ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF GEOMATICS ENGINEERING

ANALYSIS OF SPATIAL ACCESSIBILITY OF HEALTHCARE SERVICE USING GEOGRAPHIC INFORMATION SYSTEM: A Case of Adama City

A Research Submitted to the school of Engineering in partial fulfillment of the requirements for the award of degree of Master of Science in Geodesy and Geomatics Engineering

By

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Declaration

This is to declare that the thesis is prepared by Wendweson Bete, entitled: *Analysis of Spatial Accessibility of Healthcare Service Using Geographic Information System: A Case of Adama City.* This thesis has been submitted in partial fulfillment of the requirements for the Degree of Master of Science in Geodesy and Geomatics Engineering at Adama science and Technology University. First, I declare that this thesis is my work and that all sources of materials used for this study have been duly acknowledged. Secondly it complies with the regulation of the university and meets the accepted standards with respect to originality and quality. Finally I declare that this thesis is not summated to any other intuitions for the award of any academic degree.

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APPROVAL SHEET OF THESIS

ANALYSIS OF SPATIAL ACCESSIBILITY OF HEALTHCARE SERVICE USING GEOGRAPHIC INFORMATION SYSTEM TECHNIQUES: A Case of Adama City

By

Wendweson Bete

Approved by Board of Examiners

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ABREVIATIONS

AIS	Analysis and Information Systems
CHP	Community Health Posts
CSA	Central Statistics Agency
FCA	Floating Catchment Area
FMOH	Federal Ministry Of Health
GA	Genetic Algorithms
GIS	Geographic Information Systems
GPS	Global Position System
HC	Health Centers
HIV	Human Immune Virus
MALP	Maximum Availability Location Problem
MCLP	Maximal Covering Location Problem
MEXCLP	Maximum Expected Covering Location Problem
NCMS	New Cooperative Medical Scheme
NHA	National Health Accounts
PAHO	Pan-American Health Organization
PHCF	Primary Health Care Facilities
PHCS	Primary Health Care Services
WHO	World Health Organization

ABSTRACT

Access to healthcare is an important component of an overall health system and has a direct impact on the burden of disease that affects many countries in the developing world. There is a limit availability of healthcare service centres in Adama City and its surrounding. Due to this, most of the people are confronted with several problems like high cost of transportation, or travelling long distance and delay of service.This paper assesses the existing spatial accessibility of healthcare service centres found in Adama City and propose new location for future healthcare service center development. The collected primary and secondary data were processed in ArcGIS environment using network-based methods and the location of healthcare service designed to serve a dispersed population. The geographical accessibility us determined by calculating distances that people have to travel to reach a healthcare service. To serve all of the population, additional 1 district hospital, 2 health centres and 14 clinics are needed. It is found that even if the proposed services improve the spatial accessibility in terms of distance, but not improving the quantity of people which can be serving. This clearly indicates that there are mistakes made in the present allocation, either in adopting the standards or wrong densities were considered while calculating for the facilities. This study concludes that accessibility analysis can be used as a tool for evaluating the existing health service centers in the study area. Accessibility can become one of the parameters for planning urban policy. The incorporation of many parameters in the evaluation will make the study more comprehensive. The findings also indicate that such tools can be used by the authorities in earmarking these facilities at the stage of preparing the master plan.

Key words: Location allocation, Healthcare Service, GIS, Spatial Accessibility, efficiency

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Access to healthcare service is an important component of an overall health system and has a direct impact on the burden of disease that affects many countries in the developing world. Measuring accessibility to healthcare service contributes to a wider understanding of the performance of health systems within and between countries which facilitates the development of evidence based health policies. Geographic variation in population, and population need for health care service 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. Accessibility to health care is concerned with the ability of a population to obtain a specified set of health care services, with the concept of "specific" having the potential to vary depending on the policy focus or impact of disease (Oliver and Mossialos, 2004).

The provision of adequate healthcare services, particularly in metropolitan areas, is becoming more difficult because of three developments. Amongst these three developments is the rapid growth of cities and their population. This results in a situation where the carrying capacity of current service delivery systems declines with the increase in service demand. This therefore burdens facilities which already have limited healthcare resources and results in, for example, long queues and increased waiting times. These challenges, amongst others, stress the need for service delivery systems to constantly anticipate continuous change in population growth, and in turn adapt to this change (Amer; 2007).

Apart from challenges related to service operation, poor access levels to healthcare services by the population have become a major concern in developing countries. According to the South African Department of Public Services and Administration (DPSA, 2011) people often face great inconvenience, travel long distances and visit more than one service point to obtain the healthcare services they require from government facilities. This is especially true for the poor and marginalized people who experience low levels of service availability and quality while the mobility is usually determined by their economic conditions (Green et al. 2012).

This research focuses on basic concepts and measurements of accessibility to plan healthcare service centers. The objective of this research is to assess the spatial accessibility of healthcare service centers in Adama City using GIS techniques and forward recommendations by proposing additional services on the planning scheme of the city. The study tries to develop a methodology to plan social infrastructures with geographical accessibility as parameter using GIS techniques as tools of analysis. The distribution of existing healthcare service centers is assessed by evaluating the accessibility level of available services, in this case healthcare facility, for betterment of appropriate service provisions to the people.

Therefore this study aimed to assess the spatial accessibility of healthcare service as well as propose sites for new healthcare services in Adama city.

1.2. Statement of the Problem

Distance to health services impacts on health seeking behaviors' .Travel times, lack of access to transportation, and seasonally inaccessible roadways can present barriers to patient access to health facilities (Chayovan *et al*., 1984).

Community healthcare services are not located uniformly in terms of geographical distribution, because such needs depend on a wide range of demographic, life, and environmental factors that differ among areas. Physical access to health service providers is beyond the reach of the majority of the Ethiopian population, and even more difficult for the poorest segments of the population. The overall country budget is limited, resulting in inadequate financing of healthcare. In addition, healthcare service delivery is inefficient and inequitable, and quality of healthcare is generally poor due to a limited financial availability (FMOH, 2001).

The lack of adequate distribution of healthcare services is some of the important reasons for poor healthcare service accessibility not only in Adama, but also throughout the Country. It is, therefore, crucial to improve geographical access to healthcare services.

The urban-rural linkage study mentioned that there is a strong relationship between Adama and its influence (rural and urban) areas with regard to health services. There is an acute shortage of health institution in the study area and its surrounding. In the study it is reported that 88 percent of the people have been coming to Adama in search of public medical services. Yet, the level of service is not adequate to accommodate the needs of the residents of Adama let alone of those who come from the surrounding areas (MWUDFUPI, 2006).

The report analysis numerous measures and indicates that disparities exist for many groups including women, children, the elderly, rural residents and among various socio-economic groups. This also affect all aspects of health and healthcare delivery, including preventive care, acute care and disease management and affect many delivery locations in emergency care, health center and nursing home. Some study suggested the development of additional health centers and community health posts to enable the population set an improved access to health facilities (MWUDFUPI, 2006).

In assessments made so far, there is limited study related to spatial accessibility of healthcare services in Adama city. Therefore this paper tried to examine the availability, and accessibility of healthcare services in the city, to predict new potential locations and evaluate the feasibility of location allocation models for new healthcare services planning and development.

Although, the city authority tried to minimizing the service delivery problems still now no significant changes is achieved due to the absence of skilled manpower in area of GIS and good governance system. Therefore, to fill this gap the study is develop a methodology to plan healthcare services with geographical accessibility as a parameter, using Geographic Information System as tools of analysis.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of the study is to assess the accessibility of healthcare services by using GIS techniques for Adama City.

1.3.2. Specific Objectives

From the general objective the following specific objectives are drawn.

- To identify the accessibility level of the existing healthcare services in the city.
- To propose new healthcare services with an aim to improve the accessibility of health facility.
- To conduct service area analysis to develop scenario both for the existing and the proposed healthcare services in the city

1.4. Research Questions

- Is the accessibility level of the existing healthcare services in the city optimum?
- What is the optimum number and location of proposed healthcare services to achieve service coverage in the city?
- How to conduct service area analysis to develop scenario both for the existing and the proposed healthcare services in the city?

1.5. Significance of the Study

The output of this study may help urban planners to use as a baseline for planning health related services in choosing a suitable site in Adama City. At the implementation time the planners and Municipality may select location with good accessibility for provision of these services. This will have great impact on the society; saving their valuable life, time, effort and money. This study may be used for future references by urban planners and researches.

1.6. Scope of the Study

This study is geographically limited to Adama City and focuses on the spatial analysis and accessibility of healthcare services. Specifically it includes; (i) Analyzing the existing healthcare services accessibility with regard to demand points and related to policy programmed by the government in the study area; (ii) identifying the location of supply and demand nodes; (iii) preparing cost effective service area and best accessible site maps of the study area; (iv) comparing the existing and proposed service area coverage according to population density and travel time and (v) interpreting the output and forward possible recommendation.

1.7. Limitation of the Study

The lack of reliable data sources and the lack of willingness of the professionals at the Municipality. These factors might have impact on the quality of the findings of the current.

1. 8. Organization of the Thesis

This thesis is structured as follows: Chapter One focus on description of the introduction and the background of the study. Chapter two focus on description of with the related literature relevant to the study. Chapter three discusses the methodology used for the study. Chapter four presents the results and the discussion of the case study. Chapter five deals the conclusion and the recommendation.

CHAPTER TWO

2. LITRETURE REVIEW

2.1. Introduction

This literature review is taken from different documents like journals, books, master's thesis and etc. it is related to this study and the review include theoretical insight, methodology, and existing experience of some countries, failure and success of related issues.

Healthcare service is a significant indicator of social development. Access to facilities is an important component in the overall healthcare system and has a direct impact on the burden of disease that encumbers health conditions in many developing countries (Mainardi, 2007).

Accessibility to healthcare facilities has been measured in different ways, depending on the context of the application. A study in New Zealand estimated the geographical accessibility of public hospitals. Cost path analysis is used to determine the minimum travel time and distance to the closest hospital via a road network. Local average time and distance statistics were calculated by modelling the total travel time of an individual, assuming that everybody visited a hospital at least once. These types of statistics can be generated for different population groups, and comparisons can be made between regions (Brabyn and Skelly, 2002).

Two main aspects of accessibility are involved: Socio-organizational and geographic. The socio-organizational component includes all attributes of the resources other than spatial attributes that either facilitate or impede the efforts of the client to get to healthcare facilities. They embrace aspects such as the sex of the individual medical care provider, the provider's fee scale and specialization, and others. Geographic accessibility, on the other hand, refers to the "friction of space" that is a function of the time to get to and physical distance from healthcare facilities. Thus, it can be argued that accessibility is more than the existence or availability of resources (Luo and Wang, 2003).

Lee and McNally (1998) used a GIS based algorithm for measuring physical accessibility. It is based on concepts of space-time prisms that can identify feasible opportunities under different scenarios of complex travel behavior. They seek to determine if a location can be physically reached or not. If a facility is not available on the shortest path, it can be assumed out of reach within the budgeted time (Lee and McNally, 2002).

2.2. Assessment of Spatial Distribution of Health Services

A useful starting point for the evaluation of spatial distributions is the principle of equality. Equality like health is a universal human right and refers to impartiality. A distinction can be made between arithmetic and proportional equality. Arithmetic equality refers to perfect equality of treatment where exactly the same quantity of benefits goes to all irrespective of circumstances. Proportional equality, however, is output oriented: to achieve equality in results may require inequality in resource allocation. It refers to situations where there is equality of treatment in the same circumstances but different circumstances justify differential treatment in the distribution of benefits (Smith, 1994).

2.2.1. Assessing Potential Spatial Accessibility of Health Services in Rural China

The rural Chinese population is characterized by poorer health status and limited access to appropriate health services compared with those of urban dwellers. In China, life expectancy rates are lower in rural areas than they are in urban areas (Shen, 1993).

Many factors, including insufficient access to health services and insufficient income, may lead to the lower health status in rural areas. Increases in income and the new cooperative medical scheme (NCMS) pilot program are reducing financial factors that limit access to health services in rural China, while the geographical location of rural citizens is playing an increasingly important role. According to the poverty monitoring report of rural China (2010) the percentage of rural Chinese citizens who were unable to receive timely health services for financial reasons dropped by 7.8% from 2002 to 2009. However, the percentage of people who were unable to access health services due to long travel times and transportation costs increased by 10.1% from 2002 to 2009 (rural survey department of national bureau of Statistics,2011).

Eliminating disparities in spatial accessibility of health services and improving the health of the population should receive greater consideration by the Chinese public health care system. The first step entails careful government agency planning and identifying the truly underserved populations (Luo and Wang, 2003; Luo and Qi, 2009).

As a measure for determining areas with insufficient health services, spatial accessibility of health services refers to the relative access to health services in a given location. Spatial accessibility of health services is influenced primarily by travel distance or travel time and the spatial distribution of health service providers and consumers (Wang and Luo, 2005).

Based on the actual use of health services the spatial accessibility of health services can be classified into two main categories. These are potential and revealed spatial accessibility. Revealed spatial accessibility of health services refers to the actual use of health care services in a given location, whereas potential spatial accessibility of health services refers to the aggregate health service resources that are available in an area. Potential access is the basis for estimating revealed access (Meade and Earickson, 2000; Khan, 1992).

2.2.2. Access to Health Facilities in Developing Countries

Developing countries are increasingly using needs based formulas to guide their allocation of health resources. The indicators of need most frequently used are the size of the population in each area. The demographic composition of the population (given that young children, the elderly, and reproductive age women tend to have a greater need for health services), Levels of ill-health, and Socioeconomic status (given the strong correlation between ill-health and low socioeconomic status and that the poor are most reliant on publicly funded services) (Semali and Minja, 2005).

2.2.2.1. Access to Health Facilities in Uganda

Health infrastructure in Uganda refers to the physical structure and supporting equipment established for provision of health services. It usually involves a structure with facilities for different health service needs, equipment such as cold chain facilities for storage, management and use in the provision of health services to the population. Health systems in Uganda are increasingly facing challenges of ensuring health care provision to the growing population that is also disproportionately spatially distributed. The challenges are due to a number of factors including; population growth, uneven population distribution related to natural resource bases, transportation networks which have made some areas remote, human resource and the financial requirements for managing and provision of health services (MoH, 2002).

Health service provision is one of the many basic location based social services to be provided in tandem with the spatial distribution of the population. Planning for the provision of health infrastructure therefore requires quality information on location of services, capacity of facilities and catchment population. Although a country's population requires health infrastructure and health care within a given proximity, because of resource constraints, prioritization is indispensable. Prioritization of health service location would therefore consider several factors but importantly are needs and gaps. Health infrastructures are to be established in various administrative units within 2 km reach by population in rural as well as urban areas (MoH, 2002).

2.2.2.2. Health Care in East and Southern Africa

Health care in Africa is a complex and multi faceted issue. The HIV/AIDS pandemic continues to devastate sub-Saharan Africa, particularly in the southern region as well as in parts of the eastern and central regions. A recent report from the joint United Nations program on HIV/AIDS and the world health organization (2005) has indicated that about 38 million adults and 2.3 million children under the age of 15 were living with HIV at the end of 2005. Among these 40.3 million people living with HIV. It is estimated that 25.8 million live in sub-Saharan Africa. This shows that Africa affected more seriously than any other continent (Loewenson and Whiteside, 1997).

The health for all Policy for the 21st Century in the African region: Agenda 2020 identifies equity as an essential principle and a core value for health development policies focused on a vision of health for all. It states that equity is 'based on the principle of, availability of and universal access to essential health care'. The issues of equity in health care and the impact of poverty on the possibilities for health are huge concerns in sub-Saharan Africa (WHO, 2006; Commission for Africa, 2005).

If health care systems are to be more equitable, they need to embrace the basic principle of ensuring the empowerment of poor clients to have a more central role in health system design and operation. The equitable health care services are possible when citizens have equal opportunity to access the services they need, and with the expectancies to achieve to their desired health outcomes, along with an equal objective health status (Mpofu, 2004).

A health service may function differently across groups not only because of provision, but also because of different meanings of health and health services in different groups affecting how services are accessed and used. Thus, equity in health systems is premised on both technical adequacy (the objective comparability of needs and services) and socio-moral perspectives (the opportunity to access services and the consequences for consumers of the services). This explains why people centered health systems are important from an equity and public health perspective, and not merely as a matter of social justice. Strengthening district health systems is an essential step in making health services accessible and affordable for those population groups who would otherwise be unable to reap the benefits of health promotion, good quality health care and access to essential drugs (Görgen and Schmidt Ehry, 2004).

2.3. Urban Health Care and Its Guiding Principles

Health is a universal human right and a major focus of social and political concern worldwide. Health also is a somewhat elusive concept that can be defined in various ways. One definition comes from the world health organization (1978) who regards health as ‘a state of complete physical, mental and social well-being’. Such an ideal state may be desirable but is of limited practical use as it implies that most of humanity would be unhealthy at all times. More productively, we might think of health as being physically and mentally ‘fit’ and capable of functioning effectively for the good of the wider society. The healthier people are, the more likely they are able to contribute to social and economic development. Economic growth, in turn, can enable responsible authorities to provide better health care and thus improve the health status of a population. The health for all strategy aims to reach and maintain the highest attainable level of health for all people. It consists of a range of services intended to promote good health, prevent illness and treat people that have become ill. It is a practical approach to making essential health care universally accessible to people in an acceptable and affordable way (WHO and UNICEF, 1978).

Towards the beginning of 1990s, it is increasingly recognized that rapid expansion of urban areas is irreversible and resulted in profound inequalities in health status and access to health care amongst city populations. Since then, urban primary health care has become and remained a major concern of public health authorities' worldwide (Tabibzadeh and Rossi Espagnet, 1989; Atkinson and Merkle, 1994).

Since the mid 1990's national health systems in African countries are being restructured in an effort to cope with increased demand for health care in an environment of public budget constraints. The outcome of these changes is a shift away from pure state provision of health care towards a situation with greater reliance on market forces. Throughout sub-Saharan Africa, this takes the form of the emergence of market driven private health care provision and the introduction of cost-recovery measures in the more centrally planned public health care sector. These adjustments should be seen in the broader context of a resurge of global belief in 'free market' processes and a re-thinking of government roles in social policy (Creese *et al*., 1998).

When making decisions about the provision of public health services the following guiding principles apply. The first is to provide services in an equitable way. Notions of fairness and social justice are invariably stated as being at the core of public health care interventions. Normally, this view point entail that priority should be given to the more vulnerable population groups. The second objective is to provide services that are effective. Treatments should offer real benefit; resources should not be listed on providing services that offer little health gain. The third objective is to provide services that are efficient. By this it mean how to provide services that maximize health benefit to society while minimizing the cost of provision (Carr Hill, 1994).

2.4. The Broader Context of Urban Health Care Provision

In an ideal society health care systems would be capable of meeting all the health needs of a population. Experience, however, shows that this has proven to be unrealistic and contemporary health planners recognize that the need for care will almost inevitably exceed supply. In sub Saharan Africa, rapid population growth, the urbanization of poverty, malnutrition and unhealthy living conditions are the main causes of morbidity and mortality in the city. Furthermore, the severe budget constraint of the large contingent of urban poor restricts them from expressing sufficient effective demand for essential health care of adequate quality. At the same time, adverse economic conditions restrict national governments to allocate adequate amounts of public resources to health care. Current levels of government expenditure on health care in sub-Saharan Africa are generally far too low to satisfy even modest health needs (Creese *et al*., 1998).

2.5. A Concept and Tool for Spatial Equity Analysis

Spatial planning of health care facilities at the intra urban level concerns the identification of suitable locations for a given number of health facilities in a defined territory and in such a way that the health needs of a spatially dispersed population are served in an optimal way. Basic to this type of location planning is the concept of accessibility. Stated in general terms, accessibility relates to the ability of people to overcome the friction of distance to avail themselves of services at fixed points in space. Access to sources of need satisfaction has an important bearing on human wellbeing. Accessibility can be viewed upon as a scarce resource, which is dependent on distribution and redistribution through the planning process (Smith, 1974).

Accessibility in the context of service provision is consisting of three components: (i) people, (ii) the activities or opportunities that they require, and (iii) the transport or communication link between the two. Accessibility varies according to the characteristics of people, of the activity or opportunity, and of the transportation infrastructure. Accessibility is the outcome of the combined characteristics of the three components mentioned above. The spatial component of accessibility describes two elements: (i) the spatial distribution of opportunities and (ii) the spatial distribution of demand for opportunities. In general terms of health care, it reflects the spatial arrangement of health care provision in relation to the spatial variation of health needs of people (Moseley, 1979).

The transport component consists of three elements (i) the location and characteristics of the transport infrastructure, (ii) the demand for travel and (iii) observed infrastructure use (mobility). Transport itself is not the desired product but a means to an end. The purpose of the transport component is to describe how people overcome the friction of distance that separates the point of demand from the point of supply (Pacione, 1989).

2.5.1. Some Approaches to Facility Location Problems

The subject of this section is to give operational form to the concept of accessibility. It shortly describes and evaluates the following measures (i) container measures, (ii) simple distance measures, (iii) cumulative opportunity measures, (iv)composite measures, (v) time space approaches and (vi) utility based approaches.

i. Container measures

Access is determined on the basis of a simple count of facilities or services by some administrative area. There is no consideration for the structure of the transportation network, the frictional effect of distance or properties of the supply side. This approach has some merit at higher levels of spatial aggregation when resources are allocated by the political process to individual administrative units. It is not appropriate for analysis at more detailed geographic scales such as that of intra-urban health care provision (Talen and Anselin, 1998).

ii. Simple distance measures

The simplest distance measures operationalize accessibility as the straight line distance between two locations in geographic space. This type of measure is often used in situations where standards exist in terms of maximum travel time or distance to opportunity accessibility is measured from a demand location to a single (the closest) opportunity. It is very commonly used and mostly operationalized on the basis of standard GIS functionality. An advantage of simple distance measures is that the data requirements are modest and that results can be interpreted easily. This type of approaches also has clear disadvantages. First, demand is assigned to the nearest mostly Euclidian distance opportunity in a deterministic manner. A second problem with this type of approach is that although it has some merit for evaluating existing situations. It is not very suited for forecasting and scenarios building (Doherty *et al*., 1996).

iii. Cumulative opportunity measures

Cumulative opportunity measures indicate the number of opportunities or number of potential customers that can be reached within a given travel time or distance. All potential opportunities within a given cutoff distance (time) are weighted equally. Accessibility increases if more opportunities can be reached within a given travel time or distance. This increase can be the result of either a change in the ease of reaching destinations (a change in the transport component) or a change in the number of available opportunities (a change in the spatial component). They incorporate both the spatial and the transport component of accessibility but do not evaluate their combined effect. The individual component can be approached through socio-economic disaggregation of the population under study (Breheny, 1978).

The main advantage of cumulative opportunity measures is that their results are straightforward and easy to interpret by non specialists. Other important advantages are that the data requirements are relatively undemanding and that alternative scenarios can easily be generated. An obvious disadvantage is the lack of differentiation between opportunities that are near to the demand origin and those just within the specified cutoff distance. Second, all opportunities are equally desirable despite potential differences in their characteristics. Third, the choice of a cutoff travel distance or time (the range) is a somewhat subjective matter (Ritsema van Eck and de Jong, 1999).

iv. Composite measures

The accessibility measure is termed composite as it captures two parameters (the spatial and the transport component) into a single index: (i) scale impacts which are operationalized in terms of the utility of the destination location and (ii) distance impacts operationalized in terms of separation units of some kind. The accessibility of a particular location is seen as a function of its relative proximity to alternative destinations of varying utility in a given spatial system. Because of the probabilistic nature of composite measures they assume non deterministic fuzzy market areas. Composite measures are mostly used to explain why some localized activities attract more users than do others and to explain the way in which an activity impacts on the surrounding area in terms of customer flows. Composite accessibility measures describe aggregate human behavior, not individual behavior (Haynes and Fotheringham, 1984).

The main advantage of composite approaches is that they offer a probabilistic view on human spatial behavior and that their data requirements are modest. Furthermore, some argue that the measure corresponds with a concept that most non specialists would accept. It denotes a range of choice offered by the land use and transport components in the form of a sum of potential destinations (Geurs and Ritsema van Eck, 2001).

The most important disadvantage of gravity based measures is that they have only limited theoretical justification other than the analogy to a law of physics. A link to a theory of human spatial behavior is never sufficiently established. A second disadvantage is how to reconcile the individual component of accessibility with a model that describes aggregate outcomes. In practice this problem is reduced by breaking down the population under study into socio economic and demographic strata, allowing each subgroup to have its own characteristics of consumer behavior. A third disadvantage is that of self-potential in their basic form composite measures are extremely sensitive to short distances (Wilson, 1970).

v. Time Space Approaches

The time space approach attempts to define a bounded region of time and space at the individual level and to identify the main factors that constrain the individuals' freedom to occupy certain space and time locations. Movement of the individual in the spatial temporal environment is restricted by some constraints. Authority constraints refer to the limitations of access in place and time as enforced on individuals by, for example, authorities. Capability constraints refer to limitations of movement because of (i) physiological necessities and (ii) available transportation means. Coupling constraints refer to the 'where, when and for how long' the individual must join other individuals in order to finish a task (Johnston and Gregory, 1998).

The opportunities that can be reached given time and space constraints can be seen as a measure of accessibility. Accessibility can be improved either by expanding the action space of the individual or by placing more opportunities within its bounds. The main difference with cumulative opportunity and composite measures is their explicit link to the individual and the temporal components of accessibility. Time space accessibility measures are able to reveal differences in individual accessibility, where composite and cumulative opportunity measures are aggregate measures that assign the same level of accessibility to all persons or members of a socio economic group, that share the same origin location. The advantage of a time space approach is that it accounts for each of the components of the accessibility concept. The fact that it is a disaggregate approach also is its main disadvantage as it has rather demanding data requirements to be implemented. Because of the large data requirements, applications are often restricted to smaller study areas and subsets of the population (Geurs and Ritsema van Eck, 2001).

vi. Utility Based Accessibility Approaches

Utility based accessibility approaches assign particular importance to conceptualizing the decision process to explain and model individual spatial choice behavior. This type of approaches is mostly operationalized using discrete choice models. These models are generally rooted in random utility theory (Thurstone, 1927).

The probability of an individual making a particular choice depends on the utility of that choice relative to the utility of all choices. The expected choice behavior is captured using a utility function that reflects the attractiveness of the destination, the travel impedance, and the socio economic characteristics of the individual (Borgers and Timmermans, 1993).

The main advantage of utility based approaches is their solid theoretical foundation in economic theory and that they encompass all components of accessibility. The disaggregate approach, again is also an important disadvantage as data collection is a very demanding task. For every individual one needs to record what his/her perception is of all the available alternatives and how they are weighted. Because of the large data requirements, utility based applications are often restricted to subsets of the population and smaller study areas. Another disadvantage is that the outcomes of a utility based measure are not easily interpreted by non-specialists (Geurs and Ritsema van Eck, 2001).

2.5.2. GIS Based Accessibility Analysis in Developing Countries

GIS based accessibility analysis offers a useful toolkit that can be used to support location planning in the urban health sector and is increasingly being used in developing countries in order to examine potential access to health facilities and to plan the location of new treatment centers. The use of GIS for measurement of physical distribution is well established and has been applied in many areas including retail site analysis, transport, emergency services and in the allocation of public facilities (Wilkinson *et al*., 1998).

Spatial analysis is dismissed on the grounds of being too sophisticated for local circumstances given the problems of (i) availability of computing resources, (ii) the lack of trained personnel, (iii) limitations of the methods to capture the complexity of the planning problem, (iv) comprehensibility to decision makers, and (v) data availability . Ultimately, however, the success of GIS based accessibility analysis in sub-Saharan Africa will depend on its ability to provide real support to decision making by offering acceptable and robust methods of problem solving to the health planning community (Rushton, 1984).

2.6. Theories and Models in Analysing Facility Location Problem

Location problems have attracted a lot of interest by mathematical researchers for a long period of time due to its ability to solve numerous problems. The mathematical science of facility location has attracted much attention in discrete and continuous optimization over nearly last four decades. to locate a set of facilities (resources) to minimize the cost of satisfying some set of demands (of customers) with respect to some set of constraints (Farahani and Hakmatfar ,2009) .

Covering location problems is a problem which tries to determine the number of facilities to cover all demand nodes under center problems. The model introduced under a title p-centre model (minimax problem). The objective of this model is to find location of p facilities so that all demands are covered and the maximum distance between a demand node and the nearest facility is minimized (Daskin, 1995).

P-median model is used to address the issue of locating new facilities when there is uncertainty. Several possible future scenarios with respect to demand and the travel times(distance) parameters were presented. The model is applied to the location of fire stations in Barcelona (Serray and Marianovz, 1996).

Several approaches have been employed in solving location of ambulance emergency medical service in the Kumasi metropolis in Ghana by modeling the problem as non linear maximum expected covering location problem (MEXCLP) and very sensitive location problem such as maximum availability location problem (MALP) developed by Daskin (1982), genetic algorithms (GA) that uses random key coding is implemented. A formula for renormalization is introduced. Real route distances were used for computation and statistical deviation is introduced in the selection of optimal routes (Amponsah *et al*., 2010).

A study of fire and emergency service facility location selection in Nigeria looked the problem as variant of set covering problem. First, a mathematical model of facility location is introduced and solved by using optimization solver, TORA. Secondly, the balas additive algorithm of branch and bound techniques is used to solve the facility location problem. In analysis the authors discovered that both algorithms indicate the same number of fire stations in different locations. Also the results obtained by applying and implementing balas additive were more explanatory by specifying the names of the locations where the facilities are to be located and the names of the locations to be served by each of the facilities (Arogundade *et al*., 2005).

Gravity model for estimating the market share captured by competitors states that existing customer locations attract business from a service in direct proportion to the existing locations and in inverse proportion to the distance between the service location and the existing customer locations (Huff, 1966).

Locating a set of facilities (resources) in order to minimize the cost of satisfying some set of demands (of customers) with respect to some constraints has been under study for a long time. For example determined the optimum location of Mobile Telecommunication masts owned by mobile service providers in the Cape Coast metropolitan area. The general layout of sitting telecommunication mast is based on transmission and receiving conditions. The proliferation of masts across our landscapes now a day has been in direct response to increased desire for mobile communication services by the public. Factor rating method is adopted to solve this problem. The goal of factor rating is for a mobile service provider to be able to carefully derive the maximum benefit that can be used to achieve the company's objectives by considering all relevant factors involved in deciding to site a mast (Simpson, 2012).

MCLP location allocation model is used to relocation of particular facilities allowed for improved access without having to build new facilities and also develop a solution for improving accessibility (Oppong and Hodgson, 1994).

The accessibility of primary health care services to rural populations examines that the demand aggregation is incorporated into a maximal covering location problem (MCLP) model in order to determine the unmet demand for primary health care services in Idaho, based on the allocation of Idaho residents to the states existing primary health care facilities (PHCF). This procedure identified areas without adequate accessibility to PHCF (locations where demand for Primary health care Services (PHCS) is unmet). The study used this model to determine potential locations (from a set of feasible sites) that could meet unmet demand determined by the initial models. In addition, the study explored the consequences of different demand locations and different driving time constraints on all of these models results (Blake, 2010).

2.7. Identification of Suitable Measures for Urban Health Care Planning

The most appropriate Suitable measures for urban health care planning in sub Saharan Africa is answered by looking at factors such as (i) theoretical and methodological soundness, (ii) ease of interpretation, (iii) data needs, and (iv) usability for urban health care planning in the sub Saharan context. It begins with excluding container and simple distance approaches for two reasons (Ritsema van Eck and de Jong, 1999).

First, their theoretical soundness is too limited (neglect the transport, the individual and the temporal components of accessibility). Second, these measures are not suited for forecasting and scenario building which is an essential consideration for location planning in the urban health sector. Cumulative opportunity measures are also suitable for a number of reasons. First, their more aggregate nature matches the proposed level of analysis for this study. Second, the interpretation of the performance measure of accessibility is straight forward which is an important advantage over gravity based methods. Third, the data requirements of comparative approaches are comparable to gravity approaches. Fourth, cumulative opportunity measures can be usefully applied in situations in which norms exist with respect to maximum travel distance or minimum threshold (this is often the case in health care). Fifth, advanced comparative measures have recently been developed that take spatial competition effects into account (Ritsema van Eck and de Jong, 1999).

Accessibility surfaces can be constructed for situations where a new facility is planned as part of a chain of facilities and the objective is not to maximize the market area of the individual facility alone but rather that of the chain as a whole. This is clearly important consideration in planning for new public health care facilities. To summarize the above, it appears that the most sound way to represent and model a spatially equitable and efficient urban health care system in the sub Saharan context, is to use a 'what if' type of GIS based approach on the basis of a composite or a cumulative opportunity measure of accessibility (Ritsema van Eck and de Jong, 1999).

2.8. Formulation of Mathematical Models

The standard location allocation problem to be formulated is the P-median (minimize weighted impedance). It chooses facility such that the total sum of weighted impedance (demand allocated to a facility multiplied by the impedance to the facility) is minimized.

Total weighted distance is minimized when each individuals obtains service from the nearest facility and when each facility is located optimally with respect to the demand which it serves. When demand density varies in the study area, the total demand served by each facility will also vary proportionately.

Solutions to P-Median problems yield curvilinear relationship between demand density and facility density by providing relatively more facilities per unit area in areas of high demand density. The demand for a health centers is assumed to be located at a set of points, associated with each point is a weight representing the volume of demand.
Generally, the geographical accessibility is performed by calculating average weighted distances that people have to travel to reach a service. However, geographical efficiency is estimated by comparing the actual with the optimal average weighted distances. The

main objective is to determine population weighted optimal location which can be solved by the following mathematical formulation:

Min $Z=\sum_{i=1}^{n}.\sum_{j=1}^{m} \mathrm{Wi.dij.Xij}$ ……………………………………………….... (2.1)

i=1, 2, 3 ...n and j=1, 2, 3…m

Subjected to:

$\sum_{j=1}^{m} \mathrm{Xij} = 1 \quad \forall i,$…….. (2.2)

$\sum_{j=1}^{m} Yj = P$ ……………………………………………………………… (2.3)

Xij$\leq Yj \quad \forall i, j$ ………………………………………………………...… (2.4)

Xij, Yj $\in\{0,1\} \quad \forall i, j$……………………………………………………...(2.5)

Where:

i=demand location, j=candidate facility location, n=number of demand location

m=number of candidate facility location, p=number of facility to locate (site)

wi=weight at demand node i(demand of i node)

dij=shortest distance between demand location i and candidate j

xij: is equal to 1 if the demand of node i is covered by the facility that has been set up at node j, Otherwise is 0

Yj: is equal to one if a facility is set up at node j, otherwise is 0

dij: is the distance between the node of i demand and candidate node to establish facility j(dij is 0 if i=j)

In this problem equation (2.1) is used to minimize the sum of demand weighted distance that are needed to satisfy the needs of demands. Equation (2.2) states that all demands node is serviced by just one facility. Equation (2.3) states that there is an indigenous problem and proves the exact P establishment (restricts the number of facilities to P). Equation (2.4 and 2.5) states that open facilities can meet the demands thus the demand of i node cane be provided with facility established at j node (xij=1) through one facility in j node (Yj=1).

In this study heuristic (both exchange and neighborhood search) algorithms are selected. Thee algorithms are commonly used in most of real world problem.

2.9. Lessons Learned from Literature Reviewed

The aim of this sub topic is to compare and contrast previous approaches to measure accessibility with new methods built around the use of Geographical Information Systems (GIS). GIS has the potential to provide an improved evidence base with which to identify and target groups and areas with lower levels of accessibility and to monitor the impacts of any service relocations or changes in delivery on accessibility. Accessibility to healthcare facilities has been measured in different ways, depending on the context of the application. Accessibility relates to the ability of people to overcome the friction of distance to avail themselves of services at fixed points in space. Accessibility can be viewed upon as a scarce resource, which is dependent on distribution and redistribution through the planning process.

- Cost path analysis is used to determine the minimum travel time and distance to the closest facility via a road network. Local average time and distance statistics were calculated by modelling the total travel time of an individual, assuming that everybody visited a hospital at least once. These types of statistics can be generated for different population groups, and comparisons can be made between regions.
- Spatial accessibility of health services refers to the relative access to health services in a given location and is influenced primarily by travel distance or travel time and the spatial distribution of health service providers and consumers. As a measure for determining areas with insufficient health services.

- Access to health facilities in developing countries is increasingly using needs based formulas to guide their allocation of health resources. The indicators of need most frequently used are the size of the population in each area.

- The researcher reviewed some approaches to facility location problems. These are Container measures. Access is determined on the basis of a simple count of facilities or services by some administrative area. It is not appropriate for analysis at more detailed geographic scales such as that of intra urban health care provision. Simple distance measures are operationalize accessibility as the straight line distance between two locations in geographic space. This type of measure is often used in situations where standards exist in terms of maximum travel time or distance. It is very commonly used and mostly operationalized on the basis of standard GIS functionality. It is not very suited for forecasting and scenarios building. Cumulative opportunity measures indicate the number of potential customers that can be reached within a given travel time or distance. The main advantage is that their results are straightforward and easy to interpret by non-specialists and the data requirements are relatively undemanding and that alternative scenarios can easily be generated. Composite measures it captures two parameters (the spatial and the transport component) into a single index. Composite measures are mostly used to explain why some localized activities attract more users than do others and to explain the way in which an activity impacts on the surrounding area in terms of customer flows. Composite accessibility measures describe aggregate human behavior, not individual behavior. The main advantage of composite approaches is that they offer a probabilistic view on human spatial behavior and that their data requirements are modest. Time Space Approaches is attempts to define a bounded region of time and space at the individual level and to identify the main factors that constrain the individuals' freedom to occupy certain space and time locations. Movement of the individual in the spatial temporal environment is restricted by some capability constraints refer to limitations of movement because of physiological necessities and available transportation means.

- Accessibility can be improved either by expanding the action space of the individual or by placing more opportunities within its bounds. The main difference with cumulative opportunity and composite measures is their explicit link to the individual and the temporal components of accessibility. Time space accessibility measures are able to reveal differences in individual accessibility, where composite and cumulative opportunity measures are aggregate measures that assign the same level of accessibility to all persons or members of a socio-economic group, that share the same origin location. The advantage of a time space approach is that it accounts for each of the components of the accessibility concept.

- GIS based accessibility analysis offers a useful toolkit that can be used to support location planning in the urban health sector and is increasingly being used in developing countries in order to examine potential access to health facilities and to plan the location of new treatment centers. The use of GIS for measurement of physical distribution is well established and has been applied in many areas including retail site analysis, transport, emergency services and in the allocation of public facilities.

- Spatial analysis is dismissed on the grounds of being too sophisticated for local circumstances given the problems of availability of computing resources, lack of trained personnel, limitations of the methods to capture the complexity of the planning problem, comprehensibility to decision makers, and data availability . However, the success of GIS based accessibility analysis in sub-Saharan Africa will depend on its ability to provide real support to decision making by offering acceptable and robust methods of problem solving to the health planning community.

- The most appropriate Suitable measures for urban health care planning in sub Saharan Africa is Cumulative opportunity measures suitable for a number of reasons. First, their more aggregate nature matches the proposed level of analysis for this study. Second, the interpretation of the performance measure of accessibility is straight forward which is an important advantage over gravity based methods. Third, the data requirements of comparative approaches are comparable to gravity approaches. Fourth, cumulative opportunity measures can be usefully applied in situations in which norms exist with respect to maximum travel distance or minimum threshold (this is often the case in health care). Fifth, advanced comparative measures have recently been developed that take spatial competition effects into account. Accessibility surfaces can be constructed for situations where a new facility is planned as part of a chain of facilities and the objective is not to maximize the market area of the individual facility alone but rather that of the chain as a whole. This is clearly important consideration in planning for new public health care facilities.

- To summarize the above, it appears that the most sound way to represent and model a spatially equitable and efficient urban health care system in the sub

Saharan context, is to use a ‘what if’ type of GIS based approach on the basis of a composite or a cumulative opportunity measure of accessibility. Several approaches have been employed in solving location problems which is tries to determine the number of facilities to cover all demand nodes under center problems. For this study Location allocation model is used to relocation of health facilities for improved access to build new facilities and also develop a solution for improving accessibility. The objective of this model is to find location of p facilities so that all demands are covered and the maximum distance between a demand node and the nearest facility is minimized.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1. Location of the Study Area

Adama City is located at some 100 kilometers from Finfinne, on the southeast along the main road to Harar. Its grid references point that the City stretches between 8^0 33' to 8^0 36' North latitude and 39^0 11' 57" to 39^0 21' 15" East longitude. Adama lies in somewhat warm and lower badda dare climate. Hence, it enjoys hot and dry weather for the greater part of the winter and warm and sunny climate in summer. Thus, the area is generally, known for its attractive weekends and summer resort release. References to its temperature points that Adama has a minimum annual temperature falling between 19^0 and 22^0C. Its yearly minimum rainfall is reported to be 760 mm. According to NUPI (1995: 38), the humidity record based on 39 years period (i.e., 1953-1991), points that, the mean annual precipitation of the City was 822.5 mm. (Wikipedia, the free Encyclopedia, 2012)

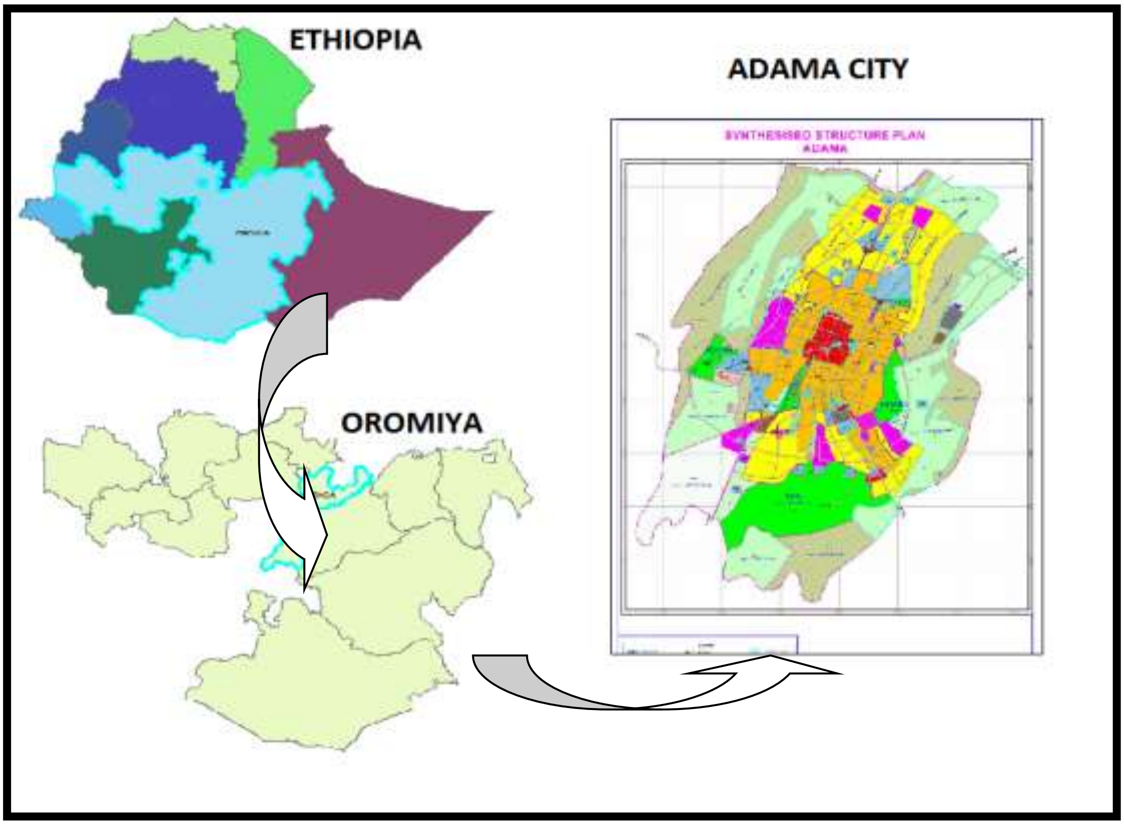

Figure 3.1: Location of study area (source: Adama municipality, 2013)

3.2.Demographic Characteristics of Adama City

The 1994 National Census Reported Adama (Nazreth) city had a total population of 127,842 of whom 61,965 were males and 65,877 were females, with an area of 29.86 square kilometers. Based on the 2007 Census conducted by the Central Statistical agency of Ethiopia (CSA), this city has a total population of 220,212 and increased over the population recorded in the 1994 census, of which 108,872 were men and 111,340 were women. In recent (2014-2017), Central Statistical agency of Ethiopia projection the total populations were 308,526. From this 151,266 were males and 157,260 were females. From 1994 to 2007 Census the growing of population size is 92,370 i.e the annual increment of 5.56%. And also from 2007 to 2017 the increment of population is 88314. This implies that the population is increasing at the rate of 5.72%. This increment has its own impact in the land use planning and the overall municipal service provision.

3.3. Road Infrastructure

As the roads available in the city center are limited and not well developed, the presence of manufacturing, and storages at the city core are creating huge traffic congestion. Moreover, large warehouses have occupied prime land from the city core areas where developments of high land value are expected to take place. The road system of the down town of the city is highly congested and is not efficient enough to serve the existing and future city's mobility pattern. Figure 3.2 shows the road network over laid on the city's master plan (Data from Analysis).

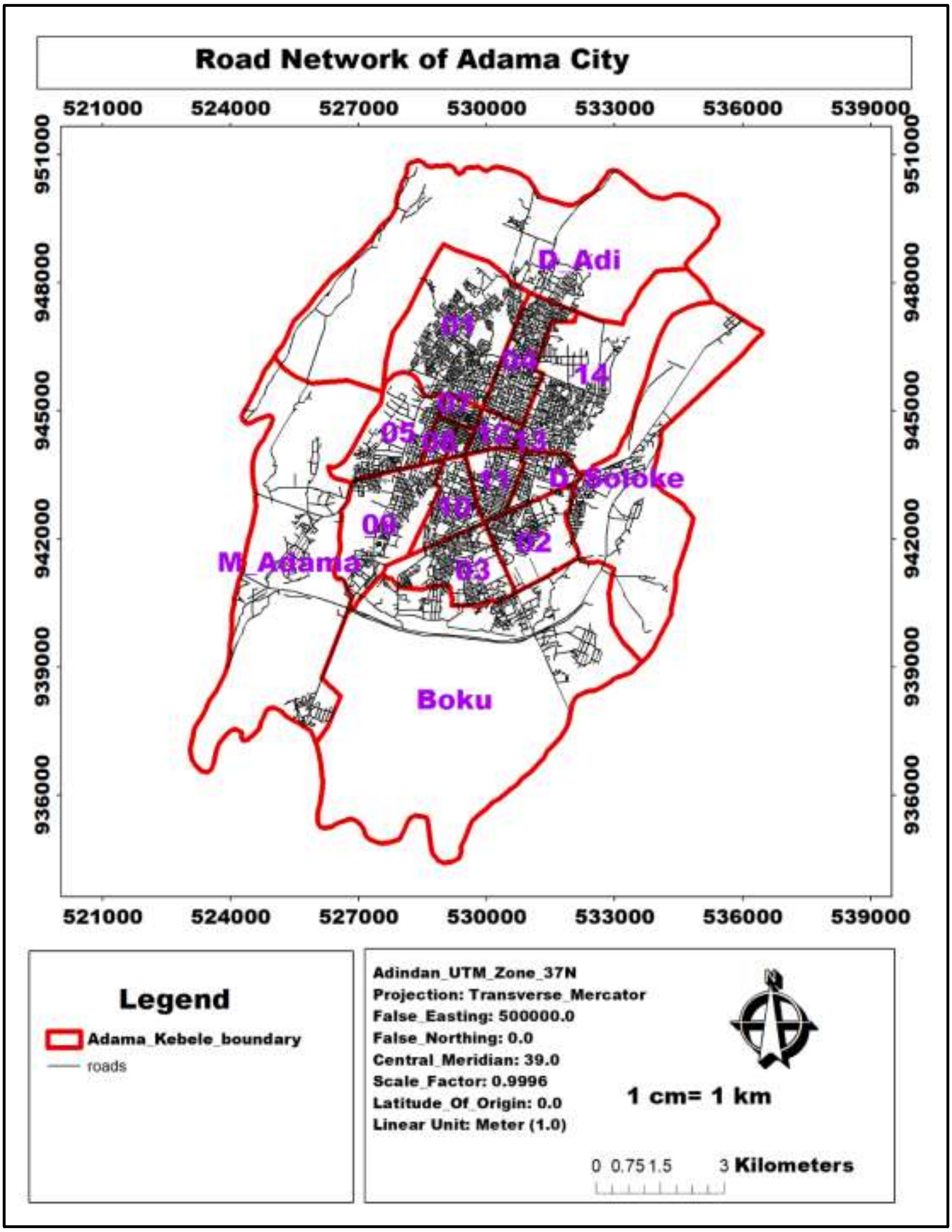

Fig 3.2.Road Network of Adama City.

3.4. Healthcare Services Centers

Concerning healthcare institutions, Adama City has got a number of different levels of hospitals, health centers and other clinics. These are: one public general hospital, one private general hospital, two medium level private hospital, ten health centers and sixty seven clinics (Primary data from GPS).

3.5 Methodological Approach

The research is mainly based on the conceptual model designed to assess the accessibility of healthcare services in view of providing reliable services to the community.

The overall procedures, work flow and approaches used in the conceptual model is shown in the figure 3.2. It attempts to present various data sources that are needed to study the appropriateness of the spatial accessibility of the healthcare services on the bases of socio-economic factors and develop the conceptual data model. Secondary data are needed to be compiled and complemented with primary data, which are collected during field survey. Both secondary and primary data feed into the personal database in ArcGIS, which is set up to match the previously identified components of accessibility. This setup covers the ‘who’ gets ‘what’ and ‘where’ of demands interests and enables proper operationalization of accessibility measures during the analysis stage.

On the analysis stage the researcher was first evaluate existing accessibility levels to healthcare services in Adama city. Then after the researcher established location allocation model for each service and carry out analysis by developing alternative scenarios of the ‘what if’ type that improve overall accessibility levels. Finally, the researcher was reflect on the outcomes of the result, and comment on the applicability of GIS based analytical techniques for strategic urban healthcare services allocation in Adama City.

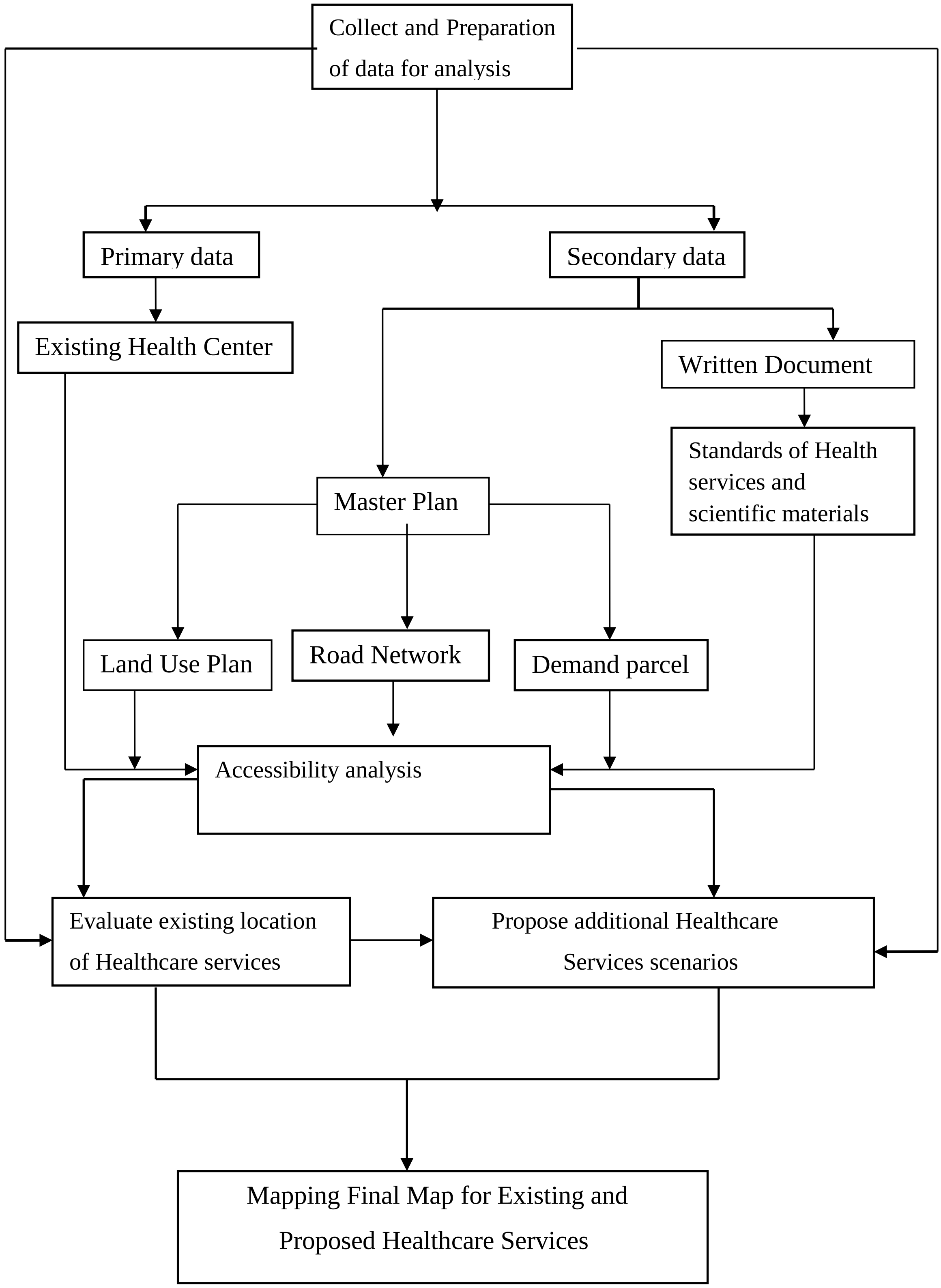

Figure 3.3: Work flow of the study

3.6. Data Sources

It is necessary to collect data from a number of different sources. Thus the researcher has obtained information from primary and secondary data sources.

3.6.1. Primary Data Sources

The location data on existing health services (supply) in all the corners of the City is collected by using handheld GPS. In addition, the information essential for location allocation analysis is reviewed from different sources (See table 3.1).

3.6.2. Secondary Data Sources

Secondary data consists of public and private health centers, national health standards, land use, road networks, topographic maps, city boundary, master plan of Adama city and population density per parcel is obtained from Adama municipality. Total population density of the city is collected from Adama city administration and Central Statistical Agency (See table 3.1).

Table 3.1: Data and its purpose

Item	**Type**	**Sources**	**Specifications**	**Purpose**
Topographic map	Secondary	Ethiopia Mapping Agency(2012)	1:50,000 Scale	To digitize administration boundary
Master plan of Adama city	Secondary	Adama municipality	Recent master plan	To prepare land use, to prepare population distribution per parcel and road network.
Coordinates	Primary	Field survey	Text (*.txt)	To georeferancing and to locate existing health centers in the map
Population data	Secondary	Central Statistical Agency(2007)	Text (*.txt)	For generation of population density or demand point

Table 3.2: Software’s and Equipment’s

No	Item	Version/ Model	Purpose
1	Arc GIS	10.3	For data analysis
2	Auto Cad 2007	2007	For data preparation
3	Hand held GPS	GARMIN GPS 72	to collect ground control points and location data of existing health centers

CHAPTER FOUR

4. DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter discusses the general processing of the spatial data used in this study. This includes a detailed discussion around each set of data and the way in which it was assembled. It must be noted that in the light of data error, inconsistencies and incomplete data, considerable time and effort was devoted to data pre-processing. As the general processing of each dataset is detailed, problem areas of the data are also highlighted and discussed. The intended outcome of the data preparation was to create a pool of reliable datasets.

4.2. Data Preparation and Processing

After gathering all the necessary data, the first step is preparing the data for further analysis. Therefore, the study has used the tabulated data in table 3.1 for the accomplishment of service area and location allocation analysis for optimal site selection in network analysis tool box of ArcGIS software. The hard copy of the road network map is geo-referenced by using coordinate system (Adindan, UTM, and Zone 37N) to bring the map into real world. This process is made at least by inputting a minimum of four ground control points (GCPs) of x, y coordinates. Accordingly these points and all other GCPs of x, y coordinates were rectified by using nearest neighborhood re-sampling technique. Also, the geographic locations of the existing health centers found within the study area are acquired by using hand held GPS receivers. After field data collection the x, y coordinates of the healthcare service centers are imported to ArcMap environment and converted into point feature shape file format. Besides, extraction of roads available in the study area is done using vector line mode digitization technique of Arc map and stored in the form of polyline shapefile. Arc catalogue of GIS software to us used to build the road network dataset that enables the user to perform network analysis.

Demand points are part of a given location-allocation analysis layer. A demand point is typically a location that represents the people requiring the services from facilities. A demand point could be a centroid weighted by the number of people residing within it. Demand points can override the distance cutoff for the location-allocation problem type. The new health centers site need to be located to best service the population. A point layer of census tract centroids is added to ArcMap.

After completing the editing process, cleaning and building of topology which is started in ArcMap by using the creates a new topology command in ArcCatalog to connect every line of the network with each other by means of a point that acts as a node. In view of that, arc-node topology is made for the layer of the whole road network. The container where these feature classes to be stored is the personal geo-database option in Arc Catalog for building and designing purpose. In the designed and developed geo-database, network dataset is built by incorporating the above mentioned feature classes in ArcGIS environment. The network dataset shall consist of three layers such as junctions as point feature (generated by the system), road segments (edges) and turn feature class as line features.

The collected data is processed by Location allocation model in ArcGIS environment using network analyst extension and it should be appropriate to the location of health facilities designed to serve a dispersed population.

4.3. Service Area Analysis on Existing Healthcare Services Centers

The analysis environment computes people lives within the given minute impedance that encompasses all the demands within the reach of the located boundary of the city. Accordingly, demands accessibility within 5minute, 10minute, 15minute and 20minute impedance existing scenario were generated for all the demand nodes locations in the city.

4.3.1. Service Area Analysis [5min impedance]

In this analysis the spatial accessibility of the population to healthcare services located in the city and the spatial coverage of the services were examined in a network model based on the span of 5 minutes walking as shown in the figure 4.1, 4.2 and table 4.1 below.

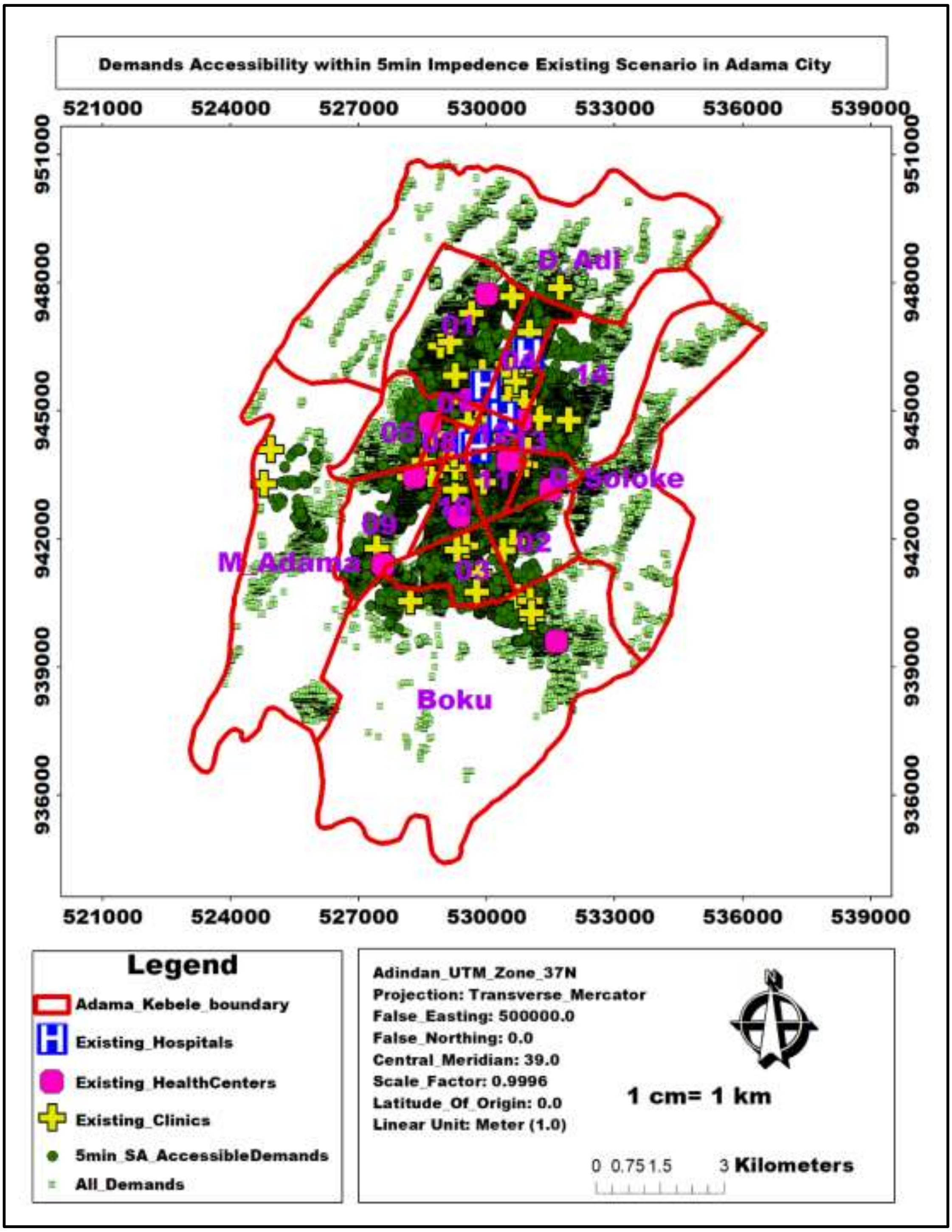

Fig. 4.1. Map of demands accessibility within 5minute impedance

Table 4.1: Summary of the Nubmer of Acceisble Demands by kebele within 5min Existing Scenario

No.	Kebele Name	Count of Accessible Demands
1	01	6473
2	02	1311
3	03	3728
4	04	4079
5	05	902
6	06	356
7	07	778
8	08	642
9	09	2576
10	10	2402
11	11	1868
12	12	828
13	13	1157
14	14	3202
15	Boku	1819
16	D_Adi	353
17	M_Adama	163

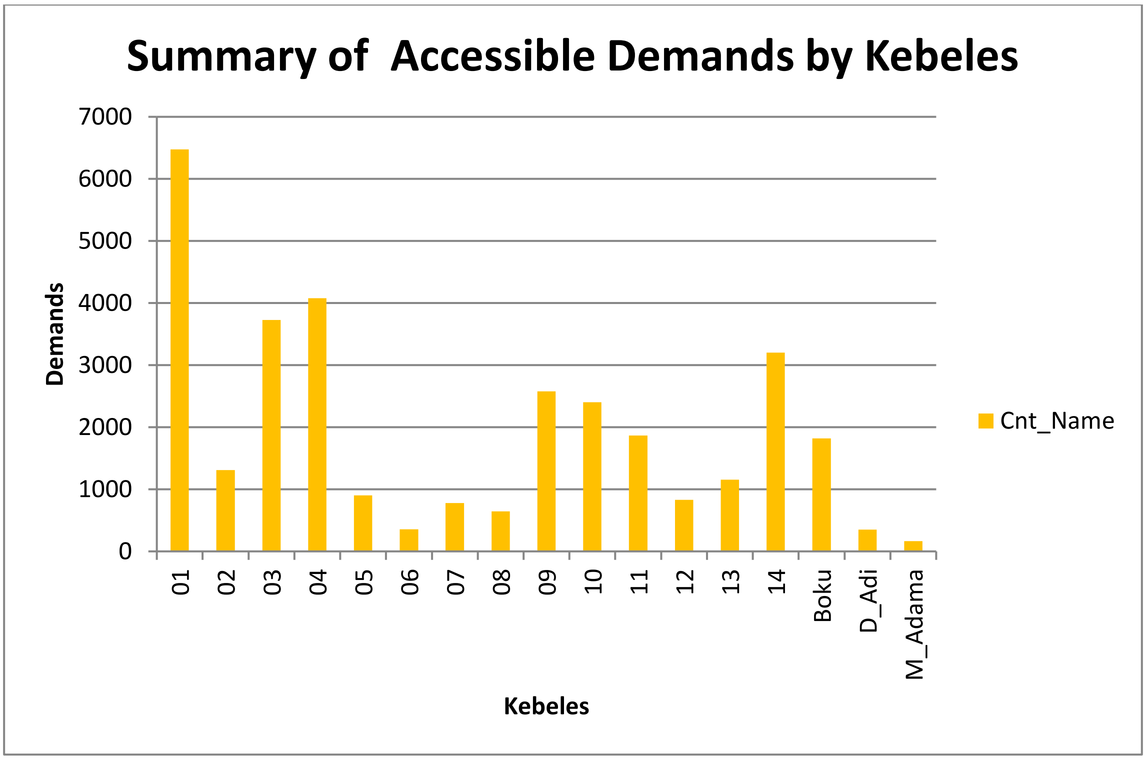

Figure 4.2: Summary of Accessible Demands by Kebeles in 5min Existing Scenario

According to the above figures 4.1, 4.2 and table 4.1 only 32,637 people live within 5 minute impedance to the healthcare services. Percentage of people lives within 5minute impedance is 10.58%. The rest of 275,889 population (89.42%) live further away from healthcare services. This means that most people don't have good accessibility level to reach the facility in terms of distance. Not only distance is the real problem but also the number of people that served within threshold distance hampers the people to access the healthcare services.

4.3.2. Service Area Analysis [10min impedance]

In this analysis the spatial accessibility of the population to healthcare services located in the city and the spatial coverage of the services were examined in a network model based on the span of 10 minutes walking as shown in the figure 4.3, 4.4 and table 4.2 below.

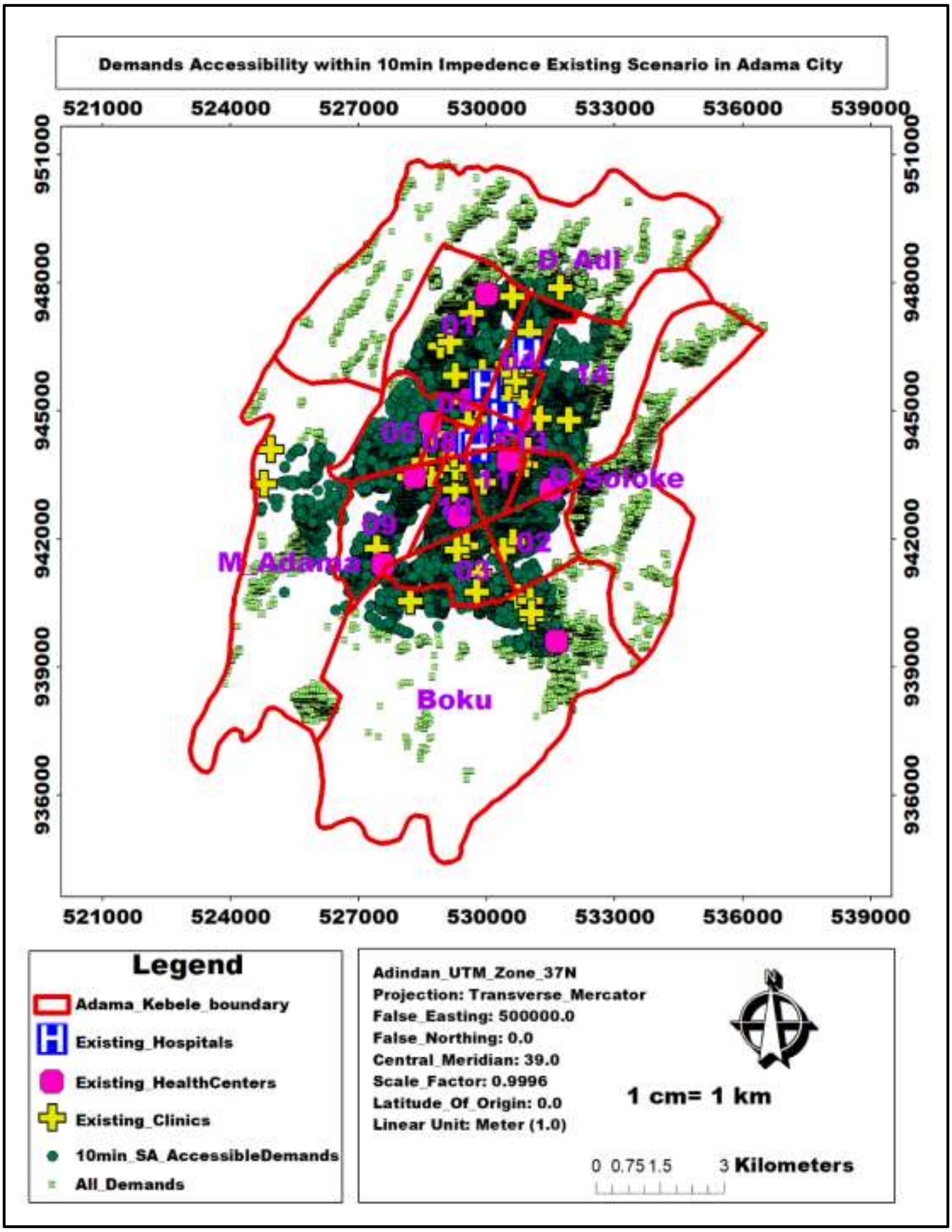

Fig. 4.3. Map of demands accessibility within 10minute impedance

Table 4.2: Summary of The Nubmer of Acceisble Demands by kebele within 10min Existing Scenario

No.	Kebele Name	Count of Accessible Demands
1	01	6760
2	02	1726
3	03	3900
4	04	4079
5	05	2151
6	06	356
7	07	778
8	08	642
9	09	3211
10	10	2402
11	11	1868
12	12	828
13	13	1246
14	14	4085
15	Boku	2343
16	D_Adi	562
17	M_Adama	552

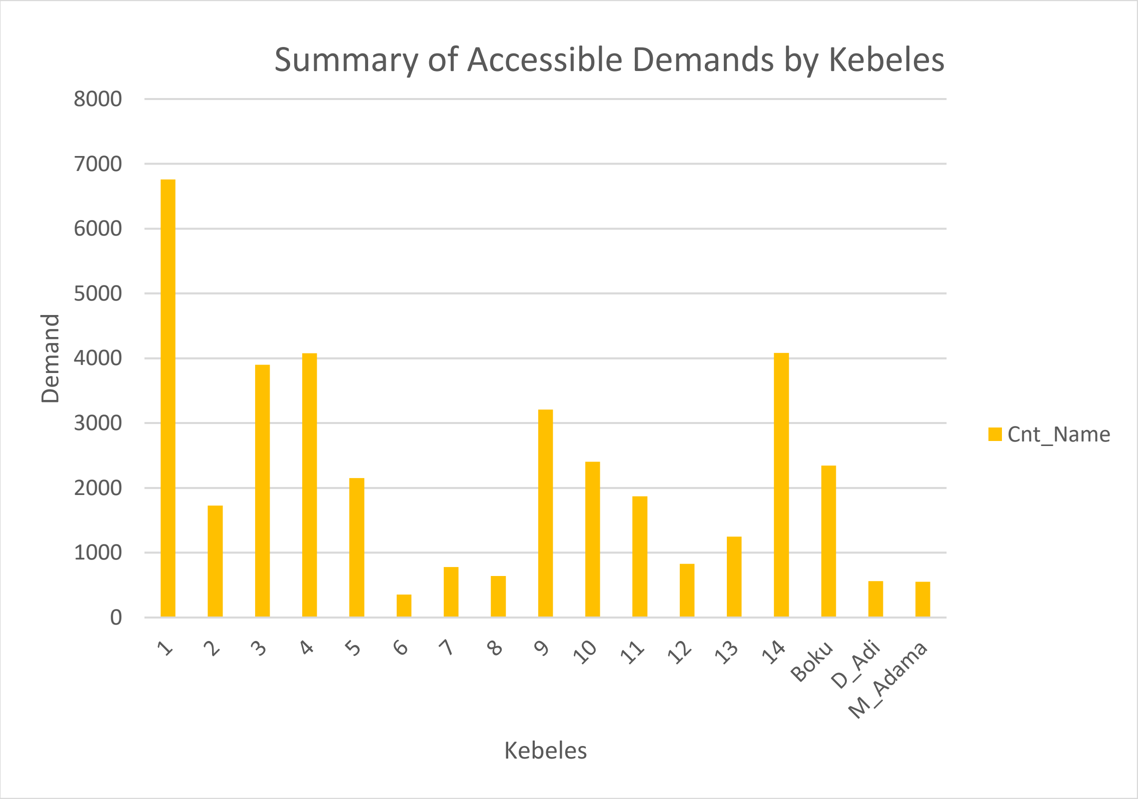

Figure 4.4: Summary of Accessible Demands by Kebeles in 10min Existing Scenario

The analysis scenario as in figures 4.3, 4.4 and table 4.2 has shown that only 37,489 people live within 10 minute impedance to the healthcare services. Percentage of people lives within 5minute impedance is 12.15%. The rest of 271,037 population (87.85%) live further away from healthcare services. This means that most people don't have good accessibility level to reach the facility in terms of distance. Not only distance is the real problem but also the number of people that served within threshold distance hampers the people to access the health center.

4.3.3. Service Area Analysis [15min impedance]

In this analysis the spatial accessibility of the population to healthcare services located in the city and the spatial coverage of the services were examined in a network model based on the span of 15 minutes walking as shown in the figure 4.5, 4.6 and table 4.3 below.

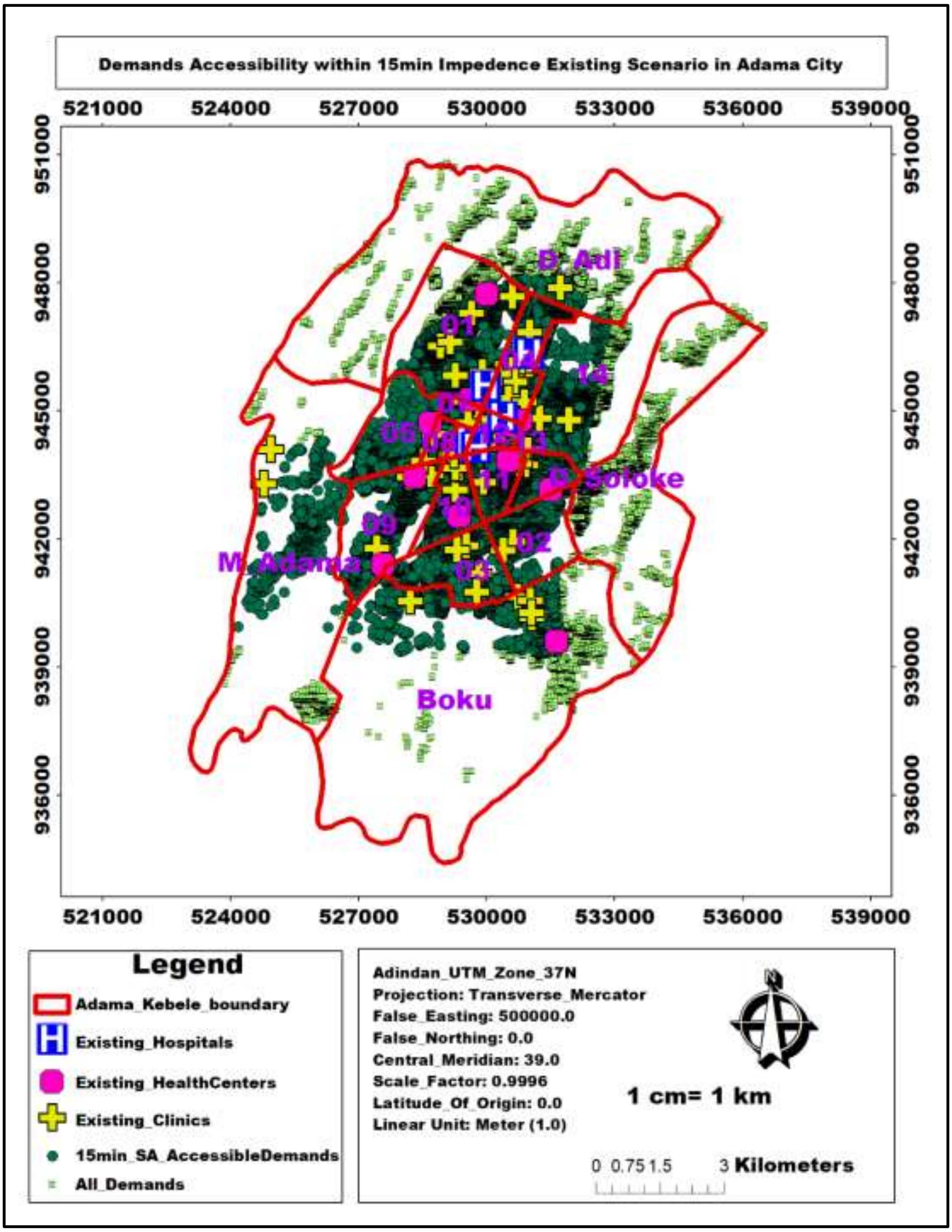

Fig. 4.5. Map of demands accessibility within 15 minute impedance

Table 4.3: Summary of The Nubmer of Acceisble Demands by kebele within 15min Existing Scenario

No.	Kebele Name	Count of Accessible Demands
1	01	7058
2	02	1775
3	03	3900
4	04	4079
5	05	2157
6	06	356
7	07	778
8	08	642
9	09	3211
10	10	2402
11	11	1868
12	12	828
13	13	1272
14	14	4443
15	Boku	2565
16	D_Adi	644
17	M_Adama	996

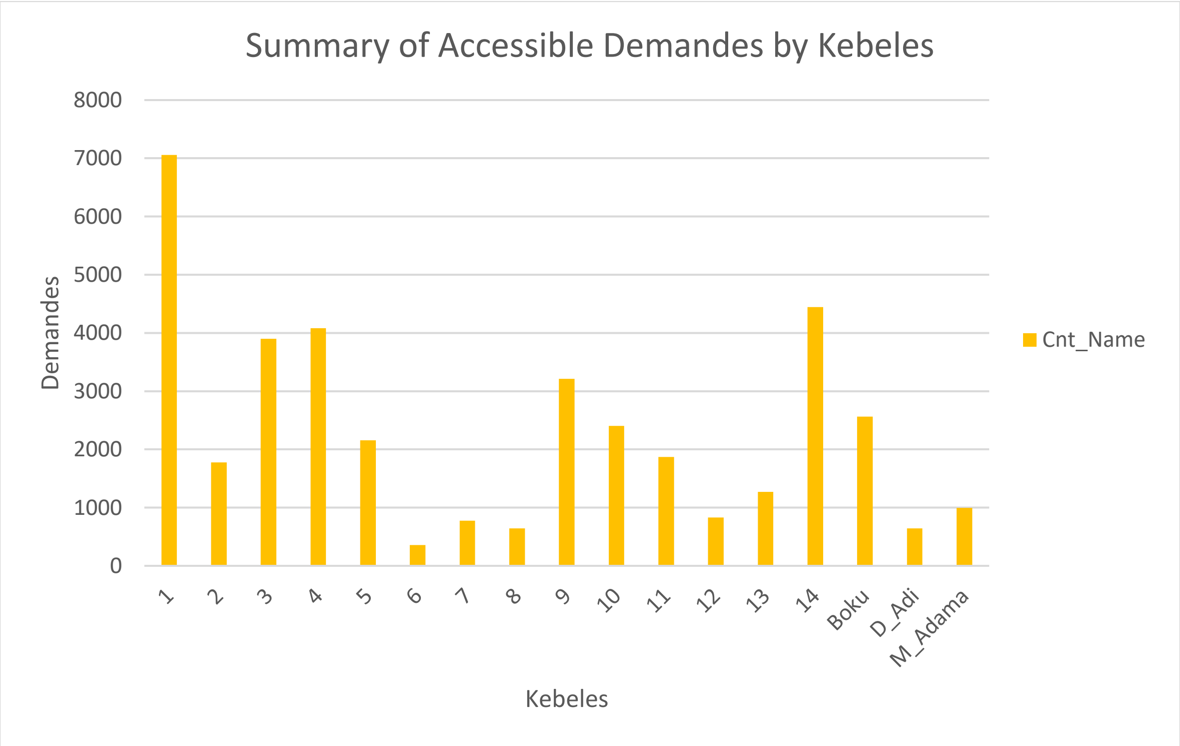

Figure 4.6: Summary of Accessible Demands by Kebeles in 15min Existing Scenario

This scenario as in figures 4.5, 4.6 and table 4.3 has shown that only 38,974people live within 10 minute impedance to the healthcare services. Percentage of people lives within 5minute impedance is 12.63%. The rest of 269,552 population (87.37%) live further away from healthcare services. This means that most people don’t have good accessibility level to reach the facility in terms of distance. Not only distance is the real problem but also the number of people that served within threshold distance hampers the people to access the health center.

4.3.4. Service Area Analysis [20min impedance]

In the last analysis the spatial accessibility of the population to healthcare services located in the city and the spatial coverage of the services were examined in a network model based on the span of 20 minutes walking as shown in the figure 4.7, 4.8 and table 4.4 below.

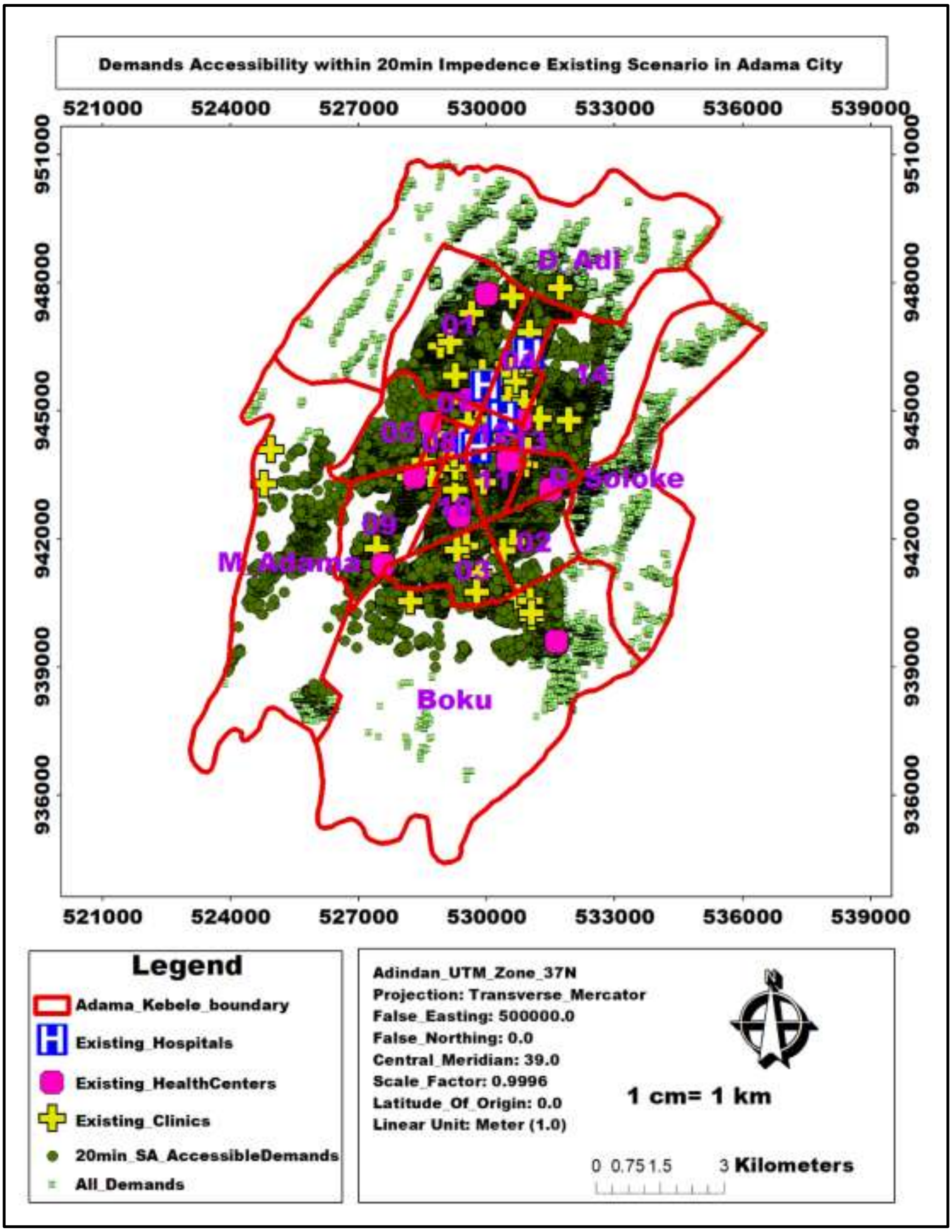

Fig. 4.7. Map of demands accessibility within 20 minute impedance

Table 4.4: Summary of The Nubmer of Acceisble Demands by kebele within 20min Existing Scenario

No.	Kebele Name	Count of Accessible Demands
1	01	7293
2	02	1777
3	03	3900
4	04	4079
5	05	2160
6	06	356
7	07	778
8	08	642
9	09	3211
10	10	2402
11	11	1868
12	12	828
13	13	1286
14	14	4649
15	Boku	2752
16	D_Adi	721
17	M_Adama	1103

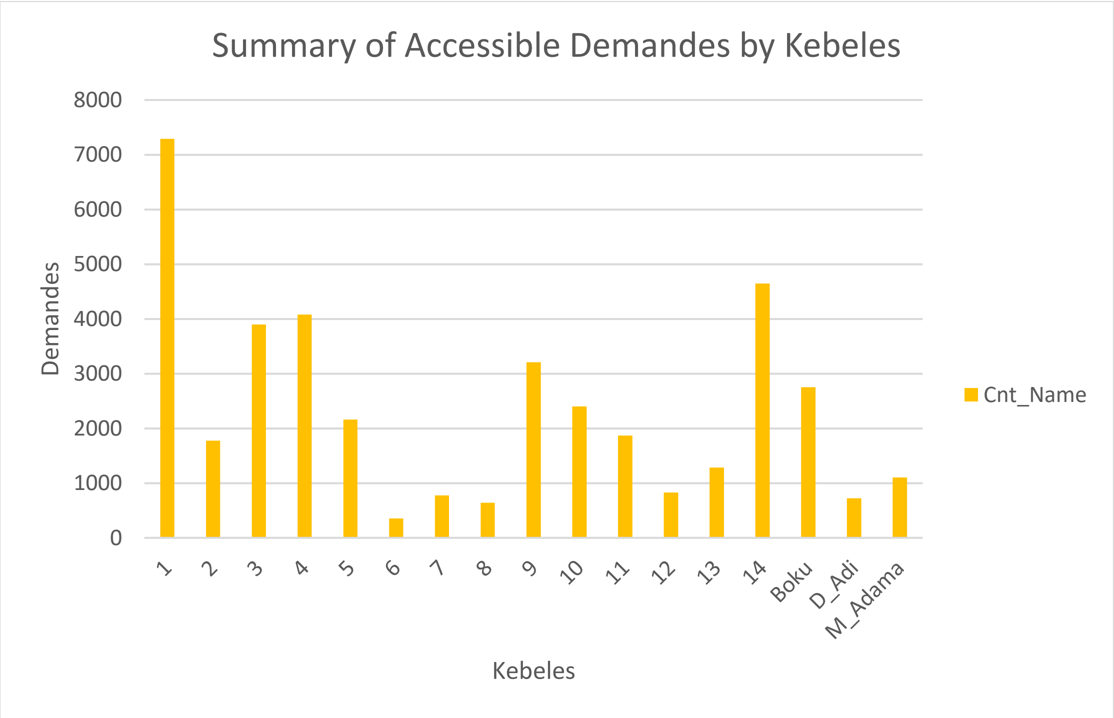

Figure 4.8: Summary of Accessible Demands by Kebeles in 20min Existing Scenario

The scenario as in figures 4.7, 4.8 and table 4.4 has shown that only 39,805 people live within 20 minute impedance to the healthcare services. Percentage of people lives within 20 minute impedance is 12.90%. The rest of 268,721 population (87.10%) live further away from healthcare services. This means that most people don't have good accessibility level to reach the facility in terms of distance. Not only distance is the real problem but also the number of people that served within threshold distance hampers the people to access the health center.

4.4. Service Area Analysis on Proposed Healthcare Services Centers

In the previous discussion part, the study considered the time traveled by the people from 5 minute up to 20 minute and the distance covered by individual house hold traveled to reach to the healthcare services. It is found that an individual house hold travels longer distance to get access to healthcare services.

In this regarded it is required to minimize the distance covered by the household to gain healthcare services. Therefore, additional candidate sites are proposed in order to solve the existing problems. This has been done on the basis of the existing demand, the maximum time, total distance, and capacity of healthcare services along with the additional potential sites within 20 minute maximum impedance for each healthcare services.

Selecting the most appropriate site for healthcare services is an important consideration for current needs and also on projected needs. Therefore, based on different countries experience, standards of healthcare services at national level and recent master plan of Adama City, new healthcare service sites are proposed. The main reason for the construction of these new healthcare services is carried out to reduce total travel distance and to reduce the overcrowding of healthcare services.

Therefore, a site with densely populated areas needs additional healthcare services than sparsely populated area. As shown in existing impedance analysis almost all area's without the central part of the city needs more healthcare services. Therefore, more sites were proposed beyond the central part of the city in order to solve the existing problems.

4.4.1. Service Area Analysis for Proposed Hospital [20min impedance]

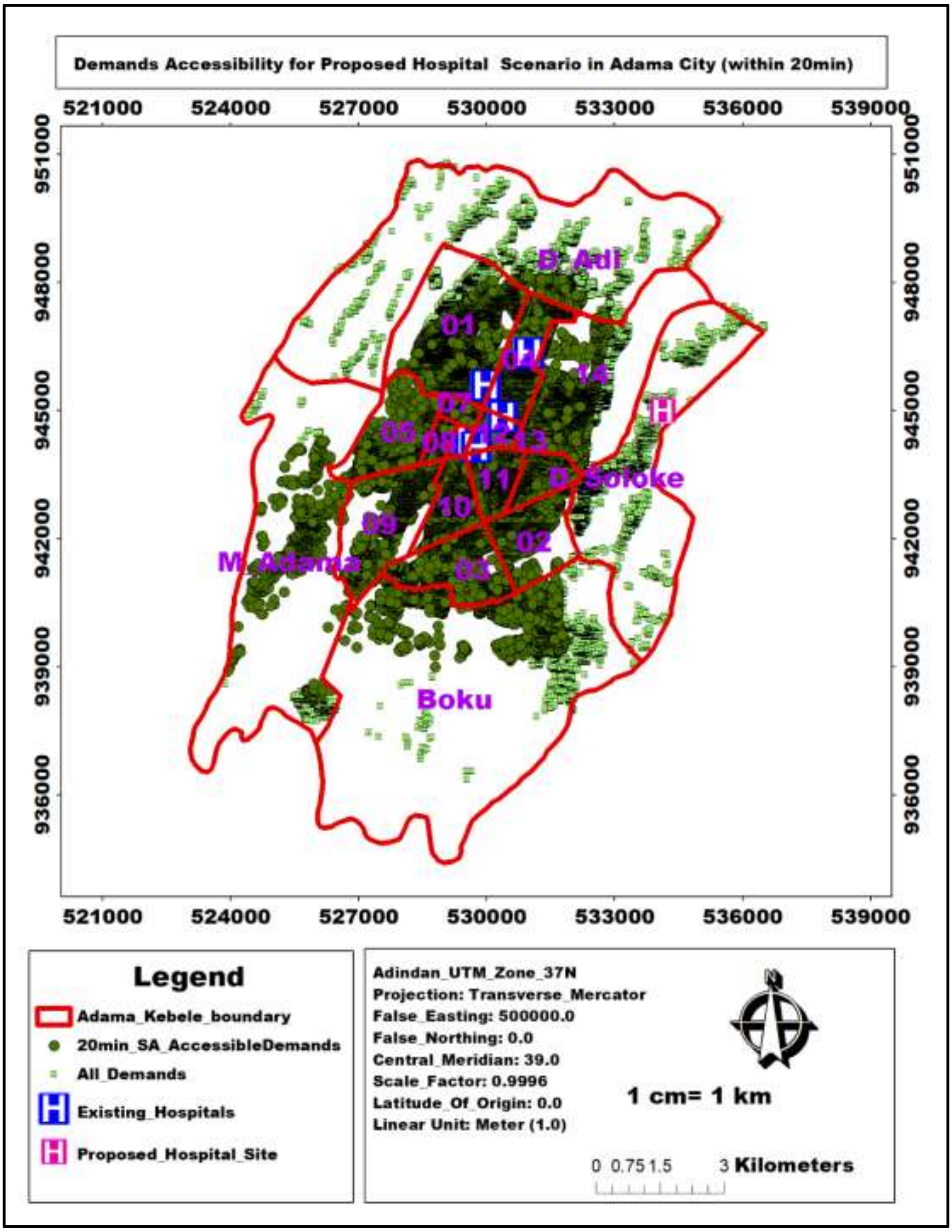

Fig. 4.9. Map of proposed hospital site within 20 minute impedance

For hospital case, based on the norms and standards for healthcare services (see Appendix A) Adama city have accessible hospital. But, the problem was the hospital is referral and it serves as a regional level. Due to this reason, the hospital is overcrowded. Therefore, the given healthcare service is not accessible for the people of the city 100 percent. Based on this understanding the new proposed site will be located as shown in figure 4.9.

4.4.2. Service Area Analysis for Proposed Health Centers [20min impedance]

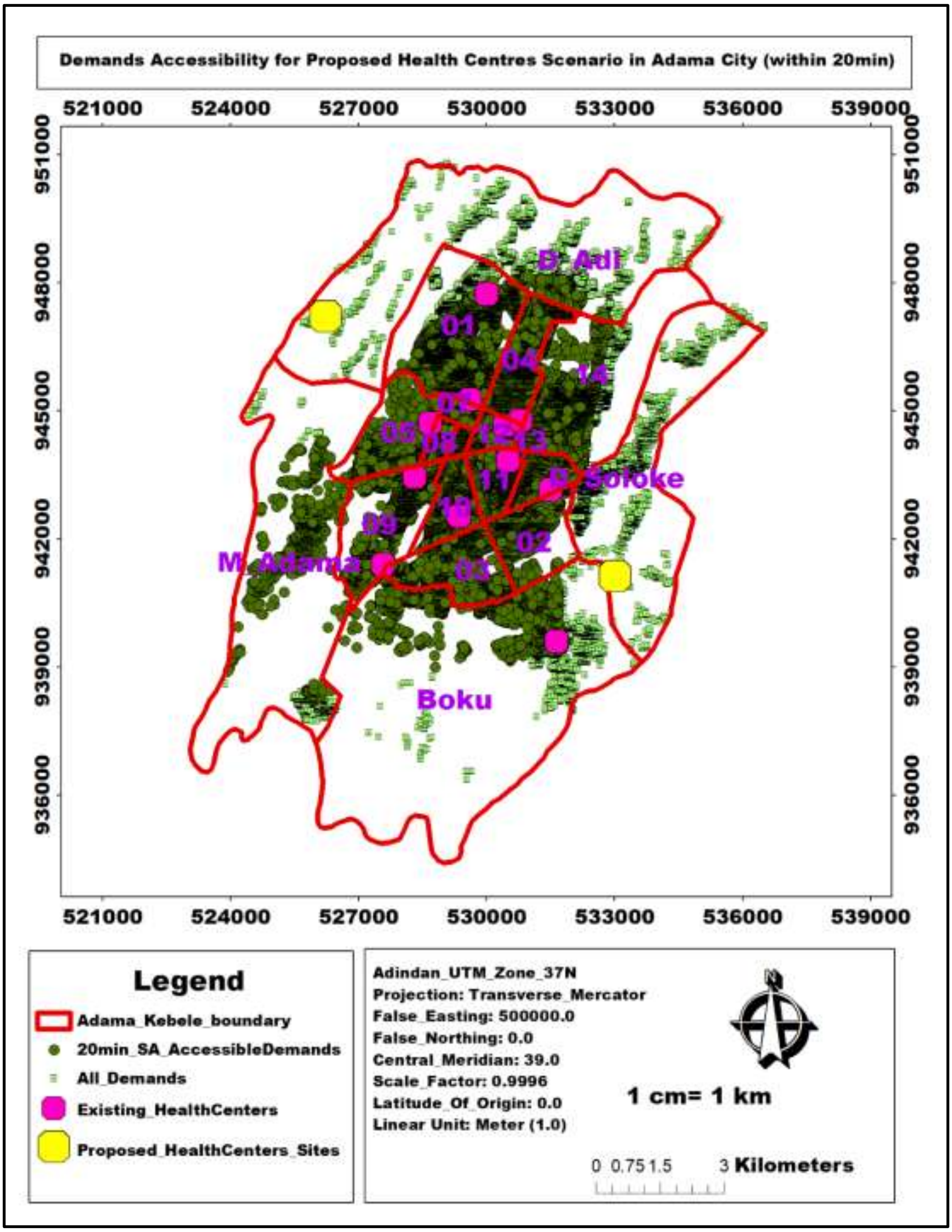

Fig. 4.10. Map of proposed health centers site within 20 minute impedance

On the other hand, for the case of health center in addition to the existing locations, using location-allocation model, the establishment of new two facilities are needed to optimally serve the population within 20 minute impedance located as shown in figure 4.10 above.

4.4.3. Service Area Analysis for Proposed Clinics [20min impedance]

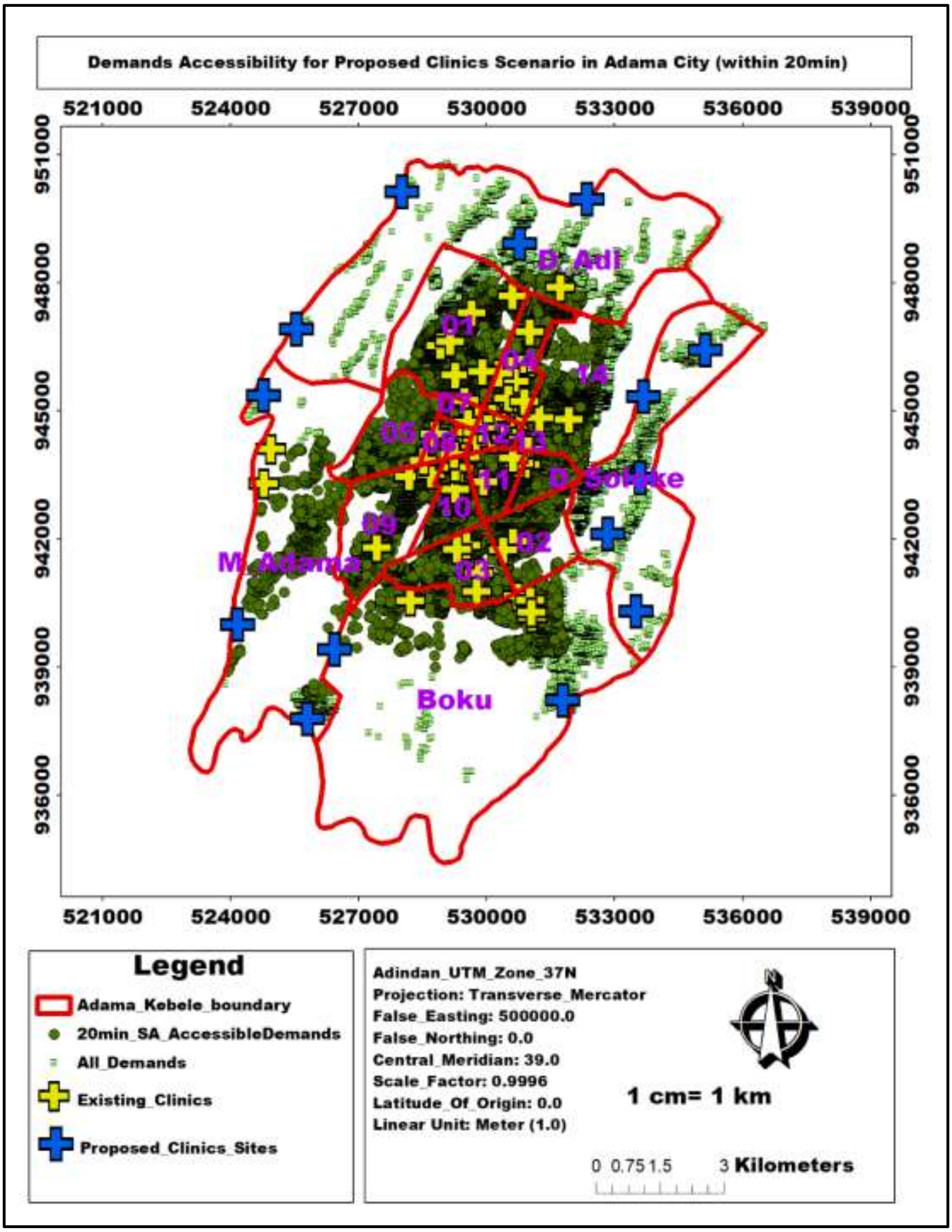

Fig. 4.11. Map of proposed clinic site within 20 minute impedance

Lastly, for the case of clinics in addition to the existing locations, using location-allocation model, the establishment of new fourteen facilities are needed to serve the total population of the city within 20 minute impedance located as shown in figure 4.11 above.

4.5. Discussions

In assessments made so far, there is no organized geodatabase based data handling. As a result, the location allocation of public facilities and planning processes are time consuming and not efficient since the routine activities are done on manual basis. However, the current option used in this study focuses on assessment of accessibility of healthcare services by the utilization of network analysis in the Arc GIS layers like transport routes, healthcare service sites and demand points. The continuation of this process has a significant impact in the betterment of the healthcare service system in the City. To mention some, spatial and attribute data managing, maintaining the existing routes, planning for additional healthcare facilities , and other related to facility location system in the overall operations in Adama city including utilization, managing, distribution of doctors and nurses, distribution of medicines or materials to store, research and others.

The outputs of the analysis (with respect to the existing healthcare services, existing road network, population, and land use) has got multitude of benefits in guiding users in selecting best sites for healthcare services management units, identifying low accessible service areas and identifying served and unserved demand with regard to standard program set by the government for urban planners and municipality of the city.

Besides in the implementation of best potential site selection Scheme developed in GIS environment helps decision making process efficient and timely. On the other hand, at the implementation time identifying of low accessible service areas and identifying served and unserved population service area analysis and location allocation analysis provides pieces of valuable information for the decision makers at different level of management in the Healthcare system.

In the previous time, Healthcare provision has been carried out using conventional methods which is not severely documented for reference purpose. To mention some of the strong points, the introduction of Geodatabase in the current healthcare services location allocation system in Adama City can make editing task much easier that can reflects any modifications in the site location segments systematically. The additional site will reduce travelling cost incurred by a patient and the additional site will help to reduce stress and over dependence on the only existing district facility.

So according to the new model:

About 87.10% of the demands are found in the farther distance away from the service area domain within 20 minute impedance. It is found that an individual house hold travels longer distance to get access to healthcare services. However because of the new potential site location the above mentioned service area domain value will be covered all of the demand within 20minute impedance.

CHAPTER FIVE

5: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Human capital in the form of basic healthcare service attainment is the collateral for economic development. It has a fundamental role in moving sub- Saharan Africa out of its present tragic state of underdevelopment. However the finding of this article revealed that there is a gross inadequacy in the distribution of healthcare services in the city in terms of available facilities. It also revealed the inequality of accessibility to basic healthcare services with antecedent impact on the development.

The problem related to healthcare service provision is related to when and how to plan for these services. The problem of when is more related to the planning stage at which these facilities should be planned. The quantity of these facilities were not earmarked in the master plan and planned in the city infrastructure plan scheme. Because such areas are planned based on pressure on development, therefore these follow the development and are not planned before development reaches an urban area. It is also seen that many of these city infrastructure plan in densely populated areas where high pressure of development already occur.

From the analysis of current condition, it is shown that not only people in densely area need additional facility; people in low populated areas need additional facility as well. Methods like location allocation analysis can be used as one of the approaches to plan the healthcare service provision. Location allocation model with reliable data on distance and demands proves that it can be used for optimal location. These models can be applied in identifying new optimal location for additional facilities in study area with various constraints. The study proves that the location allocation approach for social infrastructure planning can suggest the optimal locations which later resulted in improved geographical accessibility.

At the end, even though the final decision to plan healthcare services is lying on the hand of political leaders or decision makers, this result can be an important input for them to decide.

5.2. Recommendations

This study has explored the accessibility and efficiency of the facility in providing access to healthcare services in study area, which can provide a base for the planner or decision makers to develop a strategy to improve the accessibility of such centres.

- Use GIS results for planning through a participatory approach to healthcare service management by creating public awareness.
- The concerned authority should encourage all relevant groups (including healthcare services, health professionals, non-government organizations, media, private health insurers and governments) to provide access to evidence based, consumer friendly information that supports people in making healthy choices and in better understanding and making decisions about their use of healthcare services in a participatory way.
- Governmental, nongovernmental organization and other co-operate bodies who would like to establish additional healthcare facility in the Adama municipality should locate it at new potential area by using the prepared maps of GIS.
- Integrated Approach of GIS and Global Positioning Systems (GPS) have significant potential to address policy concerns regarding health inequalities that may partly arise through a lack of access to primary and secondary healthcare facilities. The introduction of new technologies such as GPS and detailed satellite imagery, for example, have the potential to create more accurate spatial data sets in order to estimate access measures at local scales to which local governments should give a due concern. .
- City government in collaboration with academic institutions should train GIS experts.
- Based on this method improvement to the plan was suggested in proposing new locations for the mentioned healthcare services. This was done by taking maximum travel time to each service within 20minute impedance scenarios. From this analysis to serve all of the population, one district hospital, two health centers and fourteen clinics were required.

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APPENDIX

Appendix A: Level of services, requirements and locations of health facilities

S/N	Level Service	Space Requirement	Catchment Area (radius)	Served Population	Location
1	Health post	0.11ha	< 1km	5,000-7,000	Center of catchment area, Within Residential area; Near intersection of residential roads; Far from noisy activities
2	Health Center	0.45 – 0.6 ha	< 2km	15,000-25,000	Within the serviced area ; Accessible along collector roads; Far from dumpsters, noisy activities
3	District Hospitals	2 ha	Woreda including rural areas	250,000	Within catchment area; Within walking distance from mass transport system Along collector roads
	General (Regional)	1-1.5 ha	Regional level	1,000,000	Within catchment area; Within walking distance from mass transport Along collector roads
	Referral Hospital	Variable		National	

Source: (FMOH, 2010).