EVALUATING THE SPATIAL ACCESSIBILITY OF PUBLIC HEALTHCARE FACILITIES USING GEOSPATIAL TECHNIQUES: A CASE OF LEMI KURA SUB CITY, ADDIS ABABA ETHIOPIA

TESFAYE DAGNE DIRIBA

A THESIS SUBMITTED TO THE DEPARTMENT OF GEOMATICS ENGINEERING

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PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR MASTER'S DEGREE IN GEOINFORMATICS

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Approval Page

I/we, the advisors of the thesis entitled "Evaluating the Spatial Accessibility of Public HealthCare Facilities Using Geospatial Techniques: a Case of Lemi Kura Sub City Addis Ababa" and developed by Tesfaye Dagne Diriba, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Tesfaye Dagne have read and evaluated the thesis entitled "Evaluating the Spatial Accessibility of Public HealthCare Facilities Using Geospatial Techniques: a Case of Lemi Kura Sub City" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geoinformatics.

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Office of Postgraduate Studies,	Dean Signature	Date

Declaration

I hereby declare that Master Thesis entitled "Evaluating the Spatial Accessibility of Public HealthCare Facilities Using Geospatial Techniques; A Case Of Lemi Kura Sub City" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Tesfaye Dagne Diriba	______________________	_______________
Name of student	Signature	Date

Recommendations

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled "Evaluating the Spatial Accessibility of Public HealthCare Using Geospatial Techniques; A Case Of Lemi Kura Sub City Addis Ababa Ethiopia" prepared under my/our guidance Tesfaye Dagne Diriba submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Geoinformatics.

Therefore, I/we recommend the submission of revised version of the thesis to the department following the applicable procedures.

Tilahun Erduno (Phd)	____________________	________________
Major Advisor/Supervisor	Signature	Date
__________________________	_______________________	_______________
Co-advisor/Co-supervisor	Signature	Date

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I would like to take this time and express my appreciation to all that helped me make my studies. I would like to express my sincere gratitude to Tilahun Erduno (Phd) for the persistent guidance and advice throughout my work.

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LIST OF ACRONYMS

2SFCA…………………………..Two-Step Floating Catchment Area

AACHB………………………Addis Ababa City Health Bureaus

AARA…………………………Addis Ababa Roads Authority

CSA…………………………..Central Stastical Agency

DEM…………………………..Digital Elevation Model

EPHI ………………………….Ethiopian Public Health Institute

FMOH…………………………Federal Ministry of Health

GII………………………………Geospatial Information Institute

GIS……………………………..Geographic Information System

GPS……………………………..Global Positioning System

HCF……………………………..Healthcare Facility

L.C.S.C……………………………Lemi Kura Sub City

LULC……………………………Land Use Land Cover

MFL…………………………….Master Facility List

NNA……………………………Nearest Neighbour Analysis

NNR……………………………Nearest neighbourhood Ratio

PHC……………………………Primary HealthCare

WHO…………………………..World Health Organization

ABSTRACT

This research explores potential use of Geographic information system Techniques for analyzing public healthcare distribution patterns and accessibility in Lemi Kura Sub City Addis Ababa Ethiopia. The study is principally aimed to evaluate the spatial distribution and Accessibility Analysis of public Health Facilities to determine the demand and the health facilities spatial location in the study area. Specifically the study is aimed to assess the distribution pattern of public healthcare facilities, to assess physical accessibility to health facilities, and to advise the Master Facility List Data Contents. To do this, all the required data were integrated into the GIS environment and spatial analyses and network analysis were carried out. Average nearest neighbour analysis was employed to assess the spatial pattern and distribution of the facilities. Network analyses were employed to analyze the range of service area in terms of Distance and time. The nearest neighbourhood ratio (NNR=1.231497) shows a random distribution pattern for health care facilities. According to the standards set by the Federal Ministry of health about six health institutions do not meet the criteria. According to the World Health Organization specified criteria of 4 km² catchment areas almost 172 km² area (4km - 6km) don't meet the criteria in line with WHO (1997) standards and Based on a time interval service area map the study found that the residents in Lemi Kura Sub city could get to the nearest Health Center at 20 %, 38% and 42% within 5, 15 and 30 min respectively. In general As the FMOH standard requires the existing Healthcares were not enough in the study area only four health centers meet the standards'and four Health centers don't meet the requirements and two woreda's don't have public health centers. However there is one specialized hospital in woreda 02.Therefore, it is important to plan health care for distribution improvement based on population size. The government should improve the number of HealthCare's as the population is growing and the cost of private health care is beyond the financial capacity of most residents. It will take a great deal of political commitment to increase the distribution of health information in the sub-city and to make it more affordable in terms of population distribution, as well as to implement a Master Facilitation List.

***Key Words**: GIS, Health centers, Healthcare Accessibility, Spatial Distribution.*

CHAPTER I INTRODUCTION

1.1 Background of the Study

The geography of health care access is essential to understanding health disparities. Access is a key element within the health care delivery system. It describes people's ability to use health care services when and where they are needed (Aday and Anderson 1981).

Service facilities that are commensurate with the current rapid growth of the Ethiopian people need to grow together. Basic issues such as health institutions (Clinics, health centers, Hospitals etc.), school water, electricity and so on must be taken into account along with population growth.

Access to health service is recognized as an important facilitator of overall population health, and spatial accessibility is one of the vital indexes to assess whether the distribution of health care facilities is balanced or not. Spatial accessibility usually focuses on alternatives of the ratio of supply (provider) versus demand (population) in the administrative unit or the travel impedance between population and health service providers. Geographic distribution of health services versus population distribution analysis will highly support evidence-based decision support and for health maintenance. Varying spatial distribution of the population, health care facilities and transportation infrastructure in an area often lead to spatial variations in accessibility to health care facilities, which in turn will result in disadvantaged locations and communities having poor spatial accessibility to needed health care facilities: Salahuddin, (2012).

It has been proved that spatial access plays an important role in health outcomes. Longer travel distances to healthcare facilities are related to unfavorable health outcomes, especially in time-sensitive outcomes such as traumatic injuries, heart attacks, and infant mortality rate. (Lei Zhu, Shuang Zhong , Wei Tu , Jing Zheng , Shenjing He , Junzhe Bao and Cunrui Huang (2019)).

Accessibility is the key element within the health care delivery system. Ideally, all should have equal access to quality health care. Such equal access has come to be recognized as being as essential to public health as individual health status (Culyer and Wagstaff 1993, Oliver and Mossialos 2004).

According to Deaton (2003), evidence has shown that among poor countries, increase in life expectancy is strongly correlated with increase in productivity and income. Increased productivity by individual or group of people in all sectors depends on the health conditions of the labor force, while improved health and quality of life depend to a great extent on the availability of, and accessibility to health care facilities at an affordable cost. GIS has a potential role in assessing the geographic distribution of health services, in particular evaluating the effectiveness of health facility coverage relevant to population density.

The ministry of health is responsible for overseeing the health facilities to improve health status and reduce inequalities in the health outcomes of all people living in the country. Health governance, one of the pillars of a health system, has received appreciable attention from the Ethiopian health sector over the past decade. Through the leadership of the Federal Ministry of Health (FMoH), the health sector has various coordinating mechanisms at the federal, regional, and woreda (district) levels for better health care service performance goes from supervising health facility and the supervised, However, the Geographic variation in population, and population need for health care, provides the foundation for analysis and planning of health services. People are not spread evenly across the Earth’s surface, and populations differ along many dimensions including age, gender, culture, and economic status that affect their need for health care, their ability to travel to obtain health care, and the types of services they are willing and able to utilize. Increasingly, GIS is being used to map and explore geographical variation in need for health services and to develop innovative indicators of health care needs.

In many aspects, distribution of healthcare services has shown a wide difference both by type of services provided and by the distance from other centers (Sanni, 2010). Thus, Ujoh and Kwaghsende (2014) notes that adequate and effective distribution of health care facilities contributes immensely to health care service provision and needs by rapid population growth, rising poverty and lack of resources. As Tali et al (2017), an equitable service distribution is the contrast between need for services and demand for them. Hence, access to healthcare requires an adequate supply of health services for the population's needs and the resources that meet specific characteristics such as geographic location; affordability that fits with patients' needs. Health facility accessibility analysis and mapping utilizes the technology of Geographic Information Systems to add value to information for public health planning and decision making. Geographical Information Systems (GIS) provides useful techniques regarding capturing, maintaining and analyzing spatial data.

The Ministry of Health is responsible for the quality of health service throughout the country. In order to establish an efficient and effective system to standardize the whole health system of the country at all levels of the health sector there is a tier health care delivery system throughout the country.

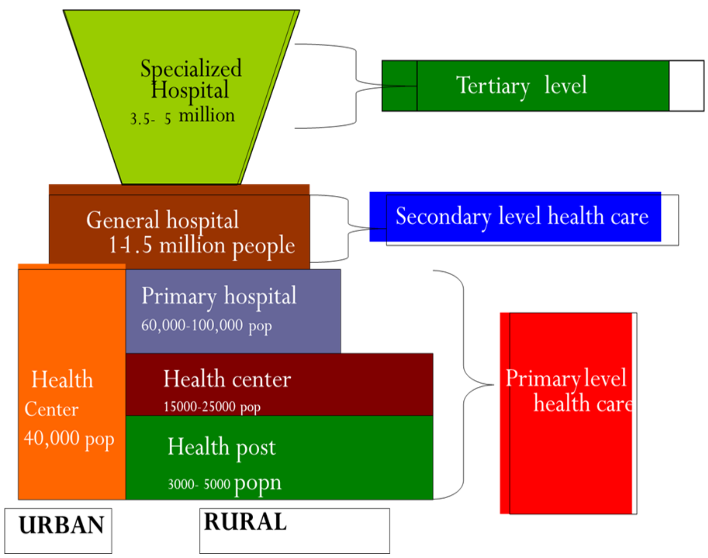


Figure 1:-Structure of the Ethiopian Health System

Source: FMOH: Health care tier and standard

Therefore, the study will focus on geospatial accessibility analysis to the public Health facilities distribution pattern and spatial accessibility of public health care facilities of the study area using Geospatial Techniques such as road network analysis.

1.2 Statement of the problem

In many health care systems, adequate, equitable and easy access to health care facilities is often considered one of the main objectives (Powell and Exworthy 2003). To ensure equal and easy access it is essential to ensure that the population, public health facilities and the transportation infrastructure are positioned in a manner that facilitates high spatial accessibility. The health sector spatial location and attribute has been fragmented and difficult to plan based on evidence without an inventory of spatial location and attribute information in relation to the distribution of the human population.

Lemi Kura is a newly formed sub-city. The sub-city is large in size and the distribution of health facilities is inadequate due to population growth.
Accordingly, in order to assess the scale of the problem, it is necessary to realistically analyze the distribution pattern and accessibility and how the differences with the standard set by Ministry of Health. Due to increasing number of populations, more health care facilities need to be provided, in terms of health facility type and accessibility there is problems of malfunctioning of some of the Health Care facilities, the distance between healthcare facilities based on the population densities, the geographic distribution, the demand for the facilities, the road accessibility. Since the study area is restructured and formed as one of the Sub City on October 20, 2020 from the existing Bole and Yeka sub-cities, it will be importance to analyze spatial accessibility, and more specifically to analyze service area in terms of time and distance to get clear spatial details about the distribution and accessibility.
(https://borkena.com/2020/10/21/addis-ababa-city-administration-restructuring-new-sub-city/)

Various studies such as (Gebreselassie and P. J Rao et.al, 2021; Dejen and Soni, et al 2019 and Andarge et al, 2016) undertaken to examine the spatial distribution and accessibility of health care facilities in Ethiopia observed that the major issue with healthcare in the country is not so much with the quality of services rendered but mal-distribution of facilities, it is often not easily accessible to those in need.

The World Health Organization (WHO) has been involved in measuring accessibility to healthcare facilities in developing countries, working in collaboration with a number of academic institutions (Black et al. 2004).

A number of countries already make their official MFL available online and even allow users to download the data in a variety of formats.

In March 2020 the afrimapr team set out to develop building blocks in R that would make open health facility data more accessible to data scientists in Africa and elsewhere. The afrihealth sites package aims to provide functionality to load, analyse, visualize, and map open health facility datasets (healthsites.io).

According to afrimapr Ethiopia is classified with no official MOH MFL, A master facility list contains information about the full complement of health facilities in a country. The World Health Organization developed a guide for countries wanting to develop their own MFL or wanting to strengthen existing MFLs. We were excited to find several African MFLs available online. (Comparing African Open Master Facility Lists Anelda van der Walt 29 May 2020)

Therefore, the study will recommend the nationwide compressive health facility spatial database to serve as an efficient system for regular updating of the health service database of master facility list (MFL) and improve the quality health service for the population based on the analytical evidence.

1.3 Objectives

1.3.1 General Objective

The primary goal of the study is to evaluate the spatial distribution and Accessibility of Health Facilities in the study area.

1.3.2 Specific Objectives

- To evaluate the distribution pattern of public healthcare facilities in the study area
- To assess physical accessibility of health facilities
- To show the coverage (service) areas of Health facilities
- To introduce Master Facility Lists Data Content.

1.4 Research Questions

The study consequently seeks to find answers to the following questions.

- What is the extent of spatial inequality in the distribution of public health facilities in the study area?
- How are the health care facilities distributed in the study area?
- How physically accessible are public health facilities in terms of distance and time within the study area?
- What is the Master Facility Lists Data Content?

1.5 Scope

The study was geographically confined to the new Sub city of Addis Ababa Lemi Kura. The research work was done in all woreda's where generalization will be made for good recommendation and better planning policies. The main aim of this study was to determine the spatial distribution pattern of the public health facilities and spatial accessibility in the study area using Geospatial Techniques. Moreover, the study looks at the issue of inequality in distribution of public health facilities and accessibility. The issue of accessibility in terms of distances and travel time to health facilities was discussed. Therefore, to assess these issues the data for this study was collected from secondary sources mainly from Federal Ministry of Health (FMOH) and Addis Ababa Health Bureau (AAHB).

1.6 Significance of the study

Health facilities should provide various health services to the population in their respective catchment areas based on this, analyzing the spatial accessibility and distribution pattern of public health facility will help to strength the planning and fill gaps based on results of the study which will be solutions for some of the very known problems such as: lack of health facilities; inadequate mechanisms and formulae for allocating resources geographically based on the population distribution;

Therefore, Findings of this study will provide vital information to make inputs for planning of service provision in relation to actual demand and usage by improving current service provision access within the study area. The Addis Ababa City Health Bureaus, (AACHB) which is directly mandated at city level for public health services delivery and implementation provision stands to benefit from the outcome of this study, which was measured physical accessibility to healthcare services in the study area. To do these two main parameters was used to measure accessibility: distance from health facilities and the travel time to reach the nearest health facility. Healthcare facilities include primary health centers (PHC), which provide some basic health services; government hospitals, which provide all types of services.

Therefore, the distribution pattern and the accessibility analysis for travel time will identify the longest distances and the time taken to reach the health facility. This will support decision makers for planning and to build the new health facilities and to increase health facilities performance. Access to a facility is a vital component in the healthcare system which has a direct influence to be one of the major important indicators of social and economic activities to improve people's healthcare system. To create good spatial arrangements of health services geographical access is required to perform spatial analysis of demand and supply in this case to analyze access to healthcare services contributes to a better understanding of how healthcare systems exist within the study area.

Generally, the result of the study profoundly supports both the local government and the society in placements and use of health care institutions.

CHAPTER II LITERATURE REVIEW

2.1 The concept of Accessibility

2.1.1 Access

Definition of accessibility varies and each carries a different interpretation. Generally, access to healthcare can be defined as the opportunity or ease for patients to come to the services, healthcare providers or facilities (Guagliardo, 2004).

Access can be described as the ‘degree of fit’ between users and a service. The ‘degree of fit’ might be influenced by the availability, accessibility, accommodation, affordability and acceptability of a service (Penchansky and Thomas, 1981).

2.1.2 Accessibility

According to Vickerman (1974), accessibility is a combination of two elements: locations on a surface relative to suitable destinations, and the characteristics of transportation networks linking points on that surface. Accessibility can be defined as the potential or ease for certain health services or health facilities to be reached and utilized by the patients (Guagliardo, 2004; Salkever, 1976).

Accessibility defined as such is similar to the notion of access, as it has a number of spatial and temporal properties that constraint an individual’s ability / capacity / preference to access specific destinations (Witten, Exeter et al. 2003).

Accessibility can be measured by (Euclidean, Manhattan or network) distance, by travel (driving, public transport or walking) time or travel cost. Accessibility can be described as travel impedance (travel distance or travel time) between patient location and health care service points (Guagliardo 2004). Guagliardo (2004) argues that accessibility and availability are not similar terms and that accessibility may depend on availability of the services. In urban areas, where multiple service locations are commonly available, accessibility and availability should be considered simultaneously (Guagliardo, 2004). With regards to health care service utilization, accessibility is generally influenced by the spatial structures of health care service supply and demand, neither of which is distributed uniformly in space (Wang 2011).

2.1.3 Spatial Accessibility

Spatial accessibility to health service locations is usually measured through addressing the geographical barriers like travel distance or time (Cromley and McLafferty 2012; Guagliardo 2004). The interaction between population in need and health care providers decrease with increasing travel distance, following a function of distance decay, Shorter geographical distance can lead to more frequent visits to health facilities, and eventually better health for individuals. For example, Buchmueller et al. (2006) found that increasing distances from hospitals result in higher death rates from heart attacks and unintentional injuries.

Health care accessibility is one of the important components towards an adequate and equitable health system. It is also widely accepted as a key goal towards realizing the human right of having a healthy life (Pillay, 2008). Ensuring a healthcare system which is accessible to the population has been a continuous concern of public health policy makers, providers and academicians (Dewulf, Neutens, De Weerdt, & Van de Weghe, 2013).

Geospatial accessibility analysis is one method applied frequently to measure the degree to which equitable access is obtained (Mokgalaka et al., 2013). Many studies have recognized geospatial access to health care services as a primary determinant of the extent to which social facilities are utilized (Chiu et al., 2017; Domnich et al., 2016; Nteta at el., 2010). Information about accessibility to facilities is of interest to planners and decision makers to achieve equitable services provision.

Penchansky and Thomas (1981) defined access as a measure of fit between the population and the services, identifying five distinct dimensions of potential access. These dimensions can be classified into spatial components (accessibility and availability) and non-spatial components (affordability, accommodation and acceptability) (Khan, 1992). Accessibility describes the burden of travel between locations, while availability describes the number of services available. As these two entities are commonly not independent of each other, we are often forced to deal with services falling within a specific distance. This fusion of availability and accessibility has been referred to as the spatial accessibility of healthcare services (Guagliardo, 2004). Specifically, healthcare services are offered from a fixed set of locations but are required to serve a population considered to be continuously distributed across a landscape (Joseph and Phillips, 1984).

(Wondwossen et.al, Bedasa et.al, 2019) works on Spatial Location Based Accessibility Assessment of Healthcare Institutions in Debre Berhan Zurya Woreda Ethiopia.

Geospatial accessibility refers to a geospatial barrier (distance, cost and time) between the demand and supply; and in a context of health care, geospatial accessibility presents an obstacle to accessing health services (Munoz 2012). Geospatial accessibility analysis is strongly linked to supporting effective planning and decision-making strategies (Tanserl., 2006; Amer, 2007; Munoz 2012; Oosterveer & Young, 2015).According to (Munoz e2012), health planning and evidence-based policy development can be improved when performance of the health system is well understood from a geospatial perspective.

Munoz 2012, works on the health care system in the Western Province of Rwanda, used geospatial accessibility to model the coverage of the existing PHC network and from there estimated the unserved population. This was done by calculating the catchment area for each facility considering population coverage capacity.

2.1.4 Travel impedance

The two most common types of distance measure used for determining spatial accessibility in the literature are the Euclidean distance (more often known as straight line distance) and the Manhattan distance (distance along two sides of a right-angled triangle, the base of which is the Euclidian distance). Ingram (1971) suggests that the Manhattan network distance measure is more appropriate than Euclidean distance in measuring gridded road network in urban areas. But Apparicio et al (2008) argues that the shortest network travel time is more accurate than any other distance measures.

Longeley et.al.2010, works on the shortest distance between two points either directly or along a network (such as roads) can be used to derive travel time. Attributes such as length, speed, restrictions on travel direction, and level of congestion can be taken into account when calculating travel time (Longley et al. 2010).

Md. Taufik Lokhmanet.al, in 2012, worked on a healthcare facility for Joharbahru city, Malaysia. A network dataset is created from the feature source or sources that participate in the network. It incorporates an advanced connectivity model that can represent complex scenarios, such as multimodal transportation networks. Preparation of the network analyst such as the Shortest Route using Shortest Path tool: the closest facilities using closest facility tool.

2.1.5 Gravity potential model

Gravity potential model is the most commonly used measure of spatial accessibility found in the literature (Pacione, 1989; Talen, 1998). The model is based on Newtonian physics, where facilities are weighted by their capacity and adjusted for the friction of distance (Cho, 2003).

The number of facilities within a specified travel impedance (e.g. travel distance, travel time or travel cost) is a commonly used method to measure spatial accessibility. Distance can be measured either from the supply perspective, e.g. catchment area for a specific health care service, or from the individual users perspective, e.g. distance to the closest health care service facility (Fryer et al., 1999, Fortney, Rost et al, 2000) or both (Parker and Campbell, 1998).

2.2 Spatial distribution

Abbas et al. (2012) investigated the spatial distribution of Healthcare facilities in Chikun local government area of Kaduna State Nigeria by employing GIS and GPS to map exiting ones, evaluate adequacy based on World Health Organisation standard. The Kernel Density tool calculates the density of features in a neighborhood around those features, which was articulated by John Ogbole, Mustapha oloko-oba, et.al (2016) to show the geograpgic distribution nature of the existing healthcare facilities. It can be calculated for both point and line features. Conceptually, a smoothly curved surface is fitted over each point. The surface value is highest at the location of the point and diminishes with increasing distance from the point. Measuring the compactness of a distribution provides a single value representing the dispersion of features around the center. The value is a distance, so the compactness of a set of features can be represented on a map by drawing a circle with the radius equal to the standard distance value. The Standard Distance tool creates a circle polygon (ESRI, 2022).

A common way of measuring the trend for a set of points or areas is to calculate the standard distance separately in the x- and y-directions. These two measures define the axes of an ellipse encompassing the distribution of features (ESRI, 2022).

Samuel and Innocent (2015) carried out a work on the Spatial Distribution of Health Facilities in the South-South, Nigeria. The spatial inequality and the polarization of development sought to determine the extent and nature of variation in socio-economic development in the 123 Local 12 Government Areas (LGAs) of south-south, Nigeria. Kamaluddeen Aliyu (2021) carried out a work on the spatial distribution of public health care facilities in GOMBE LGA for assessing the spatial distribution of the public health facilities,

The pattern of distribution of heath care facilities have been a thing of interest considering the effect it poses on the developmental level of any region. According to Inyang 1994, the level of access to health care facilities is a function of the degree of fairness in spatial distribution of the health care facilities. It was also observed that the problem that exists in the health care sector is not totally on the service quality but on the adequacy of health facilities provided and according to Ujoh and Kwaghsende (2014), the quality of services rendered is related to the level of manpower available. This explains that it is not only for the facilities to be equally distributed but to have health personnel who can deliver the services to people for which the facilities are created to serve. However, because Healthcare facility distribution in Nigeria has been characterized by significant disparity which is evident in their locational pattern of distribution where some of these healthcare facilities are concentrated in one area at the expense of other areas, the maximum benefits of total of its provision have not been enjoyed by all. This is observed to have awakened the need for researches on the pattern of Healthcare Facilities in different parts of the world and has made governments to show serious commitment towards addressing the inequalities.

According to Okoko 2002, The Nearest Neighbour Analysis (NNA) was used to determine the spatial pattern of health care facilities. According to [18] cited [19], the distribution pattern ranges from 0 to 2.15. Nearest Neighbour Index (Rn) with 0 value indicates cluster distribution, Rn with value of 1 indicates random distribution cluster while Rn with value of 2.5 indicates even distribution.

Ethiopia’s health sector over the last 20 years has seen unprecedented expansion particularly for its primary health care (PHC) system. The development of the health sector was made possible by strong commitment, a substantial increase in external support, and rapid economic growth. Rondinelli (1985) works on the distribution pattern of health facilities using ArcMap 10.8. There are several of such planning tools that can be used in spatial analysis. However, for the purpose of the study analysis will be carried out using measure of concentration, distribution quotient and measure of association introduced by Rondinelli (1985) and average nearest neighbour will be used to determine point pattern analysis which is used to evaluate the distribution of health facilities. Nearest neighbor ratio (R) calculates the distance between one point to its nearest points. (Robinson, 1998).

Traveling distance or time between the locations of the population and the health care providers is one of the important spatial impedances to the delivery of health care services (McLafferty, 2003; Aday and Anderson, 1981; Penchansky and Thomas, 1981). The impact of the distance to the health care facilities on utilization of health care services has been studied by Hadley and Cunningham (2004), Lovetta et al. (2002) and Fortney et al. (1999).

Samuel and Innocent (2015) carried out a work on the Spatial Distribution of Health Facilities in the South-South, Nigeria. The spatial inequality and the polarization of development sought to determine the extent and nature of variation in socio-economic development in the 123 Local Government Areas (LGAs) of south-south Nigeria.

Abebaw works on Health Facilities Distribution Mapping in Gulele Sub city, Addis Ababa, Ethiopia , This project mapped the distribution of health facilities point pattern analysis was conducted to evaluate the distribution of health facilities in the sub-city. Nearest neighbor statistics was calculated for the evaluation of the pattern of the distribution of the cases. Nearest neighbor ratio (R) calculates the distance between one point to its nearest points.

Temesgen, works on spatial distribution and accessibility of public Health service in Adama City, Ethiopia, the existing public healthcare center distribution and accessibility performed using service area analysis Using service area analysis and the spatial distribution of existing healthcare centers was mapped. The accessibility of a given public healthcare center to the specified distance limit, as walking mode of travel, or/and the travel distance threshold of

2,000 meters is applied and analyzed based on the norms and standards fixed by the Health Bureau.There are three important functions of the Geographical Information System (GIS) in health research and policy analysis: spatial database management, visualization and mapping, and spatial analysis (Cromley and McLafferty, 2012). WHO (1997) specified criteria for health care planning for third world countries and indicated that each service area should cover 4km2 catchment area with a population of 60,000 for primary health care in order to have adequate and equitable access to healthcare. In line with WHO (1997), the study will analyze the accessibility to health care facilities and spatial distribution in the study area.

2.3 Master Facility List

A Master Facility List is a complete listing of health facilities in a country (both public and private) and is comprised of a set of administrative information and information that identifies each facility (signature domain) (World Health Organization (2013)).The set of identifiers in the signature domain serves to uniquely identify each facility in order to prevent duplication or omission of facilities from the list. It also contains contact information, type of facility and other information that is useful for administrative purposes. The service domain contains a basic inventory of available services and facility capacity, providing essential information for health systems planning and management. Consolidating health systems information through the MFL will improve record-keeping and reporting efficiency as well as transparency in the health sector. In addition, a MFL is a prerequisite for the sampling of health facilities to conduct more detailed assessments of service delivery such as the Service Availability and Readiness Assessment (SARA). Moreover, linking health facility data and other core health system data (financing, human resources, and infrastructure) through the unique identifiers defined in the MFL will allow better analysis and synthesis of information to improve health systems reporting and planning. Several strategic choices need to be made before making a MFL. One is the level of complexity. Depending on the envisioned use of the list, this can be all from including only facility names, addresses and basic services, to a complex system also containing detailed information on service provision, allowing for referral of patients between facilities.http://library.health.go.ug/publications/health-facility-inventory/national-health-facility-master-facility-list-2018

CHAPTER III STUDY AREA AND METHODS

3.1 Description of the Study Area

3.1.1 Geography

The study conducted in Lemi Kura Sub city which is located in the Southwest, roughly between latitudes 92°21'~108°12'E and longitudes 26°03'~34°19'N, is the second largest sub city (486,000 km2) of Addis Ababa City. Addis Ababa City Council passed a decision on the re-establishment of sub- cities and woreda's to make Lemi Kura sub-city the 11th sub-city of Addis Ababa which is not an additional constituency but is made up of the existing Bole and Yeka sub-cities with 10 administrative woreda's. The new sub-city would take woreda's from Bole and Yeka. In October 20, 2020 Addis Ababa City Council, has passed a proclamation to restructure the city in to 11 sub cities establishing an additional one named "Lemi Kura" according to the council the new structure will help the residents to access equitable and efficient services by balancing the number of residents, enhancing access to services and managing capacity in a balanced and accessible way. (borkena:ht tps://borkena.com /20 20/10/21/ Addis-Ababa-city -administration- restructuring-new-sub-city).

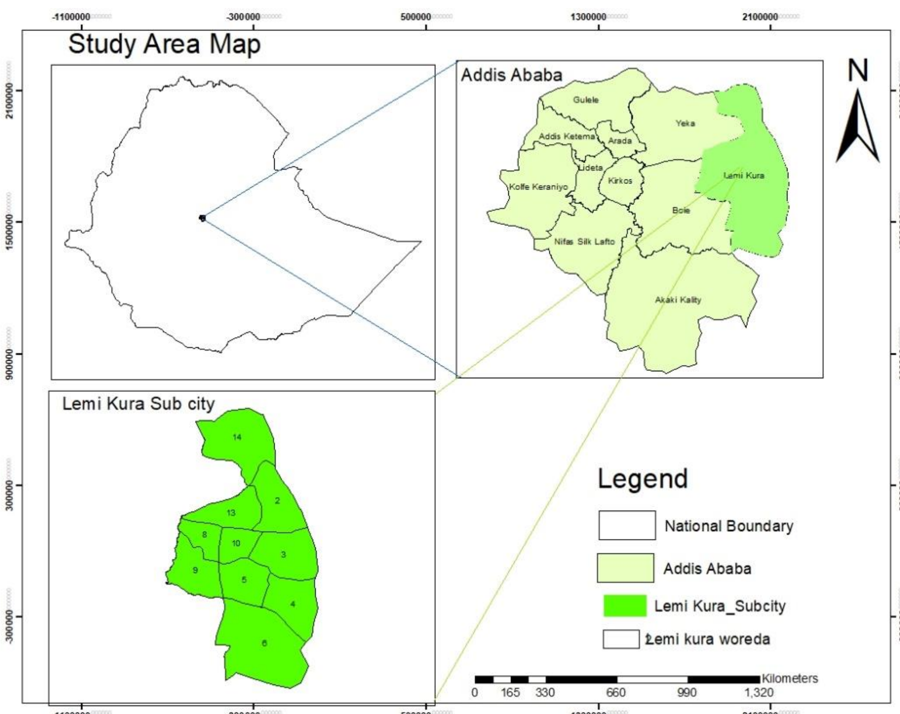


Figure 2:-Study Area

3.1.2 Population

According to the Addis Ababa Health Bureau, the projected population has been implemented with a total population of 366,922 in the sub-city. And the population distribution in each woreda has been depicted as shown in the table (see Table1), among the 10 woreda's woreda eight is the most populated with the population of 59,424 and woreda five is the least one with a population of 21,721.

No	**Woreda**	**Projected Population (2014)**
1	Woreda 2	46,987
2	Woreda 3	22,312
3	Woreda 5	21,721
4	Woreda 4	41,214
5	Woreda 13	40,677
6	Woreda 6	24,000
7	Woreda 8	59,424
8	Woreda 9	44,677
9	Woreda 10	22,226
10	Woreda 14	43,684
	Total	366,922

Table 1:- Study area Population Distribution

Based on the projected population of the study area The population density were generated and grouped in to six classes in each woreda's to show the population distribution throughout the woreda administrative extent. Figure 2 shows that Lemi Kura Sub city population density map by woreda, which is relatively high in woreda 8 and woreda 13 and declines in woreda 6, 5 and 3. Wored 8, has the highest population density (14,941 residents per km2), while wored 6, was the lowest.

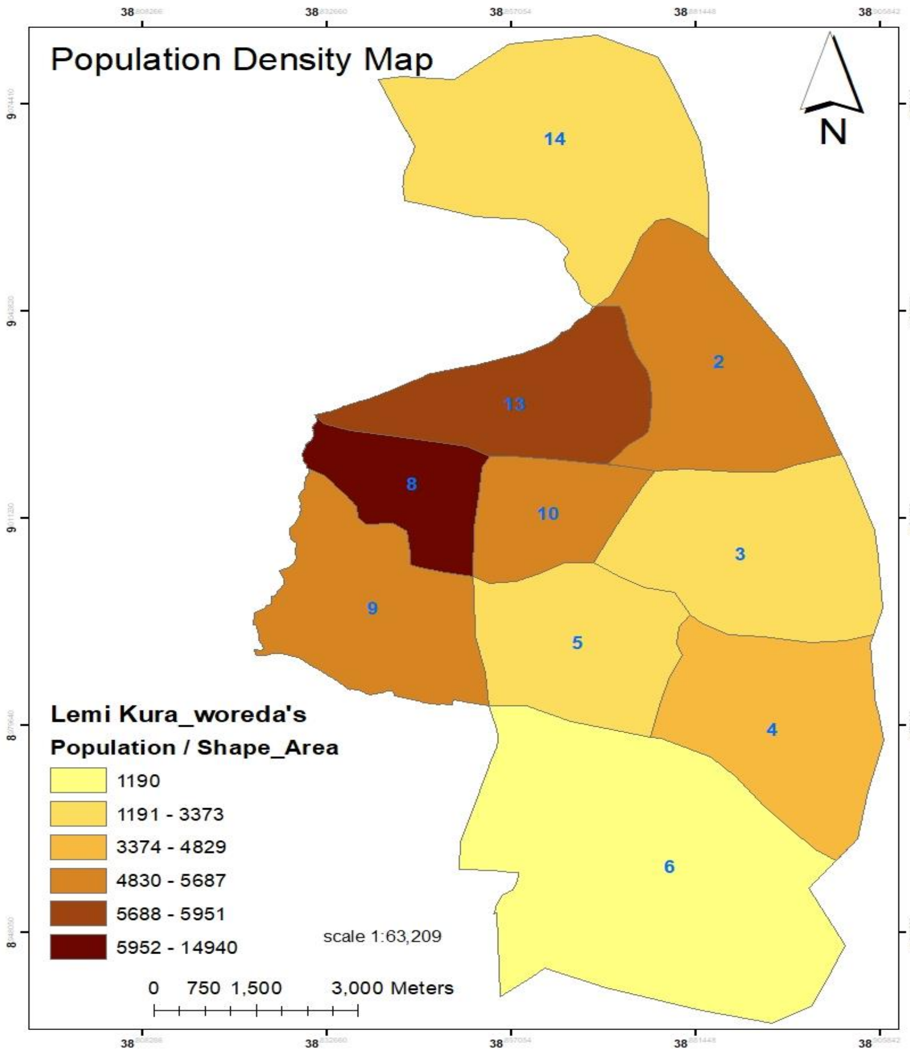
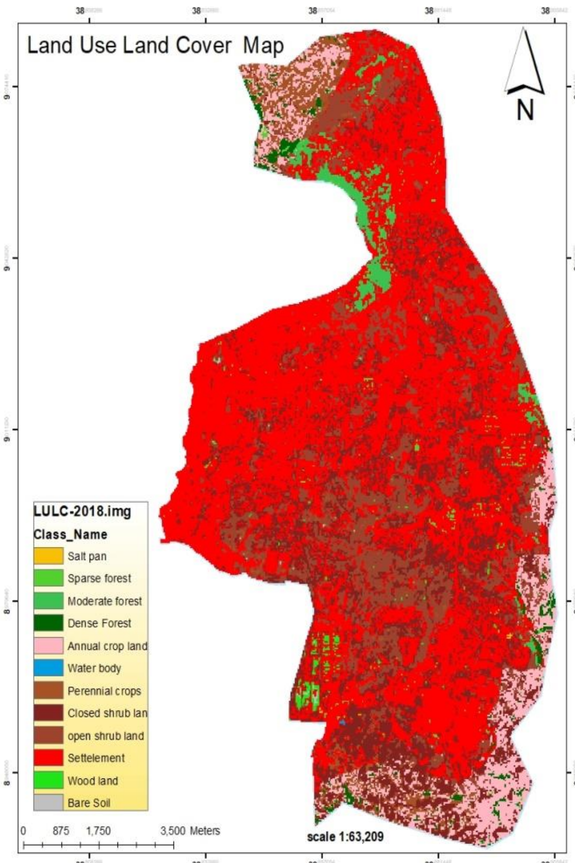


Figure 3:- Population Density map of L. K. S. C

3.1.3 Land Use Land Cover and Topography

To map the land use land cover of the study area Land use land cover classification data of the (2018) was used for visualizing the land covered in the study areas which were acquired from former Geospatial Information Institute. Urban settlements are more dominant which is about 45 hectares and Grassland is the second largest area covering about 40 hectares. Land use and coverage was help to analyze the distribution and accessibility of health facilities within the scope of the study For example, the more residential areas, more health facilities will be expected. So that as the map shows Most of the study areas were covered by residential area 90 % of the total, the remaining is only 10%. (See figure 4). To classify the topographic map of the study area DEM data were downloaded from NASA Earth data used to generate Slope, Hilshade and aspect map of the study area. Landscaping is a big factor in analyzing the time it takes to use a road network, but the map show that it is mostly flat, which means it is easy to visit health facilities by car or on foot and has little or no such impact on travel(See Figure 5).



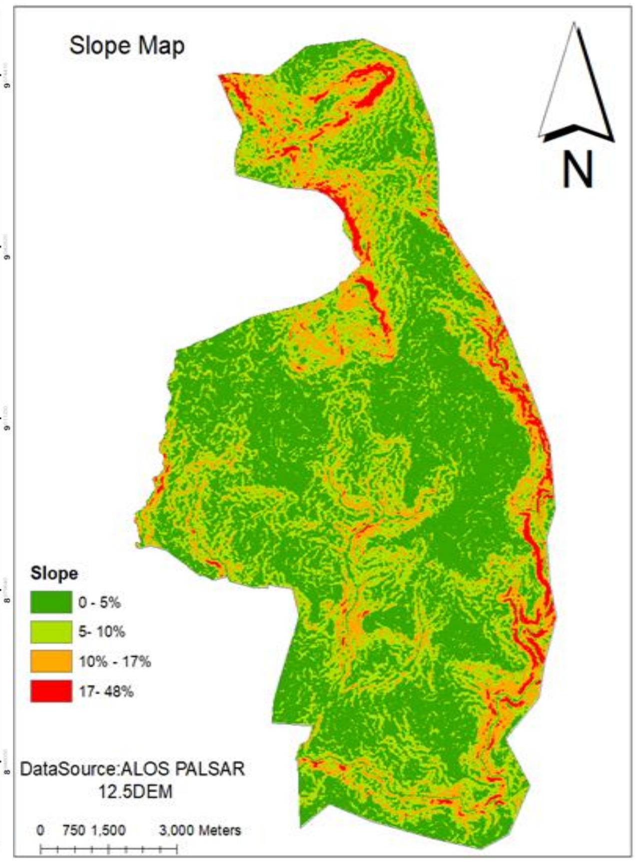


Figure 4:- LULC Map of L. K. S. C

Figure 5:- slope Map of L.K.S.C

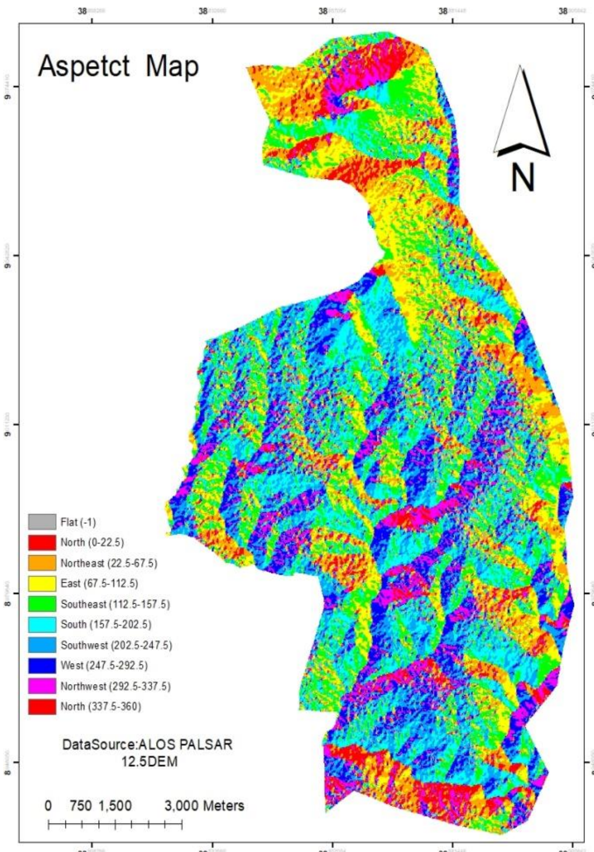


Figure 6:- Aspect Map of L. K. S. C

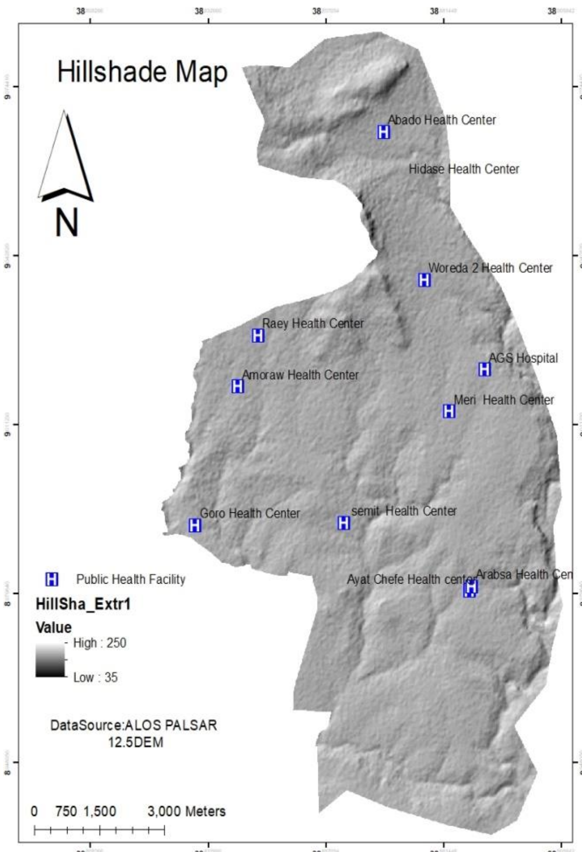


Figure 7:-Hillshade Map of L. K. S. C

3.2 Methodology

3.2.1 Data Source

Moreover The study used Secondary data sources collected from different sources: Health care facilities data were acquired from MOH sourced from EPHI and CSA and confirmed by Addis Ababa Health Bureau, The source of population data comes from Addis Ababa Health Bureau (AAHB)., Sub city Extent Data, land use land cover of (2018) and Road network data were acquired from Geospatial information Institute (GII).

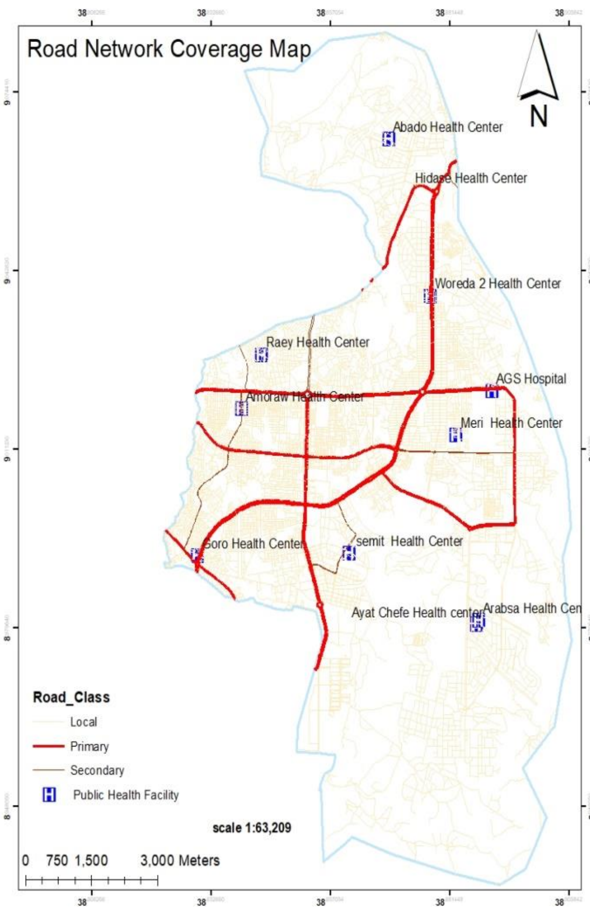
3.2.2 Data Collection

Essential data such as Data relating to the health facilities distribution, location, population distribution and study area were collected from different sources at different times. After the data was collected, the necessary quality inspection and the completeness of the data were verified before using it for further analysis.

Beside the quantitative data to be sourced, documented sources such as library search also employed for the sake of literature review, also journals and research projects were consulted and used in the study.

3.2.3 Data Integration

The health districts, as catchment areas, are not commonly available. Instead, administrative boundaries (woreda's) were used for the study. The point coordinates of each Health facility were imported and displayed in ArcGIS software for further editing and road network data was processed for further edition and analysis. Based on the stored data, spatial analyst extension and techniques was applied to determine the distribution pattern of the public health facilities and to analyze the type, location and spatial distribution of health facilities and ArcGIS Network Analyst extension was used to build a road network dataset and determine the travel time for health care facilities. GIS techniques used to analyze the spatial distribution pattern of the public health facilities and spatial accessibility in the study area. Road network analysis function was applied to compute the service area and closest facilities based on distance and time interval. According to the ERA technical standards, travel speeds are set according to the quality of the road, i.e. as 80, 60, 40 and 20 km/h for ring roads, Two sided roads, Local road and village roads, respectively.(source: Addis Ababa Roads Authority (AARA)).A good network will provide easy access to these Health Care facilities including service area and the closest facility analysis by walking and vehicle transportation model. To do this the road network data has been prepared based on the study area boundary extent. Both the geometric and attribute information was checked, and to fix some geometrical errors topology rules were applied for the vector based road network data and it was corrected. Next to this it was tested on the functionality of road network analysis such as setting the proper speed limit attribute information based on the standard. Then to compute the travel time the network analysis was performed by accessing the data set from the confirmed geodatabase created. Accordingly, the Road Network data layer in the study area has been mapped (see Fig 8 and Fig 9).



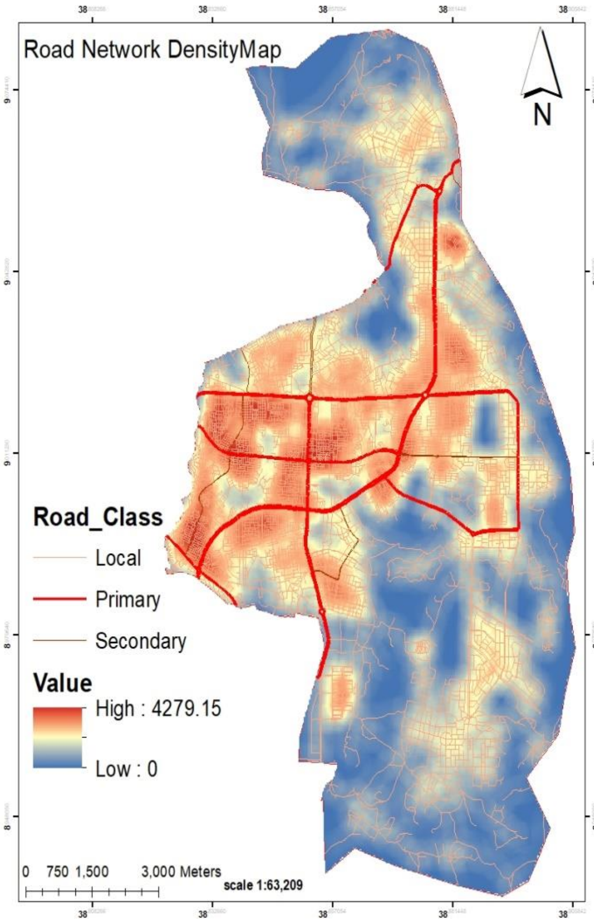


Figure 8:-Road network coverage Map of L.K.S.C Figure 9:-Road network Density Map of L.K.S.C

3.2.4 Database creation

In order to manage and easy access the spatial database, personal geodatabase was created using the Arc Catalog, to store all relevant data and their corresponding attributes. then the necessary data was imported into the ArcGIS 10.8.Environment. Then data entry about the entity Healthcare facility was created using the following; facility name, location (woreda), facility Type, X and Y coordinates, the attribute information was joined to the spatial data of each woreda and health facility in the study area.

All the necessary study area shapefile was exported from the Addis Ababa shapefile, to create study area map, the woreda's were plotted on the map in the Arc-Map environment. The coordinates of each public Health Care Facilities were then overlaid on the woreda's map to show them as found located in the different woreda's. The location of each of the public health care facilities was used to analyze general spatial distribution within the study area.

3.2.5 Methods of Data Analysis

For the purpose of data analysis, simple descriptive statistics, maps and graphs were employed in analyzing the data. The study mainly used ArcGIS version 10.8 to analyze the spatial distribution and accessibly assessment of health facilities and to get an excellent means for visualizing in the study area. Microsoft office excel and word were used for to process excel data and to report writing the Google Docs also applied for editing the thesis report easily. To achieve the objective of the research work, this data process was applied as shown below.

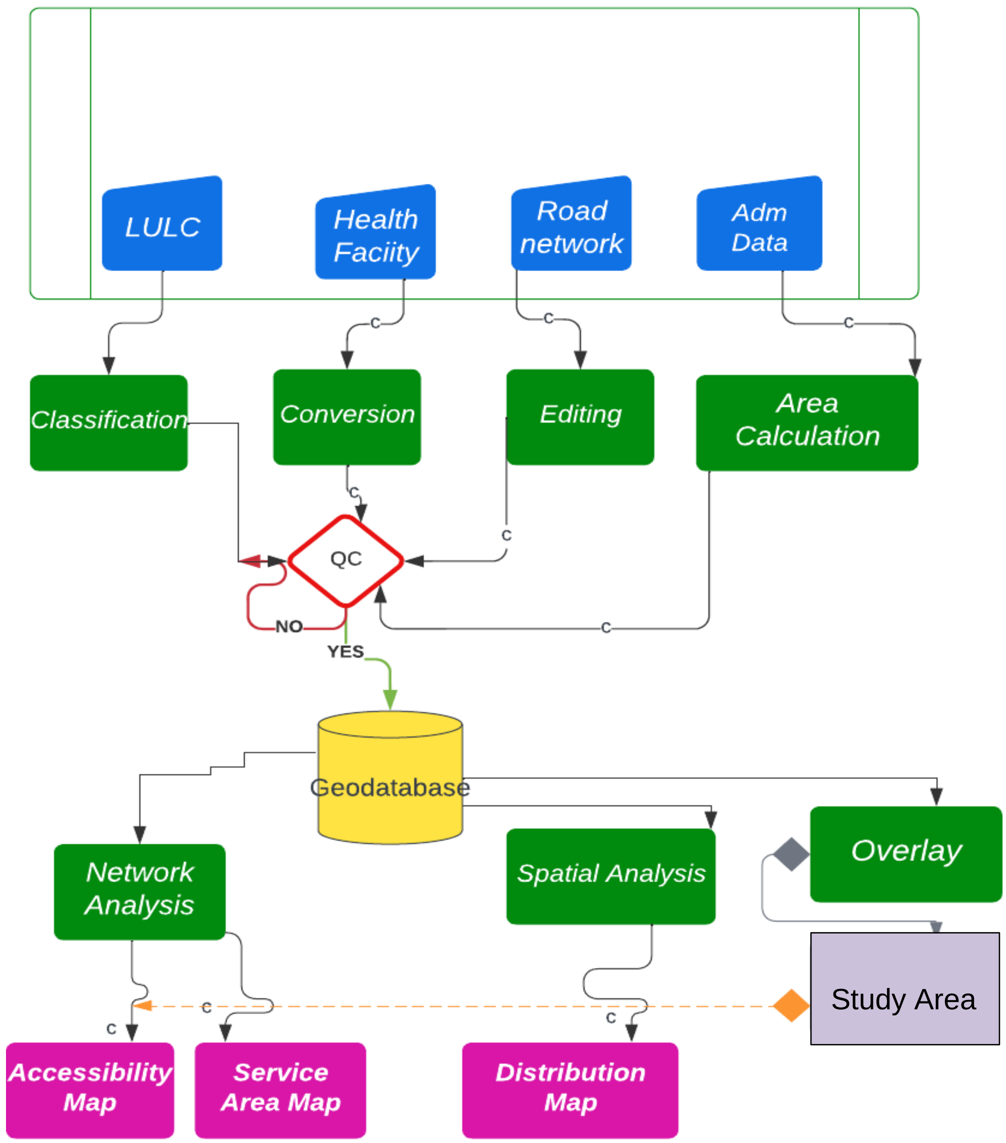


Figure 10 Flow Chart of Data Analysis

3.2.5.1 Health Care Facility Distribution Pattern

In assessing the spatial distribution of the public health facilities in the study area, all the facilities were determined and mapped, the distribution pattern of the health facilities were mapped on the map in the Arc-Map environment to show the distribution pattern. With each health facility located as point features, the attribute data of each facility which were already compiled in MS excel were linked with the spatial data.

To calculates the density of features in a neighborhood around those features The Kernel Density analysis was used to show the health care distribution in the study area and to determine the spatial distribution pattern Nearest Neighbour Analysis (NNA) was used to analyse whether the distribution of the Public health facilities in this area is clustered, random or dispersed additionally to analyze the distribution nature Mean Center , Standard Distance , Directional Distribution and Central Feature of the Health Care Facilities was used in spatial statistics tool. Based on these spatial distributions techniques the Health care facilities were analyzed in terms of the spatial distribution, the number of facilities by woreda and the overall health care facilities. Then Master Facility List (MFL) data content was studied to Provide as a recommendation for a comprehensive, up-to-date facility lists and attribute information using Lemi Kura Sub City as a benchmark.

3.2.5.2 Accessibility analysis

To measure average travel distance to nearest providers (Fryer Jr et al. 1999; Goodman et al. 1992), apply the straight line distance between the population point and the location of the health provider. However, travel routes are rarely straight lines in reality. It also cannot fully represent clusters of health providers in an urban setting and ignores the availability dimension of access. Gravity models, initially developed for land use planning, are also utilized to account for the spatial interaction between health care supply and demand (Hansen, 1959; Joseph and Bantock, 1982; Shen, 1998). The gravity-based accessibility model is essentially the ratio of supply to demand (Huff 1963, 2000; Luo and Qi 2009; Wang 2012).

A large amount of geo-coded data required for the locations of both population and health facilities. Sometimes the models also involve great effort of computation and programming (Luo and Whippo 2012; Taaffe et al. 1996).

Another development in spatial accessibility modeling is the two–step floating catchment area method (2SFCA) proposed by Luo and Wang (2003a and 2003b). The 2SFCA overcomes the restriction of using pre-defined geographical boundaries. However, the limitation of 2SFCA is mainly found in assuming a health provider inside a catchment area is accessible and one outside the catchment area is inaccessible, which tends to be arbitrary, ignoring the possibility of overlapping areas in coverage. Spatial accessibility to health services is primarily dependent on the geographical locations of health care providers and population in need, as well as the travel distance/time between them (Wan et al. 2013). Since distance decay is a fundamental aspect in understanding spatial accessibility, Network distance has gained certain popularity in recent literature as a replacement for Euclidean distance and Manhattan distance. It is considered to be a more accurate measurement for real travel distance and time (Brabyn and Beere2006; Chengetal. 2012; Wan et al. 2013). However, Apparicio et al. (2008) found that Euclidean and Manhattan distances are strongly correlated with network distances. However, local variations are still observed, notably in suburban areas. Thus in those areas, network-based distance may provide more accurate results. In this study network-based distance was applied rather than Euclidean distance and Manhattan distance.

CHAPTER IV RESULTS & DISCUSSION

4.1 Distribution of Healthcare Facilities in the Study Area

Overlay analysis was carried out on the Healthcare locations and Road network to show the pattern of distribution and relationship between them. According to the AA Health Bureau the estimated population of 2020, the population for Lemi Kura Sub City was estimated at 366,922. The city administrative body passed a decision to establish a new sub city for effective service delivery for the people and Lemi Kura Sub city was classified into ten (10) woreda's. Based on the area calculation woreda 6 has the highest with a total of 20.173158 sq.km the second is woreda 14 having 12.951959 sq.km Followed by woreda 2, and woreda 3.The number of existing Public Health Care Facilities in the study area by each woreda's is presented in Table 2.

No	Woreda	Woreda extent (sq.km)	Total Number of Health Centers	Primary Hospital	General Hospital	Specialized Hospital	Projected Population (2014)	% Increase from the standard's
1	Woreda 2	8.563308	1	-	-	1	46,987	17.5%
2	Woreda 4	8.534615	2	-	-	-	41,214	
3	Woreda 5	6.796651	1	-	-	-	21,721	
4	Woreda 6	20.173158	-	-	-	-	24,000	
5	Woreda 8	3.977568	1	-	-	-	59,424	23.6%
6	Woreda 9	7.856024	1	-	-	-	44,677	11.7%
7	Woreda 10	4.015232	-	-	-	-	22,226	
8	Woreda 13	6.836295	1	-	-	-	40,677	1.7%
9	Woreda 14	12.951959	2	-	-	-	43,684	
10	Woreda 3	9.550747	1	-	-	-	22,312	

Table 2 HealthCare's and Population Distribution in L. K. S. C

As shown in the above table, the distribution of health facilities in the study area is very limited as compared with of the estimated population in each Woreda. For instance, Woreda Eight has an estimated population size of 59,424 with an area of 4sq.km. However the number of Health Centers found in this Woreda is only one. Due to the fact that the Ministry of Health states one Health Center will serve about 40,000 people in urban areas and there is a 23% population distribution incremental according to the standard. Woreda two also does not meet the requirements set by the Ministry of Health; it shows a 17.7% incremental. Similarly Woreda 9 (11.7% increase), Woreda 4 (3% increase) and Woreda 13 (1.7%) doesn't meet the stadards. Only three woreda's such as Woreda 3, 5 and 14 meet the requirements. However Woreda 6 and Woreda 10 meet the criteria set by the Ministry of Health in terms of population distribution, however there is no any public health center in both woreda's. In this case it is estimated that if the resident wants to receive medical treatment from a governmental health facility, they would be forced to travel to neighboring woredas and travel more than 2 km or longer and in terms of international standards this will be another challenge.

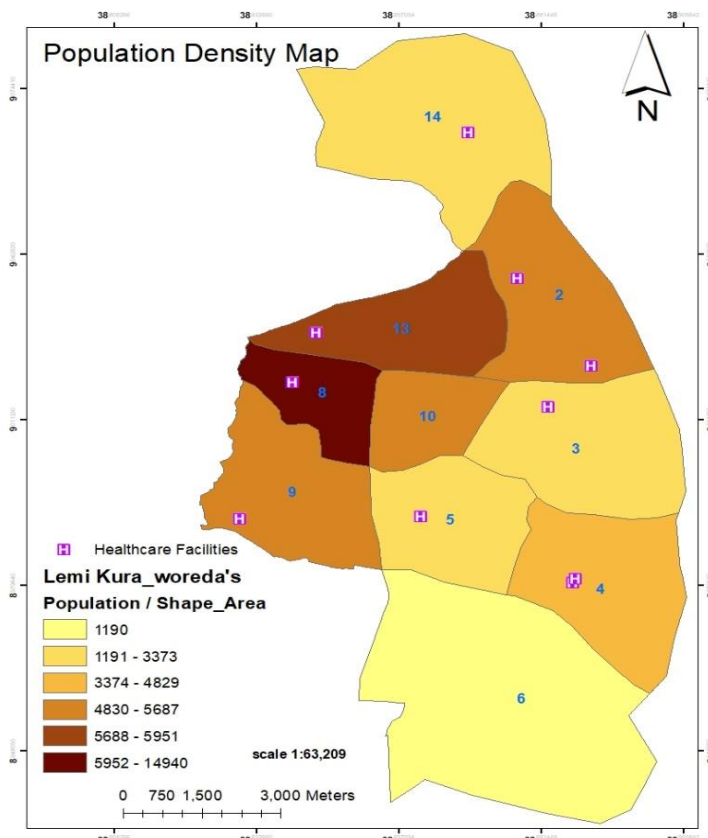


Figure 11 Population Density map & HC Distribution of L.K,S.C

4.1.1 Ratio of Public HealthCare Facilities

The ratio and the comparison between the number of health facilities and the population are disparity from the standard. (See Table 3) Only a limited number of institutions meet the standard, and two woredas totally have no health facilities (Woreda 6 and Woreda 10). woreda four and woreda fourteen have two public health cares. There is one specialized hospital in Woreda 2, which can provide services at city levels in accordance with the standards set by the Ministry of Health. Based on the Ministry of Health Standard (MOHS), it was observed that there is inadequacy in the spatial distribution of the primary healthcare facilities, specifically in six woreda's . The results of the ratio of Healthcare to each woreda in the study area are presented in the table 3.

No	**Woreda**	**Projected Population (2014)**	**No. of HCF**	**Ratio**	**Remark**
1	Woreda 2	46,987	1	1: 46,987	Un meet with MOHS
2	Woreda 3	22,312	1	1: 22,312	meet with the MOHS
3	Woreda 5	21,721	1	1: 21,721	
4	Woreda 4	41,214	2	1:20,607	meet with MOHS
5	Woreda 13	40,677	1	1: 40,677	Un meet with MOHS
6	Woreda 6	24,000	-	-	No Healthcare found!
7	Woreda 8	59,424	1	1: 59,424	Un meet with MOHS
8	Woreda 9	44,677	1	1: 44,677	Unmeet with MOHS
9	Woreda 10	22,226	-	-	No Healthcare found!
10	Woreda 14	43,684	2	1: 21,842	meet the MOHS

Table 3:- The ratio of Existing Public Healthcare Facilities

4.2 Health Care Facility Distribution Pattern

4.2.1 Mean Center

The mean center is the average x- and y-coordinate of all the features in the study area which is the simplest description of a geographic distribution. It's useful for tracking changes in the distribution or for comparing the distributions of different types of features. The mean center can also be mathematically represented as: Where xi and yi are the coordinates for features and n equal to the number of features. It was found that the mean center of the Public health center in the study area displayed on the map (see figure 12).

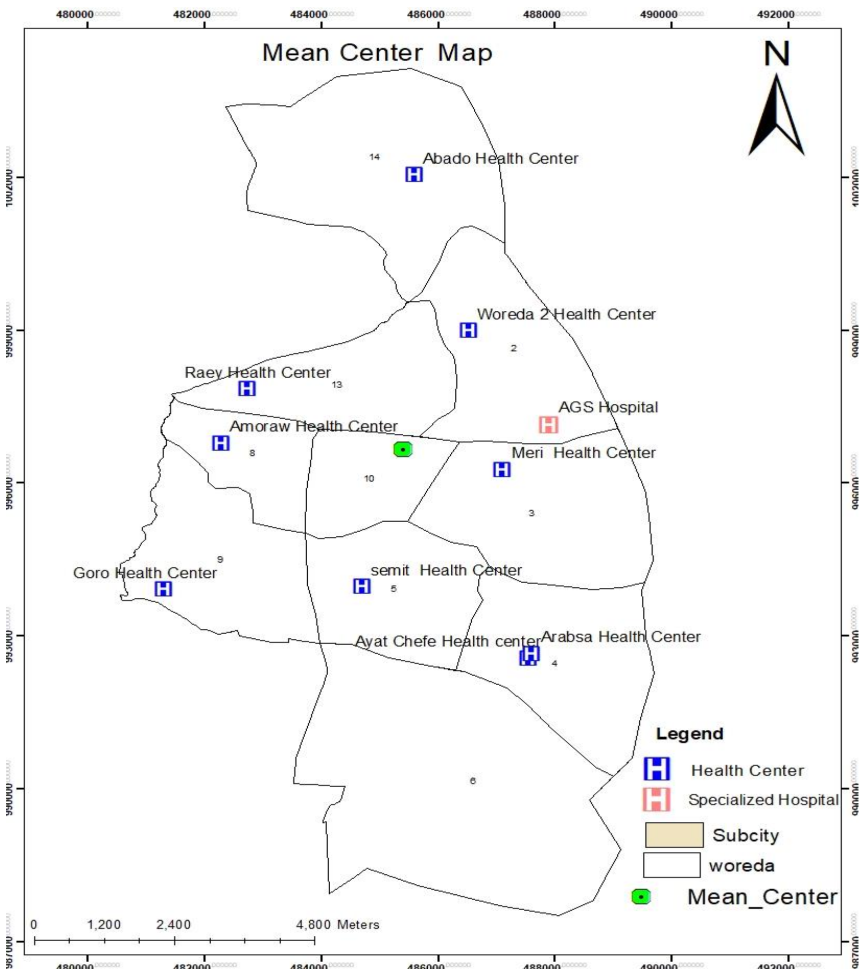


Figure 12 Mean center Map of Public Health facilities of L.K.S.C

4.2.2 Standard Distance

Measuring the compactness of a distribution provides a single value representing the dispersion of features around the center. The value is a distance, so the compactness of a set of features can be represented on a map by drawing a circle with the radius equal to the standard distance value. The Standard Distance tool creates a circle polygon. In this case the Standard Distance was applied to measure the degree to which health facilities are concentrated or dispersed around the points (or feature centroids) in an input feature class. In a Normal Distribution mostly it is expected to be around 68% of all points to fall within the Standard Distance. The output circle created by this tool is defined by standard deviation and can include one, two, or three standard deviations. In this case it was found that 54.5% of health cares were located in the circle (see fig 13).

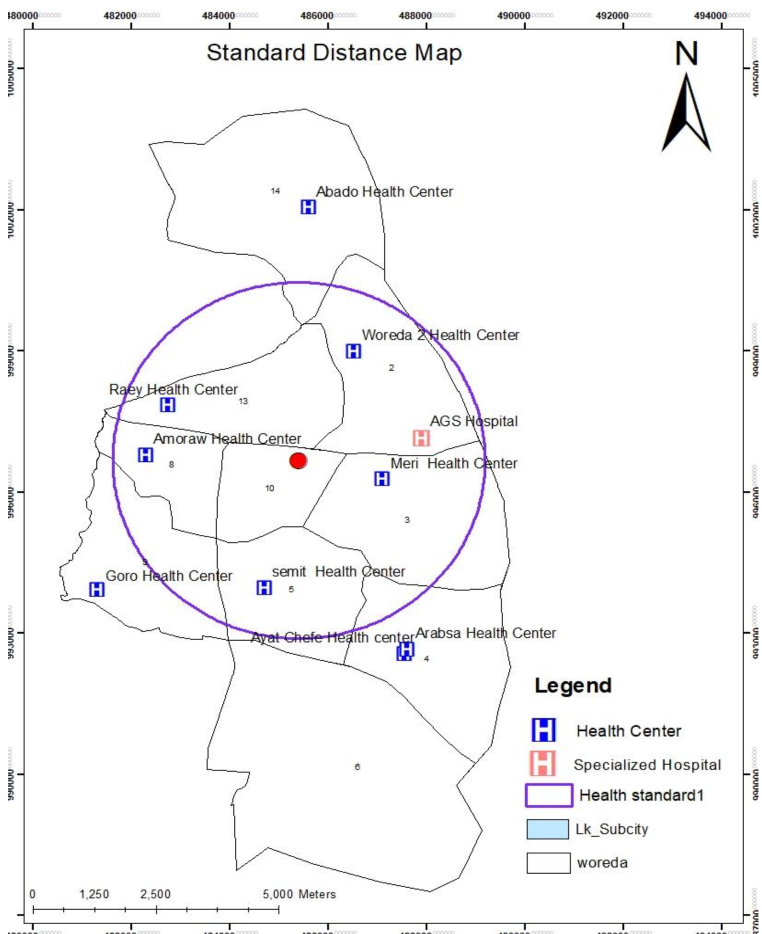


Figure 13 Standard distance Map of public Health facilities of L.K.S.C

4.2.3 Directional Distribution of the Health Care Facilities

A common way of measuring the trend for a set of points or areas is to calculate the standard distance separately in the x- and y-directions. To summarize the spatial characteristics of geographic features, including central tendency, dispersion, and directional trends Directional Distribution of healthcares facilities was done. The ellipses are centered on the mean center. This tool calculates directionality, centrality, and dispersion. The created ellipse is referred to as the standard deviational ellipse and allows seeing if the distribution of features is elongated and hence has a particular orientation.

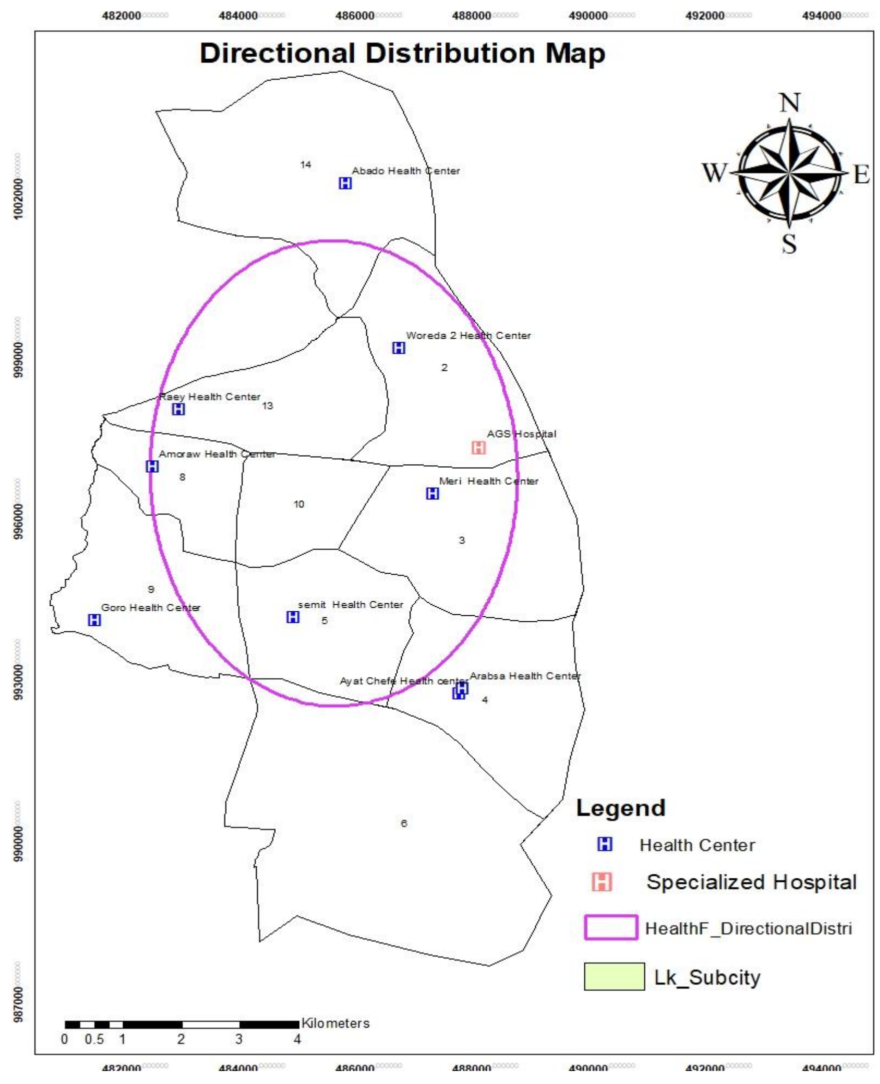


Figure 14 Directional Distribution Map of the healthcare facilities of L.K.S.C

4.2.4 Central Feature

The Central Feature is the point that is the shortest distance to all other points in the dataset and thus identifies the most centrally located feature. The feature associated with the smallest accumulated distance to all other features is the most centrally located feature; this feature is selected and copied to the newly created output feature class. The Central Feature created on this process can be used to find the most accessible feature. In this case It was found that Meri Health center is the most centrally located health center.

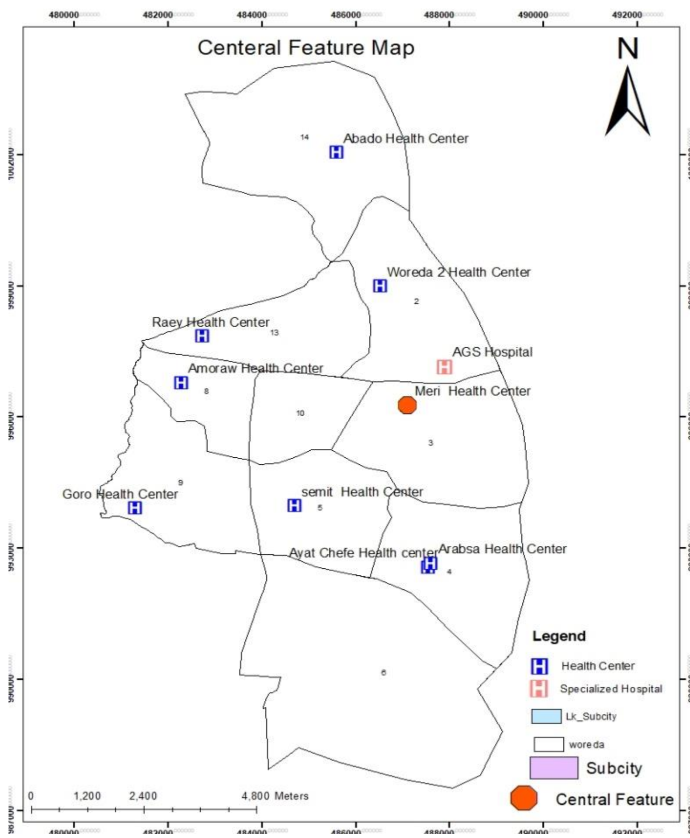


Figure 15 centrally located HCF Map of L.K.S.C

4.2.5 Kernel Density Map

The Kernel Density tool calculates the density of features in a neighborhood around those features. It can be calculated for both point and line features. Conceptually, a smoothly curved surface is fitted over each point. The surface value is highest at the location of the point and diminishes with increasing distance from the point. Therefore the result shows that at each health center the result was high with a maximum value of 0.428407 and 0 values such as in woreda 6 and 10.Conceptually, a smoothly curved surface is fitted over each point. The surface value is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the Search radius distance from the point. The density at each output raster cell was calculated by adding the values of all the kernel surfaces where they overlay the raster cell center. The kernel function was based on the quartic kernel function described in Silverman (1986, p. 76, equation 4.5).

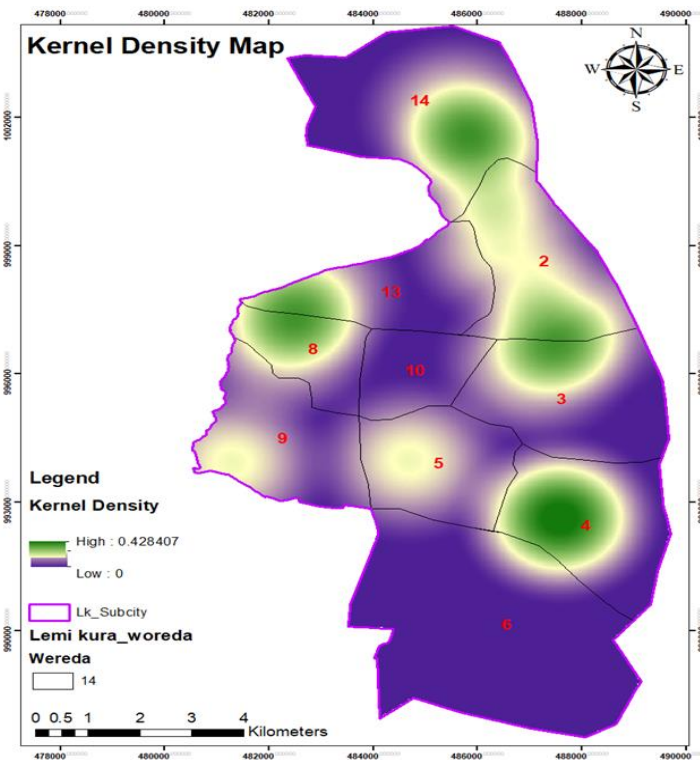


Figure 16:- kernel density map of L. K. S. C

4.2.6 Nearest Neighbour Analysis (NNA)

A nearest neighbor analysis (NNA) is a descriptive statistics that shows a pattern of locating features by comparing graphically the observed nearest neighbor distance. That is, it describes a phenomenon based on its distance from another phenomenon in space. The nearest neighbor analysis does not only examine distance between points, it also examines the closest point to it (Fotheringham, et al 1994 and Woulder 1999). The nearest neighbor index measures the degree of spatial dispersion of features over distance. Its value ranges between 0 to 2.15 and it shows if a settlement is clustered, random or regular.

A value of 1.0 provides the standard of randomness, increasing R values are indicative of increasing dispersion leading to a limiting case of regularity, and decreasing R values provide evidence of increasing clustering (Clark and Evans, 1954; Dacey, 1960; Neft, 1966; Taylor, 1977). Nearest neighbor analysis measures the linear distance between two or more specified neighboring locations. Upton, G. and Fingleton, B. (1985) asserted that nearest neighbor analysis is a method of exploring pattern in locational data by comparing graphically the observed distribution of functions of vent-to event or random point-to-event nearest neighbor distances, either with each other or with those that may be theoretically expected from various hypothesized models, in particular that of spatial randomness Nearest neighbor analysis utilizes the fundamental concept of randomness. A distribution is random when each spatial unit in the area containing the points has an equal opportunity of receiving a point. A non-random point pattern is either more clustered than random or more uniform than random. It is used for spatial geography (study of landscapes, human settlement, CBDs, etc).

nearest neighbour analysis stated as:

Rn=2đ√n A

Where;

Rn= nearest neighbor value describing the point pattern.

d=observed average neighbor distance.

n=total number of phenomena under study

A= area of the phenomena under study in kilometres square.

Average Nearest Neighbor Summary	
Observed Mean Distance:	1401.9394 Meters
Expected Mean Distance:	1138.4023 Meters
Nearest Neighbor Ratio:	1.231497
z-score:	1.468835
p-value:	0.141877

Dataset Information	
Input Feature Class:	HealthFacility\Lk_HealthF
Distance Method:	EUCLIDEAN
Study Area:	57022233.048340

Figure 17 Average NNR Summary1

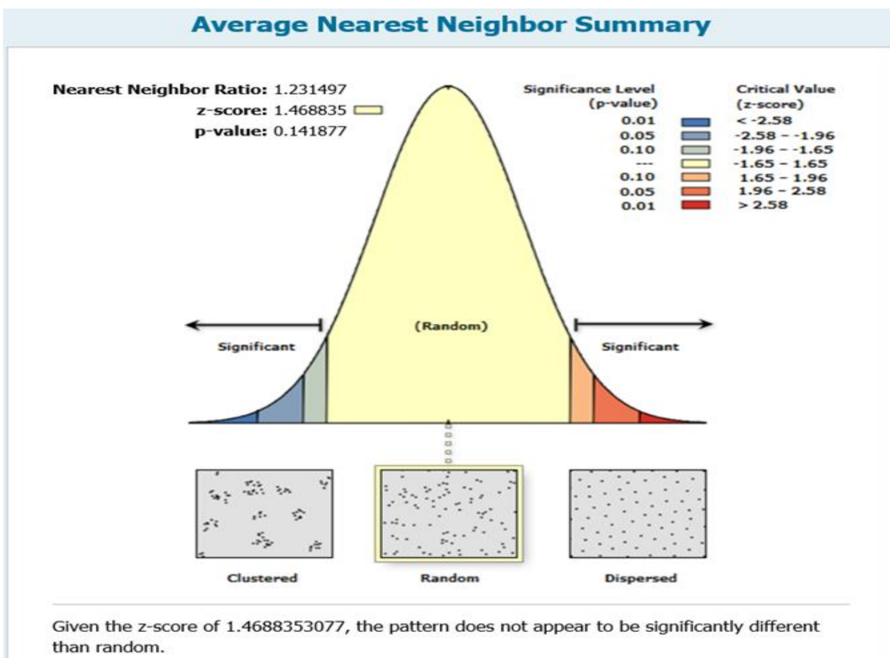


Figure 18 Average NNR Summary2

The average NNA was used to analyze the spatial pattern of distribution of the healthcare facilities. The Nearest Neighbour Ratio shows a random distribution pattern for health care facilities (Figure 1). Thus, given the z-score of 1.468835, the pattern does not appear to be significantly different than random .The result of the analysis shows that Rn 1.231497 (Rn >1) was obtained at a z-score of 1.468835 (table1).hence there is significance random of healthcares facilities. The data obtained is processed using quantitative descriptive methods with ArcGIS application. Conducting nearest neighbor analysis (NNA) is methods used for measuring the degree of spatial variation of features points in a space.

4.3 Health Care Facility Accessibility Analysis

To analyze the accessibility level of the HealthCare's in the study area in ArcGIS environment Network analysis extension was applied. Road network analysis is used for identifying the most efficient routes or paths for allocation of services. This involves finding the shortest or least-cost routes in which a location or a set of locations in a network can be visited. Among the different types of network layer closest Facility and Service Area are selected to analyze and show the level of service effectiveness and level of accessibility to Public health care facilities in the study area. A network service area is a region that encompasses all accessible streets, that is, streets that lie within a specified impedance (travel time). This shows the results of the accessibility problem.

4.3.1 Service Area

a) Service Area Based on Distance Interval

Based on the results it's varying according to the minimum requirement set by world Health Organizations (WHO). Within the range of 2 km distance it is the smallest area recorded in all facilities, but more than 2 km to 6 km the area coverage is wider. For instance in the range of 4km to 6km distance, The results shows that it is the widest of all ranges specified on the map e.g. Facilities such as the summit Health Center is over 28 km sq. which was wide in the range of 4 km to 6 km. Ayat chefe, Arabsa and Meri Health Centers found to be 21 sq.km from 4 km to 6 km range, Woreda 02 Health Center found to be 21sq.km ,Ray Health Center is 16 sq.km wide, Goro and Amora Health Station 14 sq.km wide, Hidase Health center is 4 sq. km wide in the range of 4km to 6km. The health care facilities within the study area are in fact only accessible for a limited number of populations by car and by walking according to criteria. Using road network analysis function travel distances to nearest health care facilities and service area has been calculated for each public Health Facilities. Within the specific health care facilities and its surrounding localities the light blue and pink colors are indicates low accessibility as the results displayed on the map (see Figur 19).

The total area served by the public health facilities within 2 km is 37 km², from 2 km to 4 km is 108 km² and from 4 km to 6 km is 172 km², Specifically for distance interval of more than 2 km the total area would be 280 km² This means in the surrounding of each health center the people don't have a good accessibility to the health centers facility in terms of distance. If the distribution of health Centers was sufficient, long distances would show a small number.

Therefore additional health care centers need to be provided in the area outside the yellow color which is light blue and pink color.

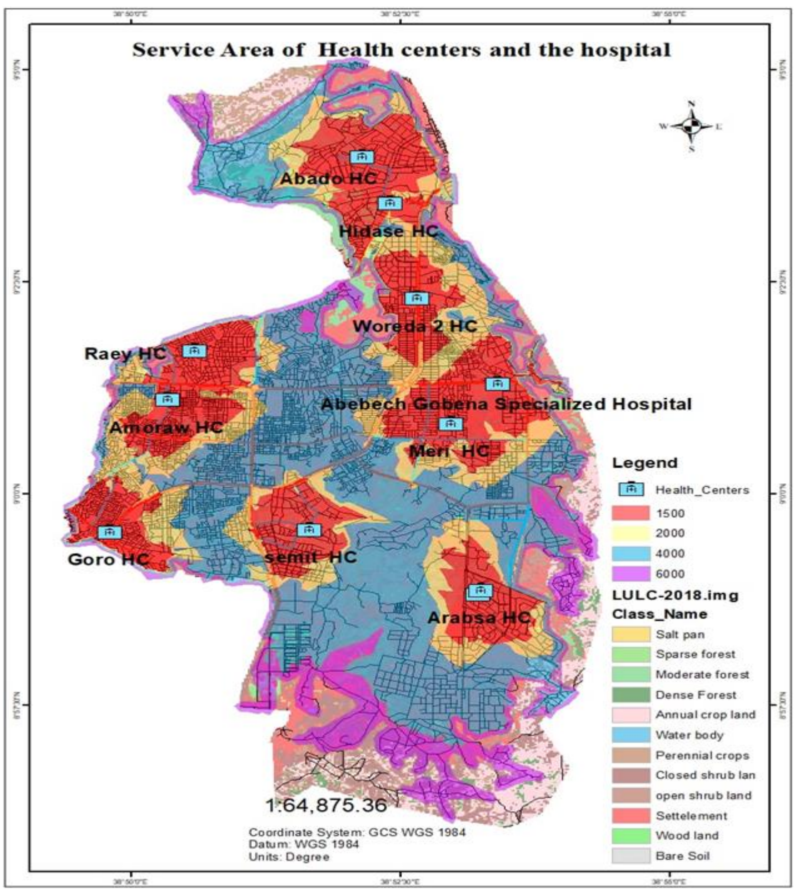


Figure 19:- Distance Based Service Map of L. K. S. C

No	Health Center	Type	Service Area Distance Range			
			From 4 – 6km distance	From 2 – 4km distance	From 1.5 – 2km distance	From 0 – 1.5 km distance
1	Abado	Health Center	07 Sq.k.m	6 Sq.k.m	2 Sq.k.m	3 Sq.k.m
2	Hidase	Health Center	10 Sq.k.m	7 Sq.k.m	2 Sq.k.m	2 Sq.k.m
3	Woreda0 2	Health Center	20 Sq.k.m	11 Sq.k.m	2 Sq.k.m	2 Sq.k.m
4	Rae	Health Center	16 Sq.k.m	9 Sq.k.m	1 Sq.k.m	2 Sq.k.m
5	Amoraw	Health Center	14 Sq.k.m	11 Sq.k.m	2 Sq.k.m	2 Sq.k.m
6	Goro	Health Center	14 Sq.k.m	7 Sq.k.m	1 Sq.k.m	2 Sq.k.m
7	Semit	Health Center	28 Sq.k.m	16 Sq.k.m	1 Sq.k.m	2 Sq.k.m
8	Arabsa	Health Center	21 Sq.k.m	13 Sq.k.m	2 Sq.k.m	2 Sq.k.m
9	Meri	Health Center	21 Sq.k.m	15 Sq.k.m	3 Sq.k.m	2 Sq.k.m
10	Ayat	Health Center	21 Sq.k.m	13 Sq.k.m	1 Sq.k.m	1 Sq.k.m
	Total		172 km^2	108 km^2	37 km^2,	

Table 4:- Health Facilities and Service area Coverage

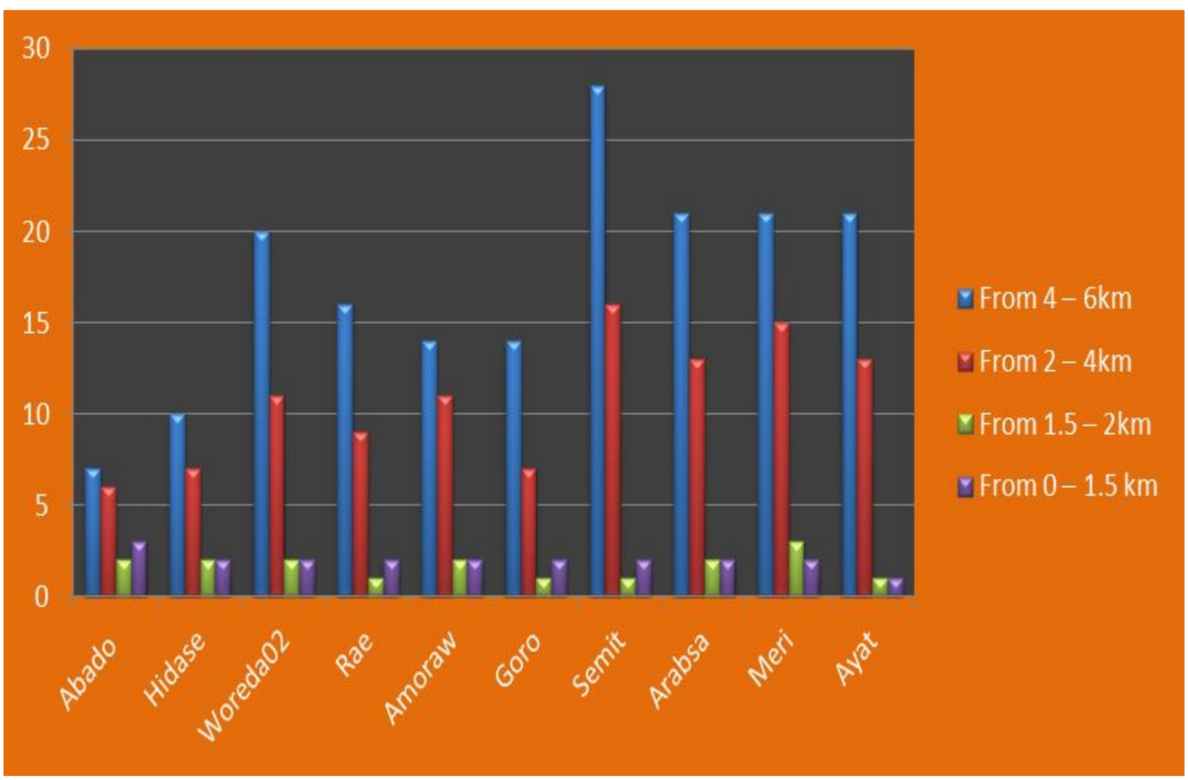


Figure 20:- Health Facilities and Service area Coverage Chart

b) Service Area Based on Time Interval

The service area has been analyzed based on distance and time. This helps to analyze the distance and time spent from a health facility. Based on this, the analysis was performed in 5 minutes, 15 minutes and 30 minutes time interval. As shown in the map, to travel within 5 min it covers about 20 % area, within 15 minutes 38% area coverage and the 30 minutes is about 42% area coverage (see Figure 21).

This means from 15 minutes to 30 minutes time interval about 80% of the total the people don't have a good accessibility to the health centers facility in terms of time. This indicates that more health facilities are needed in the context of the study area. The Time interval based service area analysis was done for each health center found in the study area considering each health centers as a bench mark. The pink color shows that the household within its region gets to its nearest health facilities within travel time of 5 minutes, while the household within the yellow color gets to its nearest health facilities within 15 minutes. The household within brown color gets to its nearest health facilities within 30 minutes. The total area served by the health facilities in the study area is 178 km^2. It is observed that the served areas within the defined time interval are within the pink, yellow and brown colors.

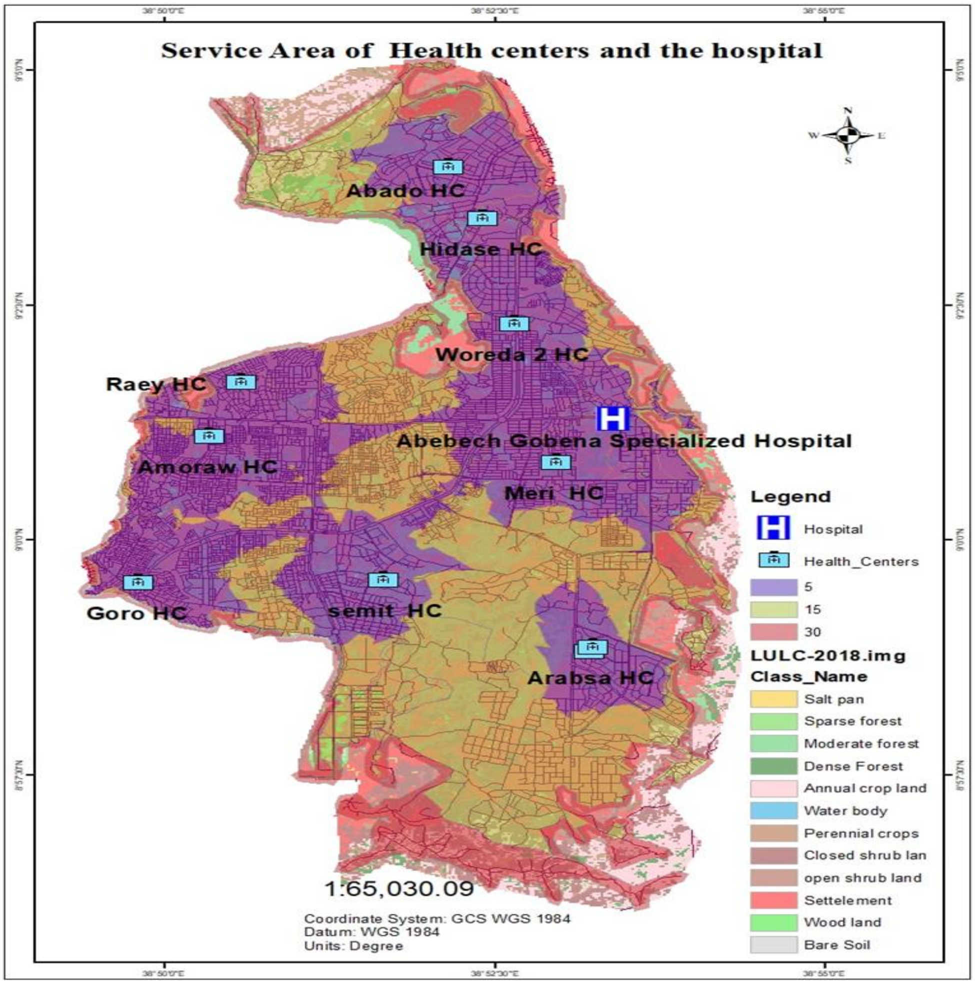


Figure 21:- Time Based Service Area of HCF Map

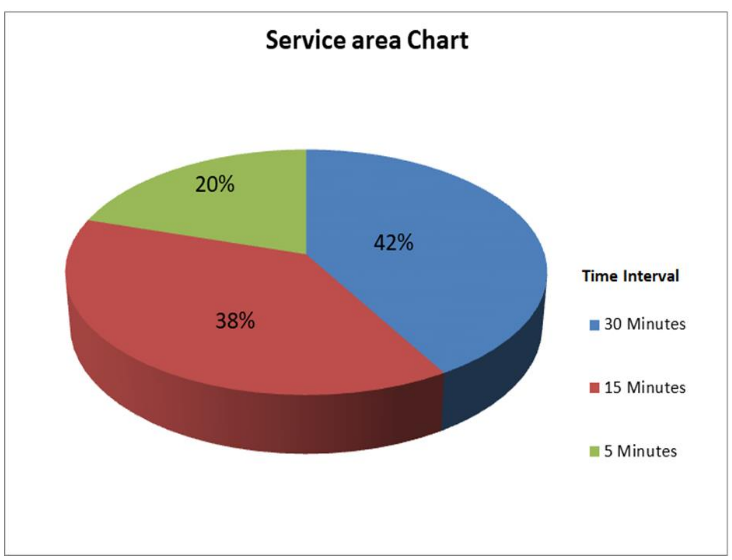
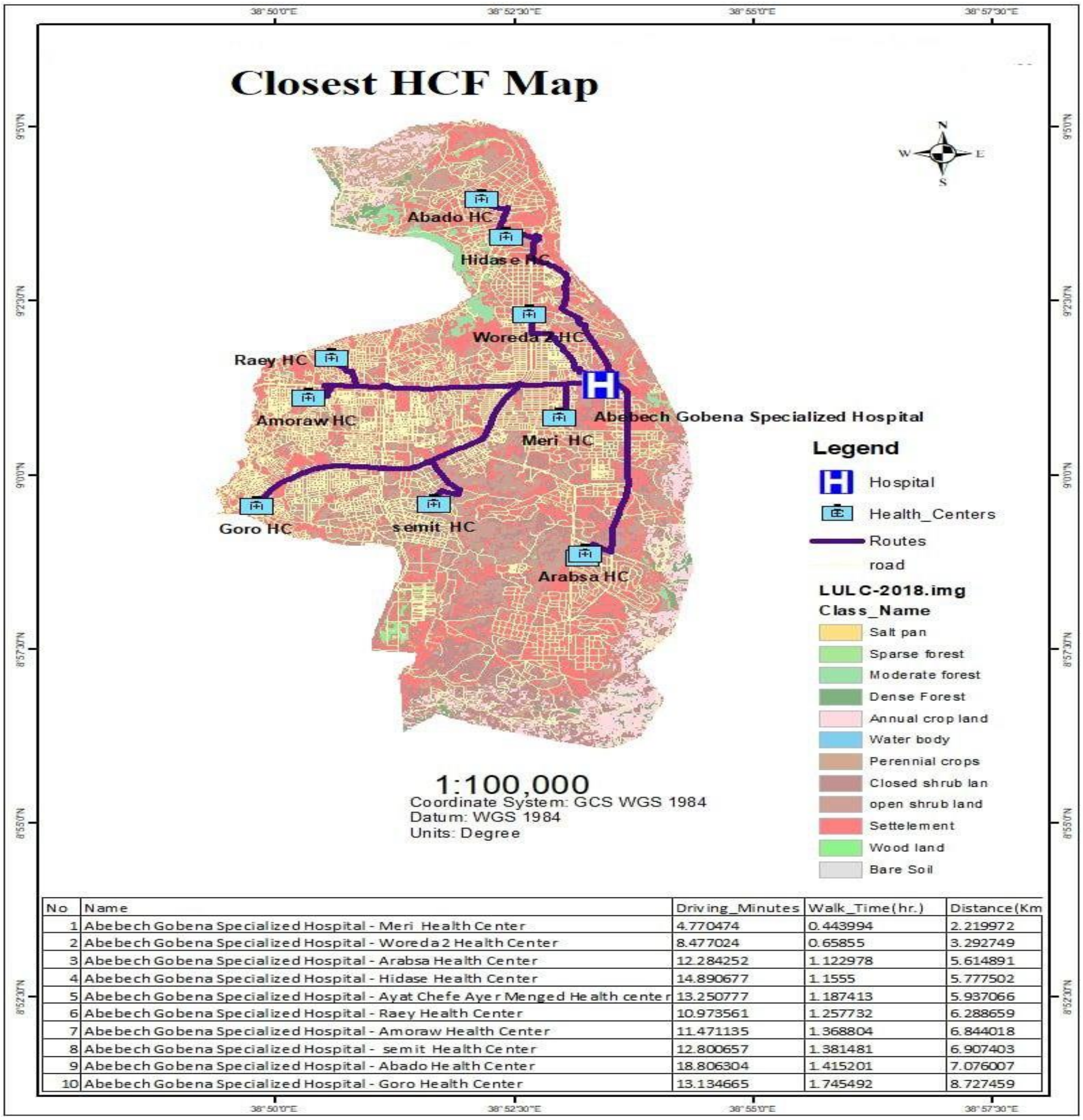


Figure 22:- Time Based service area of the HCF Chart

4.3.2 Closest Facility Analysis

To analyze the Closest and travel time to the Health center the study made an initial point about Abebech Gobena Specialized Hospital to other health facilities. Based on vehicles and walking between the health center and Abebech Gobena Specialized Hospital. This is Due to the lack of a Primary hospital in the study area; it was possible to take it as a starting point at a specialized hospital. In Fig. 10 the travel times by road transport system (vehicle and by foot) were between 2, 3, 5 and 7 minutes respectively.



No	Name	Driving_Minutes	Walk_Time(hr.)	Distance(Km
1	Abebech Gobena Specialized Hospital - Meri Health Center	4.770474	0.443994	2.219972
2	Abebech Gobena Specialized Hospital - Woreda 2 Health Center	8.477024	0.65855	3.292749
3	Abebech Gobena Specialized Hospital - Arabsa Health Center	12.284252	1.122978	5.614891
4	Abebech Gobena Specialized Hospital - Hidase Health Center	14.890677	1.1555	5.777502
5	Abebech Gobena Specialized Hospital - Ayat Chefe Ayer Menged Health center	13.250777	1.187413	5.937066
6	Abebech Gobena Specialized Hospital - Raey Health Center	10.973561	1.257732	6.288659
7	Abebech Gobena Specialized Hospital - Amoraw Health Center	11.471135	1.368804	6.844018
8	Abebech Gobena Specialized Hospital - semit Health Center	12.800657	1.381481	6.907403
9	Abebech Gobena Specialized Hospital - Abado Health Center	18.806304	1.415201	7.076007
10	Abebech Gobena Specialized Hospital - Goro Health Center	13.134665	1.745492	8.727459

Figure 23: Closest Health centers to Abebech Gobena Specialized Hospital

There is no primary Hospital in the study area but there is one specialized hospital. The Primary Hospital is expected to be found in the study area to provide high level health care's services especially to monitor and support closely for health centers in the study area.

In this regard it is clear that patients in the study area will find difficulties to refer for additional support or referral treatments. According to the Ministry of Health standard General Hospital should serve 60,000 to 100,000 people and it is needed in terms of providing high quality medical care as categorized under the primary level hospital. This could have been closer to supporting health in terms of health materials support, knowledge transfer, and the acceptance of treatments beyond the health facilities. The specialized hospital is categorized under Tertiary Level Healthcare and it will serve more than 3.5 million people. This specialized hospital can serve at city level potentially, however to calculate the distance and closest Facility the study used Abebech Gobena Specialized Hospital as a benchmark.

Therefore Abbado Health Center is the longest distance from Abebech Gobena Specialized Hospital which is 13.13 minutes by vehicle and 1.74 hours by foot. And From Abebech Gobena Specialized Hospital to Goro Health Center was 13.13 minutes by car and by foot it tooks 1.74 hours. The study reveals that travel distance via road network to nearest health care facilities from the specialized hospital to the health centers and Meri,woreda 2 and Rae Health center are the three nearest health centers while Abado, Hidase and Goro Health centers are the longest distances from Abebech Gobena Specialized Hospital(see Table 4) and the average distance was 5.86 km the average travel time is 12.07 minutes by vehicle and 1.26 hour by walking in average .

No	From	To	Driving (Min.)	Walking (Hr.)	Distance (Km)
1	Abebech Gobna Specialized Hospital	Abado	18.806	1.74	7.07
2	Abebech Gobna Specialized Hospital	Hidase	14.89	1.15	5.777
3	Abebech Gobna Specialized Hospital	Ayat Chefe	13.2	1.8	5.94
4	Abebech Gobna Specialized Hospital	Goro	13.13	1.74	8.72
5	Abebech Gobna Specialized Hospital	Summit	12.8	1.38	6.9
6	Abebech Gobna Specialized Hospital	Arabsa	12.2	1.12	5.61
7	Abebech Gobna Specialized Hospital	Amoraw	11.47	1.36	6.84
8	Abebech Gobna Specialized Hospital	Rae	10.97	1.25	6.288
9	Abebech Gobna Specialized Hospital	Woreda02	8.47	0.65	3.29
10	Abebech Gobna Specialized Hospital	Meri	4.77	0.44	2.21

Table 5:- Health Centers Closest facility result

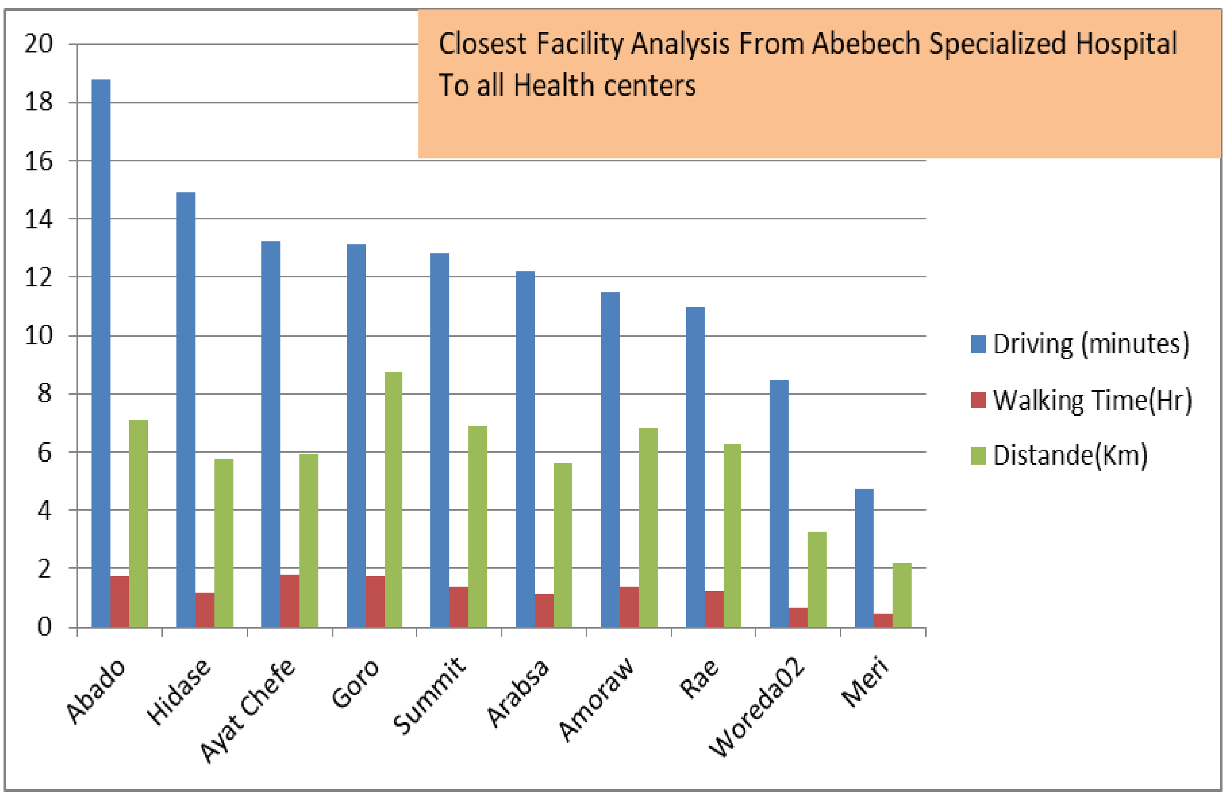


Figure 24: Closest Facility Results Chart

4.4 Master Facility List

Master health facility lists need information both on: administrative information to identify and contact the facility (signature domain), and information on the services they offer (service domain). It is an advantage to include only information that does not change too much over time. Information that varies a lot, makes updating the list a challenge.

Olusesan ,Samson et.al.(2014) worked on the Development of a Master Health Facility List in Nigeria MFLs are essential components of a Health Information Sytems; which, according to some experts, are considered the foundation of public health. Additionally, the MFL proposes the inclusion of geographic coordinates as part of the record for each health facility. Applying this platform to health facility data analysis can help for the Development and adherence to standards for national health information Infrastructure.

The administrative information needed is the name of the facility and a unique identifying code, in addition to the type of facility, who owns it and contact information. Other important information is administrative affiliation, geographical coordinates, whether the facility is operational or not, which year the information refers to, is important information.

The availability of geographic coordinates and the type of health services offered in each health facility in the MFL can also inform objective investment in the building or upgrading of facilities. The proximity of facilities providing needed services can be analyzed, and the need for additional health facilities may be determined based on the target population. Olusesan ,Samson et.al.(2014)

In addition information on the service production must be included what kind of medical services that are offered, the availability of medical staff and number of beds. Other information such as infrastructure can also be collected, like the availability of medical equipment and electricity.

Some important requirements of the MFL are stated in the following Table.

No	Administrative information (Signature Domain)	Level Requirement
1	Facility codes	Required
2	Facility name	Required
3	Facility type	Required
4	Ownership/managing authority	Required
5	Location / Address	Required
6	Administrative units	Required
7	Contact information	Required
8	Geographic coordinates	Required
9	Operational status	Required
10	Data year	Required
	Production of health services (Service Domain)	
1	Services offered	Optional
2	Beds and cots	Optional
3	Human resources	Optional
4	Infrastructure	Optional

Table 6:- MFL Requirements

The signature domain is a set of data elements that can be used to establish a fingerprint for a facility, which should not change significantly over time. Much like a person's signature can ensure his or her identity; the elements of the signature domain would ensure a health facility's identity. This domain contains all the information necessary to identify a facility uniquely and therefore the majority of these data elements are required in the MFL. If a coding system is already in use, it will probably be wise to continue using the existing system, regardless of the advice on facility codes given below.

The administrative area refers to the regions, zones, woreda's or other administrative level that a facility is in. In order to assure that linkages with other data sources are possible, a standardized listing of administrative units should be used. If the geographic coordinates of the facility are available along with sufficiently detailed and accurate administrative boundaries, the administrative unit can be derived from these coordinates. The MOH may maintain health districts or zones, administrative areas that are specific to the function of the health sector and distinct from the geographic units used in other aspects of a country's governance.

Geographic health facility information would be very useful in increasing the accessibility of health services, as well as in determining health service capacities. The codes can make it possible to produce maps of available services. Furthermore, both operational status and geographic coordinates ought to be collected and included in the list, even if the information is not disseminated. Such information is imperative when updating and reconciling the master health facility list. In order to be able to collect accurate information, it is necessary to develop clear definitions for the information that is going into the MFL.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

In general, it is observed that Lemi Kura Sub City has a total of eleven (11) public healthcares, the distribution of the public health care facilities is not even; Having 1 tertiary health facilities and 10 Primary health centers. The study area is subdivided into ten (10) woreda's, and based on each woreda administrative extent the existing healthcare accessibility status and the distribution pattern were analyzed.

This study revealed that most of the existing Public health facilities don't meet the standards set by FMOH and WHO. As the available demand most of these facilities are not enough. It was discovered that there exist inadequacy and unevenness in the spatial distribution of healthcare facilities in the study area.

The goal of the National Health Policy (1993) is to emphasize the importance of achieving access to a basic package of quality primary health care services by all segments of the population.The policy seeks to promote access to care "…via a centralized system of governance". The plan envisages that "each health Center will serve 40,000 people.

As a result four woreda's fairly meet the standard and four of them don't meet the standard based on the population distribution and the remaining 2 woreda don't have public health centers. On those woreda's the Patients may be forced to travel long distances to get services.

The result of the analysis shows that Rn 1.231497 (Rn >1) was obtained at a z-score of 1.468835. Hence there are a significant random number of healthcares facilities. Network analyses were employed to detect areas that are relatively poorly or well served the accessibility to the identified public healthcare facilities. Based on distance parameter the service area map was produced for all HealthCare's in the study area And the total area served by the all the public health facilities within the range of 2 km is 37 km², within a range of 2km to 4km distance the area found was 108 km² and from 4km to 6km distance the area found was 172 km². As a result, the distribution of health facilities in the area was extremely limited and inadequate; According to the standards set by the Federal Ministry of health about six health institutions do not meet the criteria. And according to the World Health Organization specified criteria almost 172 km^2 areas don't meet the criteria and are not accessible for the community in line with WHO (1997) standard's.

Based on time interval service area analysis was performed in 5 minutes, 15 minutes and 30 minutes time intervals. Within 5 minutes driving time 20 % of the area was covered, within 15 minutes 38% of the area was covered and in 30 minutes 42% of the total area.

In general, the finding shows that it is important to plan health care for distribution improvement based on population size. The government should improve the number of HealthCare's as the population is growing and the cost of private health care is beyond the financial capacity of most residents. It will take a great deal of political commitment to increase the distribution of health information in the sub-city and to make it more affordable in terms of population distribution, as well as to implement a Master Facilitation List.

The Master Facility List has a significant role to play in the management and sustainability of health facilities in terms of the information it contains. This option is better suited to consolidate infrastructure and complementary information to increase the distribution of health facilities relative to population and settlement. Information can be easily stored in the Master Facility list if the health facility is upgraded or to build a new health facility.

5.2 Recommendations

The main objective of this study was to shed light on the spatial distribution of public health care facilities in Lemi Kura Sub city, Having carried out this research, the following recommendations have been outlined which may be useful in assisting the ministry of health and the government body at large in planning the further distribution of facilities and improving the efficiency of the already existing ones.

i. It is important to apply GIS application for health facilities planning and management and Efforts should be intensified to build more health facilities to cover all woreda's based on population distribution healthcare service delivery in Lemi Kura Sub city to meet the national standards.

ii. Efforts should be intensified to build quickly and implement the Master Facility List platform which would consist of multiple formats, which would ensure the broadest possible use of the MFL providing access to the information to the widest possible audience which is very critical for decision making.

iii. In the study, Catchment area is not available instead, administrative boundaries were used for further analysis, but it would be better to have a health service catchment area in its own right to provide medical care.so that the healthcare service providing catchment area map should be studied.

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