this, the area in which un-allocated population beyond the limit distance lives is identified as Scarcity area.

### 4.3.2. The Spatial Analysis

While some solution sites are more stable (Fig. 4.19) than others, the results show that almost all locations can be shown to be "optimal" for the health center facility location. The optimality of a set of sites obtained from SA analysis only pertains to a general set of zonal demand data and not necessarily to the true underlying demand structure. When optimality is discussed therefore in relation to the solution of SA analysis using combined data, it has a good sense. Thus it has a clear implications for the use of spatial analysis technique to find the most reliable sites for health center depending on the optimized sites by SA analyses. The purpose of using the p-median problem type in SA in this study is to maximize health center coverage in the focus area so that the walking distance for each patient attending health center is minimized. This possibly be achieved using Euclidean distances, or network distances as explained in Wondwosen's study in 2016. Wondwosen Mindahun in his research has used the former one but in this study however the criterias are only six and the reclassified standards are not set. In this study the maximum criteria's are used.

### 4 .3.3. 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 health centers, distance from , distance from school, distance from religious institution, manufacturing and storage, distance from river, distance from main road, distance from existing health center, distance from population and distance from suggested sites is the most 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 resulted the final output aimed to be acquired. The result is thus affianced or suitable areas for health center buildings as displayed below in Fig. 4.19.

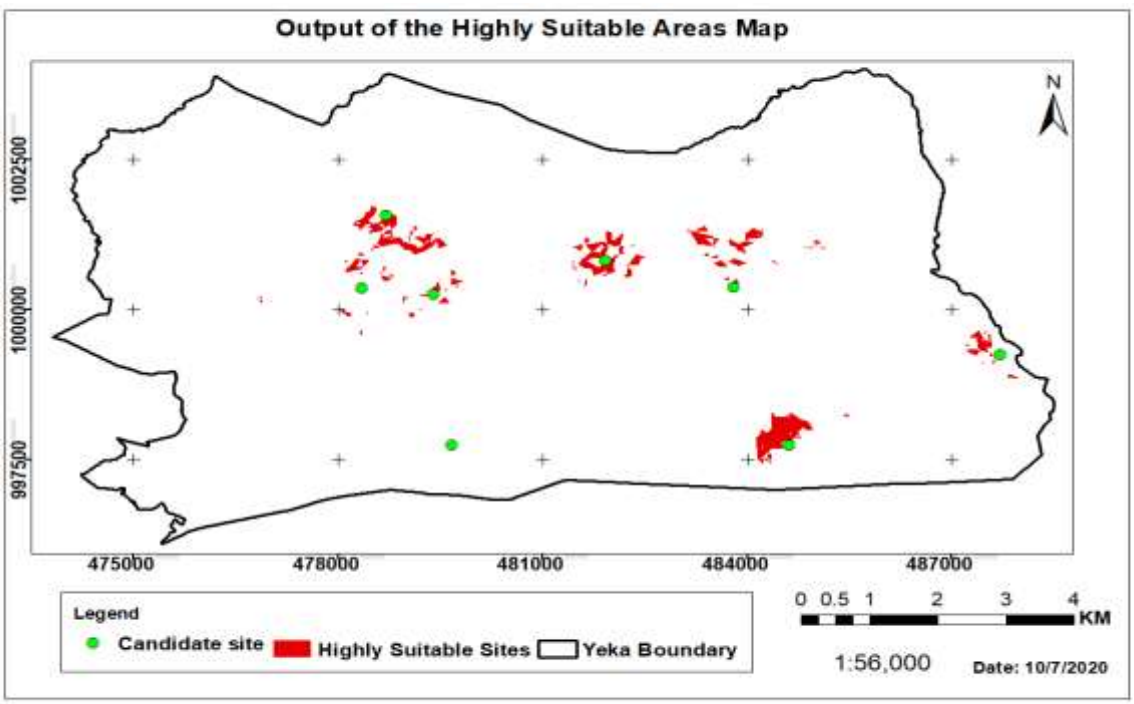


Figure 4. 19: The Final Output of the Suitable Areas for New Health Center Construction

### 4.3.4. Vulnerability of the Final Selected Sites from Flood Hazard Aspect

Vulnerability of a particular area to flood of course depend highly on the topographic nature of the terrain. It is broadly discussed in the background chapter of the study area that the topographic surface of Yeka Sub-City is characterized by slopes at various degree of steepness. The focus area of the solution on the other hand is found on almost upper plateau part of the Sub-City where the rain drops rapidly rundown the surface. The flow accumulation probability is very low. Thus it can possibly be decided that almost all parts of the Sub-City is not susceptible to flood hazard. In contrast to this, some neighboring sub-cities like Bole and Kirkos are found on low and flat landscape where the probability of flood incidence is high. Thus Flood hazard risk assessment for Yeka Sub-City is not given any consideration in this study. In this research work the author combined two Location finding methods to identify the best location of new health center services. The first approach is SA modeling analysis which is used to identify candidate sites and highlight approximate location from the candidate sites for new health centers in the underprivileged area, while the second approach is spatial analysis technique of optimizing and relocating the chosen candidate sites in the first approach as well as examining the existing ones for predicting the future. Of course there might be several techniques of introducing such services and other social common goods in the community. But the researcher found these techniques easily help towards finding better result in the problem solving procedures.

# CHAPTER V. CONCLUSION AND RECOMMENDATION

## 5.1. Conclusion

SA analyses result indicated in Fig. 4.3 and Table 4.2, and series of suitability analyses show that within distance cost of 2.5km more than 80% of the health center population are accesible to health centers services currently existing in Yeka. There is no planned mode of health center distributions in the demanding environment of the community so that health centers are highly concentrated at infrastructure and utility filled areas where as rare number of health centers are seen in other areas of population. This situation intern caused some parts of the population remain unreachable while the others are bounded by high potential of coverage and accessibility. Additional health centers facilities are required in the northern parts of Yeka Sub-City whose cost attribute values (distance and time) are beyond the recommended.

It is apparently that GIS analysis has shown how much is miss-planning of health center locations along the populated community (Figure 4.1). This can effectively help MoH decision makers to take an immediate action towards distribution of health center and the urgent needs for either establishing new health center or relocation of others to provide complete services and easy accessibility to the community. And Therefore GIS based SA and Spatial analysis are the best methods of finding locations that are most suitable for new health center sites and other related public services. Governments can consider such scientific studies before the area is developed to districts, towns and cities etc.

Road network available in the Sub-City is not uniform and as well at very low standard. In the ArcGIS special function, one of the main inputs for network analyst is road network. This could negatively affect the SA analysis because the road network in Yeka Sub-City is irregularly developed. This created a big disorder in locating demand nodes to nearest facilities.

## 5.2. Recommendations

It is found that the following points must be recommendable issues to the respective gover ment organs at both City and Sub-City levels.

- From suitability analysis, the Health office of Yeka sub city can use the output of the results that were selected sites for new health center construction that has been indicated by the researcher, it can use easily the highly suitable sites for the puporse of additional health facilities.

- Potential sites for health center purpose should necessarily be reserved before they are occupied I considerably. The spatial data of land use that has been used in the study has no reserved places for health center building purposes. Land use map of Yeka Sub-City (Table 3.4 & Fig. 3.9) is received from the Sub-City Land Management office. According to these data, there is no spatial land kept for health center expansion so that Yeka land planners and relevant bodies shall take considerations on how to deal with such matters for the future fast growing urban population.
- Data organization of Yeka Health 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, Access and Quality that are prepared by AA City Health Bureau shall also be at Yeka and Woreda office levels in detail.
- Studies that are conducted related to health facility are significant and contributing to both the government and the academic community with their findings and problem solving ideas and supports. Because of this, evidences and materials for research shall be open to experts in unlimited manner in the Sub-City Health Bureau. Because AA Health Bureau is at the highest responsibility from the existing health bureaus in the city, health issues that are to be dealt at city level must be handled by the Bureau. Regulations set by the city government on how to locate and construct health center shall be implemented in accordance with the rules and regulations vested on the paper.
- Road is one of the basic infrastructures that highly affect both the population density and de tiny. Therefore the AACRA shall take special care in expanding the roads on the basis of standard quality and grade levels to keep the normal and even value of the land.
- Yeka Sub-City Administration shall prepare a ground for regular distribution of services, Infrastructures and control the irregular population resident areas and human life activities and as a result the land value throughout the entire Sub-City will be balanced. Administrations at all levels shall make pre and post customer and facility link studies before establishment of the so called public service centers either for governmental or private services.

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APPENDECIES

i. Coordinates of Existing Health Center

| No | X Coordinate | Y Coordinate |
|---|---|---|
| 1 | 475200.000 | 999352.000 |
| 2 | 475107.000 | 997376.000 |
| 3 | 475469.000 | 997736.000 |
| 4 | 481220.000 | 998061.000 |
| 5 | 486393.000 | 998880.000 |
| 6 | 480336.000 | 999319.000 |
| 7 | 475176.000 | 1000190.000 |
| 8 | 476044.000 | 1001280.000 |
| 9 | 474959.000 | 1001420.000 |
| 10 | 483875.000 | 998395.000 |
| 11 | 476201.000 | 997694.000 |
| 12 | 482729.000 | 997823.000 |
| 13 | 477285.000 | 997440.000 |
| 14 | 485981.000 | 1001000.000 |
| 15 | 485503.000 | 1001990.000 |

ii. Results of Service Area Analysis by Distance and Time

| Distance in Km | Population Parcels | Population | % Population | Time in Minutes | Population Parcels | Population | % Population |
|---|---|---|---|---|---|---|---|
| 0.5 | 5277 | 36939 | 8.10 | 5 | 7109 | 49763 | 10.91 |
| 1.5 | 24427 | 170989 | 37.50 | 15 | 16454 | 115178 | 25.26 |
| 2.5 | 22310 | 156170 | 34.25 | 25 | 19088 | 133616 | 29.30 |
| 3.5 | 6860 | 48020 | 10.53 | 35 | 12944 | 90608 | 19.87 |
| 4.5 | 2598 | 18186 | 3.99 | 45 | 5247 | 36729 | 8.06 |
| >4.5 | 3671 | 25694 | 5.63 | >45 | 4301 | 30104 | 6.60 |
| Total | 65143 | 455998 | 100 | Total | 65143 | 455998 | 100 |