



SCHOOL OF ENGINEERING, CLASS OF POST GRADUATE STUDIES

M.Sc. Degree Thesis Entitled

**LOCATION ALLOCATION ANALYSIS FOR URBAN PUBLIC SERVICES USING GIS
TECHNIQUES: A CASE OF PRIMARY SCHOOLS IN YEKA SUB-CITY, ADDIS ABABA,
ETHIOPIA**

By

Wondwossen Mindahun Eshetu

**Submitted to the School of Post Graduate Studies in partial fulfillment of
the requirements for the award of Degree of Master of Science in
Geodesy and Geomatics Engineering**

July 2016

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DEPARTMENT OF GEOMATICS ENGINEERING
MASTER'S DEGREE PROGRAM

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A Thesis

***Submitted to the School of Post Graduate Studies, Master's Degree
Program of Adama Science and Technology University, in Partial
Fulfillment of the Requirements for the Degree of Master of Science in
Geodesy and Geomatics Engineering***

July 2016

Adama, Ethiopia

DECLARATION

I, Wondwossen Mindahun with Registration Number: GSR/5557/06, hereby declare that this thesis is my original work and that it has not been submitted partially; or in full, by any other person for an award of a master's degree in any other university or institution.

Name of Author: _____ Signature: _____ Date: _____

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This Thesis has been submitted for examination with my approval as School Supervisor

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July 2016

APPROVAL

Thesis submitted by Wondwossen Mindahun, Entitled as “Location Allocation Analysis for Urban Public Services Using GIS Techniques: A Case of Primary Schools in Yeka Sub-City, Addis Ababa, Ethiopia” In partial fulfillment of the requirements for the award of a Master’s Degree in Geodesy and Geomatics Engineering

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ABSTRACT

The main topic of this study is entitled as Location Allocation Analysis for Urban Public Services Using GIS techniques; A Case of Yeka Sub-City, Addis Ababa, Ethiopia. Yeka Sub-City is geographically found at north-eastern part of Addis Ababa, having dynamic topography with gorges, undulating and slopes in various steepness. As estimated by CSA population projection for the year 2016, Yeka Population is 424,217. The 127 primary schools give service to 60095 students enrolled in the same year. The main Purpose of the study is to increase the coverage level of the primary schools in the Sub-City to enhance access of all school age population in the same area. The general objective set to deal with the problem is to make analysis and find results on balancing the distribution of primary schools and demands of the society for the services in the entire area of Yeka. Specific objectives followed are: to add new primary school sites; to select the most accessible candidate sites; to validate the new locations using site suitability in spatial analysis; to assess and evaluate the existing school locations and to develop justifiable frames of service distribution for government stakeholders or decision makers. The study profoundly helps both the government and the society in placements and use of primary schools in the research area based on scientific reasons. The study work is stretched up to the preparation of baseline information for the development of firm service-demand tie between the society and the primary schools in the interest area. Both qualitative and quantitative approaches are followed with an applied type of research in the study. The effort employed data which comprise empirical and theoretical works of different individuals and organizations. The secondary data are supplemented by primary data for consistent findings. Location allocation analysis Method supplemented by GIS techniques of network and spatial analyst is used. In the result it is identified that schools are not evenly distributed resulting in densely situated around infrastructures such as transport facility, road network and population, Schools are not properly separated from sources of noises, Existing Schools have been adequate for the current demand if they would have been constructed on the basis of planned distribution, Road network of the Sub-City is not properly structured so that this intern affected the analyses made based on the network analyst in GIS.

Key Words: Location allocation, facility (service), demand, Network analyst, spatial analyst, Service area, Primary school, Yeka Sub-City

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LIST OF ACRONYMS

AA	Addis Ababa
AACA	Addis Ababa City Administration
AACAILIC	Addis Ababa City Administration Integrated Land Information Center
AACG	Addis Ababa City Government
AACRA	Addis Ababa City Road Authority
AAEB	Addis Ababa Education Bureau
ABE	Alternative Basic Education
AIR	Apparent Intake Rate
BoFED	Bureau of Finance and Economic Development
CSA	Central Statistics Agency
DEM	Digital Elevation Model
EC	Ethiopian Calendar
EFA	Education for All
EMIS	Education Management Information System
ESAA	Education Statistics Annual Abstract
ESDP	Education Sector Development Programme
GCE	Global Campaign for Education
GER	Gross Enrollment Rate
GNP	Gross National Product
GPE	Global Partnership for Education
GPS	Global Positioning System
GTP	Growth and Transformation Plan
HCB	Hollow Concrete Block
IDA	International Development Association
ILIO	Integrated Land Information Office
LA	Location Allocation
LDP	Land Development Plan
MDGs	Millennium Development Goals
MoE	Ministry of Education
ND	Network Dataset

NER	Net Enrollment Rate
NGO	Non-Governmental Organization
NIR	Net Intake Rate
PTR	Pupil-Teacher Ratio
RTE	Right to Education
SA	Service Area
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UPE	Universal Primary Education
n.d	No Date

CHAPTER ONE

INTRODUCTION

Public policy makers and city planners need to design mechanisms of providing services especially in developing countries. From the present day situation, where world is facing the rapidly growing population contradictory to unalterable size of land to survive on, there must be a special means of resolving the challenges of providing services and facilities such as schools, health institutions (Clinics, healthcare centers, Hospitals, Ambulance stations etc.), water supply, market centers, power supply, infrastructures, fuels etc. in both urban and rural areas.

Education is an outstanding economic and social investment for long-term development, and a vital building block for weathering and recovering from crisis (GCE, 2010, P. 11). Since 1990, targeted actions by a number of countries and their development partners have helped to reduce by half the number of out-of-school children around the world. Yet 61 million children today are not in school—and there is abundant evidence that learning outcomes in many developing countries are alarmingly low, especially among disadvantaged populations. This global learning crisis is a major impediment to expanding both individual opportunity and national development (World Bank, 2013, P. 1). The Global Out-of-School Children Initiative, launched by UNICEF and the UNESCO Institute for Statistics in 2010 to accelerate efforts towards universal primary education by 2015, now operates in 26 countries (United Nations, 2013, P 2).

Africa is the leading continent to be noticed in which educational problems are devastating. Kevin Watkins (2013) states that, there are still some 30 million primary school-age children out of school one in every four in the region and progress towards universal primary education has stalled. Instead of hitting the Millennium Development Goal target of universal primary education by 2015, the out of school number could rise by 2 million. The combined effects of restricted access to education and low learning achievement should be sounding alarm bells across Africa (<http://www.brookings.edu>).

The political focus of primary education and its related implementation have placed Africa on track to achieve full enrollment by 2015. A significant number of African countries have excelled in this regard through committed policy interventions and adequate resource allocations. Ethiopia had a low initial net enrollment rate (50 percent in 1990), but this now

stands at 86.5 percent (2009/2010). This robust progress is based on, among other measures, the construction of classrooms: 16,000 in 2004 and 25,000 in 2008/09, of which 80 percent are in rural areas. In addition, education is emphasized in public policies and prioritized in public spending (MDGs Report, 2011, 26).

The market study shows that the present supply gap of education facility at primary level is 1,184 sections and at secondary level 1,116 sections. If additional primary and secondary schools are not materialized the supply demand gap will increase to 1,669 sections for primary school and 1,576 sections for secondary schools by the year 2018 (Addis Ababa City Government, 2002 E.C.). For instance in Ethiopia, the Ministry of Finance and Economic Development (MoFED, 2002 E.C.) quantified, Primary education, tertiary education and technical and vocational training are given high priority in the resource allocation and account for 46.4%, 22.9% and 15.9% of the overall Program cost, respectively. Formal primary education alone accounts for 41.7% of the total Program cost. This shows that primary education is number one priority. Besides, over 50% of the recurrent budget will go to finance formal primary education leaving only 7.4%, 6.8%, and 17.7% to secondary, TVET and tertiary educations, respectively. Other sub-programs of education and administration account only for less than 18% of the total estimated recurrent expenditure (P. 96).

The purpose of proceeding with this research problem is not to elaborate the primary education crisis in our capital but to raise mechanisms on levelling accessibility and coverage so that each primary school is accessible to the student population in the city at proper space with minimum distance cost particularly of the interest area.

1.1. Background of the Research Problem

The trend of public services delivery upon realistic scientific studies is not yet fully developed in Ethiopia. The demographic explosion in developing world countries has created a tremendous pressure on resources and public facilities (Ahmed M. W. Abdel-Latif, 2007, Background Section Para. 1). According to Abdel-Latif, lack of even distribution of the services causes population density to be very crowded around the service sites even leading them to be challenging to city planners while degrading other locations which are at remarkable distances from the facilities (Background Section Para. 1). This is best exemplified using Yeka Sub-City even though it is also affected by chronological order of City expansion. According to Atlas of Yeka Sub-City 2014, from the 13 Woredas in the Sub-City, Woreda 6 is occupied by 266 persons per hectare while only 19 persons per hectare in Woreda 10 in the 2007 census

report (P. 27). Another important factor for the uneven scattering of the population in fact is the topographical location of the Sub-City. Yeka Sub-City is characterized by vigorous type of topography with noticeable elevation deference and steep landscape especially in the northern part (Atlas of Yeka, 2014, P. 22).

Yeka Sub-City is located in part on the external border of the city exposed to both urban and rural inhabitants (i.e. partially urbanized and partially rural). This implies that it is subjected to rapid urban expansion for the coming few years.

This paper work particularly aimed at the emphasis on how the formerly constructed primary schools in Yeka Sub-City of Addis Ababa City are seen after location-allocation analysis in demand and service setup; where and how many new schools shall be established to achieve the objectives anticipated in the study; what maximum distance shall be covered by a student to get to the school nearest to him or her etc. Location allocation problem is implemented in ArcGIS software extension of network analyst. Among the problem type to be dealt in this analysis, minimizing impedance problem type is specifically chosen to undergo through existing and newly established primary schools to customer request location in the entire area. Service areas for the school facilities are generated to identify populations that are accessible to the facilities from the others based on the limited distance taken to reach the school destinations.

A technique of finding suitable areas for schools using spatial analyst extension tools from ArcGIS is applied to determine the most optimal location of the new schools to be established as a supplemental part of the Location allocation analysis.

1.2. Purpose of the Research

Identifying Locational problems of the schools in relation with the local community that holds student population then, the researcher's main intention is raising schools service coverage so that each primary school in Yeka Sub-City is accessible by students living in the Sub-City at a minimum distance.

1.3. Research Questions

Results from the research works are anticipated to be critical basis for mutual association between demands and school services in Yeka Sub-City. Shares of the population concerns that triggered the researcher to undertake the study is to come up with solutions to the following questions:

- How many additional primary schools are needed for Yeka Sub-City student population to balance distances covered by the students to get their schools?
- Where shall be the optimal locations for the school sites to be added to achieve better location in reducing the longest student-school distance?
- How can locational suitability of new school sites be achieved in relation with former schools, sources of noise to schools and existing population?
- How are the existing schools allocated in terms of distances from one another, sources of noises and existing population after suitability evaluation?

1.4. Objectives

1.4.1. General Objective

The main objective is to make analysis and find results on how to balance distribution of the primary schools in Yeka-Sub-City that provide services for the demands of the society in the area based on the norm that people tend to use more at nearby facilities than distant ones.

1.4.2. Specific Objectives

- To add new primary schools in the study area so that the transportation cost (distance to the facilities from the demand population) is minimized
- To select the most accessible candidate sites from among the added schools such that the longest distance is reduced
- To validate location of the newly proposed schools using suitability analysis.
- To assess location of existing schools using suitability analysis in Spatial Analyst Tools of ArcGIS extension
- To develop justifiable frames of service distribution for government stakeholders or decision makers

1.5. Significance of The Thesis

The result of this study profoundly helps both the government and the society in placements and use of primary schools in the research area based on scientific reasons. It is obvious that primary schools take the largest share in educating population. According to Addis Ababa City BoFED (2002 E.C), in Ethiopian case primary education is one of important areas of development endeavors (P. 16).

Therefore, this thesis work result after completion is believed to contribute to solve the various emerging problems on the subject matter of demand and facility relationships in the district of Yeka. It can be used for relevant urban land management stakeholders such as planners,

surveyors, Engineers, and other municipal personals as a reference to make concrete locational decisions related with services that have scientific basis.

1.5.1. Value for The Community

Making researches like this primarily benefit the society that are affected by the distributions of the service centers among their residence areas. After solving the problems, the time and impedances consumed for getting the service will be reduced. The most important among the implications of this research are averaging time and transportation cost for the students who specially take long distances from their home to their schools and forth daily. Different problems that encounter students due to long distance coverage such as traffic accidents, violations, sexual harassments, bad habits, addiction and Criminal acts etc. will also be minimalized.

Increasing school service on the other hand considerably increases children literacy. According to Eden (2012), educated children make the “entire community” beneficiary and thus education becomes the heart of the society (P. 8).

Nowadays adults that have not fully completed the primary knowledge even though it is mostly seen in rural of the country is also the problems of cities where the tendency of every kinds of job opportunities are high.

1.5.2. Contribution of Primary Schools in Adult Education

Another important issue in the needs for facilitating the full coverage of the primary schools in this area of interest facilitates adult education. The first goal for Education Sector Development Programme (ESDP IV), was improvement in access to quality primary education to make sure adults acquire the competencies, skills and values that enable them to participate fully in social, economic and political development of Ethiopia (P. 16).

High literacy rate (or low illiteracy rate) indicates a wide coverage of the primary education system and/or literacy programs in that a large proportion of the population have acquired the ability of using the written word in daily life and to continue learning. The higher the illiterate population of the country, the more the need for expanding primary education and adult literacy programs (UNESCO, 2009, P. 4). Improving adult literacy rates will also support other development goals such as children with literate parents staying in school (ESDP V, 2015, P. 17). The Functional Adult Literacy program aims to improve productivity and to contribute in the building of a healthy member of society; to prepare an individual able to participate in civic and other social issues meaningfully (EFA, 2015, P.).

1.5.3. Value for The Government

It is apparent for government again to see how primary schools are role playing in educating the society beside educating generations at school age. It is significant to the government to go through such kinds of studies for several applications. Public-sector facilities, such as schools, hospitals, libraries, fire stations, and Emergency Response Services (ERS) centers, can provide high-quality service to the community at a low cost when a good location is chosen. For example according to the MoE, Education and Training policy of 2002 E.C, from among the list of educational levels, primary education has given highest “priority” reasoning that it is the “right of every citizen” and “chief instrument for social and economic growth” (PP. 77-78).

1.6. Scope of The Thesis

The study is commenced by collecting the spatial locations of all primary schools in the area. Based on these spatial locations, additional locations are designated for further schooling to manage distance and time cost disproportion. Locational Judgments of the chosen sites are made through spatial analysis in terms of distance from existing schools, sources of noises and population and relevance of the selected sites are observed.

It also extends its analysis on examining the pre, ongoing and upcoming construction of primary school facilities in terms of suitability. It deals with extracting general information about how to locate the primary schools through location-allocation analysis in the ArcGIS environment. In general, it will be stretched up to the preparation of baseline information for the development of firm service-demand tie between the society and the primary schools in the area of interest.

1.7. Organization of The Thesis

The paper generally comprises of six chapters beginning from introduction (explaining backgrounds of the problem, setting purpose and objective statements) and ends at analysis and result discussion. Chapter two reviews terminologies and technical problem solving methods from the literatures. Both theoretical and empirical concepts of location allocation analysis are explained in detail. Primary education related literatures that describe efforts on education at a global, continental, country and local contexts and participatory organizations’ reports are also summarized. In Chapter Three, Historical, Physical and Socio-economic backgrounds of the study area is explained in detail. Chapter Four presents the research design, methodology and methods followed as well as the backgrounds of implemented data are involved. Brief

description of data and datasets used as inputs of analyses is also specified in the same chapter. Chapter five analyses and discusses the practical solutions of the problem towards the attainment of the designed purpose and objectives set in chapter one. The thesis is finalized by Summarization, Conclusions and Recommendations of the author in Chapter six.

1.8. Limitations

The researcher has been encountered different hindering problems and that could not be resolved. Most of Private School owners fail to cooperate. Owners or associates when meet researcher in want to know their school situation, are biased because of fear for government actions like tax collection, registration and renewal etc. They are suspicious and most of them are not volunteers to state and show the reality of their school situation even with officially supported letters of cooperation. The researcher because of such reasons in turn deprived of additional detail information from schools apart from education bureaus. Some of academic information that could not be available at sub-city level highly affected the study. Absence of student population sizes of Yeka Sub-City in certain years (or 2005EC, 2006EC, 2008EC) is one of the best example of reasons to be taken. Yeka District holds portion of student population in Addis Ababa city that is not distinctively separable from neighboring Sub-Cities. This issue was not dealt in the study to clearly identify student figures only within the subject area because no evidences are available. It needs high time and financial consumption to achieve it by exploring from either the population that schools serve or the schools themselves.

1.9. Delimitation

The schools existing in Yeka Sub-City have different capacity, grade levels, quality, ownership, infrastructural facilities and utilities. But these were not gone through because it is beyond the location allocation and spatial analyses methods.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

2.1. Definitions and Concepts

Research Design: - A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure.” In fact, the research design is the conceptual structure within which research is conducted; it constitutes the blueprint for the collection, measurement and analysis of data (Cothari, 1990, P. 31). C.R. Cothari stated, the preparation of such a design facilitates research to be as efficient as possible yielding maximal information (P 14).

Research Method: - is a particular research technique or way to gather evidence about a phenomenon. Therefore, methods are the specific research tools we use in research projects to gain fuller understanding of phenomena. That is, the range of approaches used in research to gather data which are to be used as a basis for inference and interpretation, for explanation and prediction (Abiy Zegeye et al. 2009, P. 17).

Research Methodology: - is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically (Cothari, 1990, P. 8). Methodology describes “the theory of how inquiry should proceed” that “involves analysis of the principles and procedures in a particular field of inquiry.” It involves the researchers’ assumptions about the nature of reality and the nature of knowing and knowledge. In other words, methodology represents “a theory and analysis of how research does or should proceed.” Methodology encompasses our entire approach to research. Our assumptions about what we believe knowledge is are embedded in methodological discussions and therefore have consequences for how we design and implement research studies (Abiy, et al. 2009, P. 17).

2.2. Location-Allocation Analysis

A number of researchers have defined the concept of location-allocation, from various aspects. But all of them have corresponding ideas at the concept level except the ways they explain. A. Stewart Fotheringham et al. (1995) have written as; **Location-allocation Analysis** is a frequently used set of techniques for solving a variety of locational problems, some of which can be politically sensitive. The typical application of a location-allocation model involves locating facilities by selecting a set of sites from a larger set of candidate sites, with the

selection procedure being a function of “optimality” in terms of the allocation of demand to the selected sites (P. 60). From these authors’ point of view, there must be certain grounds and tools in location-allocation analysis based on which judgments are made on alternative candidate sites from which the ultimate one is selected that is considered best of all for further analysis activities. By Monica Pratt et al (2014), Location-allocation analysis is described as a tool in the ArcGIS Network Analyst extension which determines an optimal location for one or more facilities that will service demand from the surrounding population (P. 56). Location-allocation is also defined on the other hand by Teitz & Bart (1968) as cited by Abdel-Latif (2007) as, mathematical programming models based on operation research techniques (methodology Section Para. 7).

Common Terminologies

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

- I. Facility:** - is used in location allocation problem to define an object whose spatial position is optimized through model or algorithm considering interaction with other pre-existing objects. In many location allocation models, one of the properties of the facility is the number of new facilities that need to be established in the area of interest. Thus a single facility problem inside the location allocation model needs to establish only one new facility considering the existing facilities. This is very simple instance of location allocation model. Multi facilities inside location allocation model are more common where more than one facility is located simultaneously. Another important property of facility is type. Facility type includes the capacity of the facility and the services of the facility. Facility can be characterized as capacitated and uncapacitated considering how much demand it can meet. If facility can supply an infinite demand then it is uncapacitated and when facility’s capacity is limited then it is capacitated. Facility can also be classified depending on the number of service it is providing. A facility can provide only one type of service or a group of services. Example of a single service facility is food shop which only provide food and example of multiple services is general hospital that provides multiple health supports.

Cost is another property of facility though which location allocation models can be differentiated. Facility cost can be two types. One is fixed cost and another is

variable cost. Fixed type of cost depends on the establishment expense of facility. Variable cost has a relation with service delivery.

II. Demand or Customer: - the second essential component of location allocation algorithm is demand which is also known as customer. A demand or customer is a person who needs accessibility to a service or to a supply of a good. Since location allocation problem is connected with satisfying demand, it is important to know their distribution, quantity and behavior. If we consider demand distribution in space, it can be assigned uniformly over the area or network. It can be assigned to specific point (geocoded) over the area. It can be assigned on the centroid of the area. However it can also be assigned randomly to simulate the problem over the area if there is no real data. Another hindrance of depicting reality into the research is using demand in the location allocation model. In the classical location allocation, demand is used as weighted value in the node or in the smallest unit of continuous space. Weighted demand means the aggregation of some customers on one point. Since the location allocation is NP hard problem, if the size of the demand decreases, it makes the decrement of computational complexity. When the quantity of the customer is very large, for example a million, then it is better to use weighted demand. The demand of the customer can also be either deterministic or stochastic. In case of deterministic, there is prior knowledge of demand while it is used into the model. In other case, demand will vary depend on the type or service of facility.

III. Location or space: - the third essential component of location allocation problems is space or location. There are three types of representation of space in location allocation problem. These are discrete, continuous and network based. In discrete space model, it is assumed that there is a prior knowledge of the candidate or potential sites. Since some best locations are selected from pre-selected potential locations, it is also referred as selected location model. Decision makers make the choice of candidate sites due to geographical or economical factor. Examples of these factors are zoning regulation, presence of structure and land availability etc. Some of the location allocation problems deal space as continuous. One or more continuously varying coordinates determine all the possible site locations. These continuous site locations are normally considered in Euclidean space. It is also known as site generation model. Because there is no presumption of potential sites for the model, rather appropriate site generation is done as an output by the model.

Another type of representation of space network based. Network space depends on graph-theoretic approach. Model using these approach can solve problem with much larger size. A network with either continuous or discrete space is considered in this type of space or location. Continuous network considers links of network for a continuous set of candidate locations.

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

Determining factors in the distribution of urban public services

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

- A. the amount of resources available (this affects the overall service level, which may explain the allocation pattern rather than the distribution);
- B. the composition and distribution of population, especially the geographical concentration of socio-economic characteristics of users, may explain some of the service distribution patterns;
- C. the number and intensity of political demands may affect service distribution, particularly to higher income groups; thus, these politically powerful groups are expected to be more effective in affecting the distributional patterns;
- D. the needs of citizens must be reflected by the demand to be effective in the distributional patterns; even when the needs of citizens are considered in service distribution, they are mostly defined by its providers (P. 354).

2.2.1. Location Allocation in GIS Software

Public-sector facilities, such as schools, hospitals, libraries, fire stations, and emergency response services (ERS) centers, can provide high-quality service to the community at a low cost when a good location is chosen (Arc-GIS 10, Version 10.0.3600). The ArcGIS location allocation analysis layer offers only six different problem types to answer specific kinds of questions which are minimize impedance, maximize coverage, minimize facilities, maximize attendance, maximize market share and target market share (Arifin, 2011, P. 22).

Arifin (2011) stated that:

Classical location allocation problem like P-median problem is same as minimal impedance where both case the objective is to minimize the sum of distances from demand points to facility. This problem type is used to locate private facility like warehouse and also public facility like library, Museum and airport in order to reduce the distance or driving time from facility to demand. By reducing distance the solution wants to reduce the transportation cost.

To implement emergency rescue center location like fire station, police station in order to cover maximum distance, maximize coverage type problem is used. If the objective is to cover 100% demand for emergency support this solution will help to model it.

In minimizing the facility the output of the solution will be the optimal number of facilities to cover all the demand. The difference between minimizing facility and maximizing demand problem is in determining the number of facility. In maximizing demand the number is predefined where in other type the solution finds the minimum number. These two type solution can be used in hierarchical order. With the assumption of demand weight will decrease in relation to the distance between the facility and the demand point, facilities are located. This is designed for implementing private facility like superstore, pizza shop etc. (P.22).

2.2.1.1. P-Median Model

As written by R L Church (n.d), the p-median location model involves the location of a fixed number p of facilities. The objective is to locate the p facilities in such a manner that the total weighted distance of serving all demand is minimized. According to this view, the amount of demand for facilities are multiplied by the shortest distance to the facility resulted in weighted distance for the demand point. The goal of the p-median problem is to determine p facilities in a predefined set with n ($n > p$) candidate facilities in order to satisfy a set of demands, so that the total sum of distances between each demand point and its nearest facility is minimized (P. 299). The p facilities composing a solution for the problem are called *medians* (Elon Santos Correa et al, n.d, 2nd Section para. 1). Gustavo Buzai (2013,), explained it as P-median model is an initial and simpler form of the location-allocation modelling procedures. Its objective is to minimize the sum of the total of the products of the population displacements from the points of demand (centroids that group the dispersed demand) to the supply points (P. 391). Fotheringham et al (1995), have also described this model as the most common location-allocation model is the p-median: facility sites are chosen from a set of candidate sites to

minimize the aggregate travel from each demand point to the nearest facility. Demand sites are therefore allocated to the nearest facility location and the output from a p-median solution is a set of locations and their associated service areas. Demand sites are therefore allocated to the nearest facility location and the output from a p-median solution is a set of locations and their associated service areas (P. 60).

2.2.2. ArcGIS Network Analyst

ArcGIS Network Analyst is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis (ESRI, 2005, Network Analyst section Para. 1). ArcGIS and its network analyst tool is the main software that is going to be employed in this study. ArcGIS for Desktop and Network Analyst will help the county make more informed decisions (Monica Pratt et al, 2014, P. 56).

2.3. Worldwide Perspective of Accessibility and Coverage

In the context of urban public facility planning, spatial equity means equal spatial separation from or spatial proximity to public facilities among residents. Of the many available means for measuring spatial equity, accessibility indices have therefore been the most widely used (Talen and Anselin study as cited by Chin-Hsien Liao, Chang Hsueh-Sheng, Ko-Wan Tsou, 2009, P.139). The “primary enrollment” and “primary completion” rates collected by UNESCO and reported by agencies like the World Bank rely on self-reporting by individual developing country governments, and they are based on estimates produced by central education ministries rather than household surveys (David Stasavage, 2006, P. 7).

Around the world today, UNESCO estimates that there are 755 million young people and adults who cannot read and write, of whom 127 million are aged 15 to 24 (Beyond2015, 2013, P. 5). Another report says, Today education remains an inaccessible right for millions of children around the world. More than 72 million children of primary education age are not in school and 759 million adults are illiterate and do not have the awareness necessary to improve both their living conditions and those of their children. Sub-Saharan Africa is the most affected area with over 32 million children of primary school age remaining uneducated. Central and Eastern Asia, as well as the Pacific, are also severely affected by this problem with more than 27 million uneducated children (Humanium, 2015, <http://www.humanium.org>).

Post2015.org in 2014 stated:

However, the report also makes a critical point that increasing access to primary education doesn't necessarily prove valuable unless it is seen as stepping stone toward secondary and higher education. The logic is that as the education demands of modern economies expand, getting children through primary schools will not be enough in itself. According to UNESCO, each year £80 billion is wasted globally on education initiatives, with 130 million school children around the world unable to read a single sentence after four years' attendance in primary school. The second goal in the United Nations MDGs is to achieve UPE, more specifically, to "ensure that by 2015, children everywhere, boys and girls alike will be able to complete a full course of primary schooling." Education is vital to meeting all other Millennium Development Goals: "Educating children gives the next generation the tools to fight poverty and prevent disease, including malaria and AIDS." Despite the significance of investing in education, the recent report, *Fixing the Broken Promise of Education for All: Findings from the Global Initiative on Out-of-School Children*—produced by UNESCO Institute for Statistics and UNICEF found that the world has missed this 2015 target of universal primary education, and there are currently 58 million children, of primary school age, out of school worldwide (<http://post2015.org>).

2.3.1. Organizational Efforts

I. Amnesty International

Amnesty International is a global movement of more than 3 million supporters, members and activists in more than 150 countries and territories who campaign to end grave abuses of human rights (Amnesty International, 2012, P. 2). Governments that have formally agreed to implement international human rights treaties have the obligation to respect, protect and fulfil the right to education including by making education available, accessible, acceptable and adaptable (P. 44).

II. Education For All

The Education for All Global Monitoring Report is an independent annual publication.

It is facilitated and supported by UNESCO. It is the product of a collaborative effort involving members of the Report Team and many other people, agencies, institutions and governments (EFA 2015, P. 2).

III. Global Campaign for Education (GCE)

GCE is an international coalition of child rights activists, teachers' unions and development organizations around the world, united in their determination to make the right to education a reality (GCE, 2012, Last Page).

Our analysis shows that governments have not consistently used these key interventions, despite broad consensus on their impact. ... Our research suggests that political interest in access to education is much greater than attention to the outcomes of education (GCE, 2010, P. 11). Despite the massive challenges facing education systems across the developing world, the last decade has seen significant improvement in certain countries. Countries with relatively low GNP per capita can still be effective in providing widespread access to good quality education – by ensuring that they allocate sufficient funds for education and prioritize teachers, textbooks and classrooms (P. 13). GCE UK is advocating for the UK Government to continue to play a leading role in pressing for reform and strengthening of the GPE to effectively fulfil its vital role in galvanising resources and focus to achieve education for all before and after 2015. Fundamental to this is strengthening the GPE's independence from the World Bank, and its capacity and governance. GCE UK will also be seeking a strong commitment from the UK Government at GPE's next replenishment in 2014, to galvanize other donors (GCE, 2013, P. 52).

IV. Oxfam International

Oxfam is an international Confederation of 15 organizations working together in 92 countries to find lasting solutions to poverty and injustice (Oxfam 2010 – 2011, P. 3). Sixty one million children are not in primary education. To get them there and to ensure all children receive equitable, good quality basic education, \$26 billion is needed (Oxfam Int. 2012-2013, P. 29). Oxfam works with donors and institutions to press for more funding for education, primarily working in countries with communities to improve the situation for their children. Oxfam and partners are involved in a three-year campaign, '2015 is Tomorrow, Act for Education'. It aims to ensure that the government keeps its promises to allocate more funds to education, and to facilitate community involvement in holding local government to account. While the promise to increase the education budget has not yet taken place, the campaign has achieved engagement at the community level, and Oxfam has convened civil society actors who are now working together for a joint cause (P. 30).

V. Right to Education Project (RTE)

The Right to Education Project promotes social mobilization and legal accountability, focusing on the legal challenges to the right to education. It conducts research, builds capacity, develops resources for advocacy, and collaborates with a wide network of human rights, development and education practitioners (Rishmawi & Elliott, 2012, P. 6).

VI. Save the Children

Save the Children works in more than 120 countries. We save children's lives. We fight for their rights. We help them fulfil their potential (Save the Children 2012a, Page Cover). Save the Children has been a child rights pioneer for more than 90 years. In 2012, Save the Children's programs and campaigns touched the lives of more than 125 million children around the world (Save the Children, 2012b, P. 3). Every child has a right to education, but not every child enjoys this right. Indeed, 61 million children worldwide are unable to attend school. Some children are let down by authorities not honoring their commitments to education. In many countries, humanitarian emergencies or armed conflict mean that children are not able to go to school (P. 5). Despite significant progress reducing the number of out of school children worldwide, recent data show that the number of children who are excluded from education is still 58 million (Save the Children, 2014, P. 1).

VII. The Global Partnership for Education

The Global Partnership for Education, of which UNESCO is a member, provides an international, multilateral framework for cooperation in education (UNESCO 2011, P. 21).

VIII. United Nations Children's Fund (UNICEF)

UNICEF supports Back – to – School (BTS) and its initiatives such as Back – To – School, Go – To – School (GTS), Stay – In – School (SIS) and Welcome – To – School (WTS) (UNICEF, 2013, P. 4). These campaigns have also involved efforts to improve quality education to keep children in school who have enrolled but for a range of reasons are likely to drop out of school. The UNICEF Back-to-School Guide was created from data and analysis gathered about Back-to-School programs from 55 countries in all seven regions in which UNICEF operates (P. 5). Back-to-School campaigns can burden the capacity of education systems due to lack of infrastructure and human resources, they can also provide opportunities for the government to build education systems capacity. Documentation has shown this in areas such as the

establishment or strengthening of education information management systems (EMIS), school construction, education financing, and teacher training and certification policies (P. 71).

IX. United Nations Educational, Scientific and Cultural Organization (UNESCO)

UNESCO is the only United Nations agency with a mandate to cover all aspects of education (UNESCO, 2011, P. 7). The universal right to education proclaimed by the Universal Declaration of Human Rights (Article 26) is at the very heart of UNESCO's mission and is an integral part of its constitutional mandate. UNESCO's Constitution expresses the belief of its founders in: "full and equal opportunities for education for all to advance the ideal of equality of educational opportunity." (P. 8). UNESCO has provided targeted support to countries considered among those least likely to achieve EFA. In the 2010-2011 biennium, 20 priority countries were thus given special support in the areas of literacy, teachers, TVET or sector-wide policy and planning, in order to speed up progress towards EFA. These countries are Afghanistan, Angola, Bangladesh, Burundi, Cambodia, Chad, Democratic Republic of the Congo, East Timor, Ethiopia, Guinea, Haiti, Lao People's Democratic Republic, Lesotho, Madagascar, Malawi, Mali, Mauritania, Rwanda, Togo, and Yemen. UNESCO is targeting some 15-20 additional countries in the 2012-2013 biennium, while continuing to support the 20 initial priority countries through extra budgetary resources. (P. 21).

X. World Bank

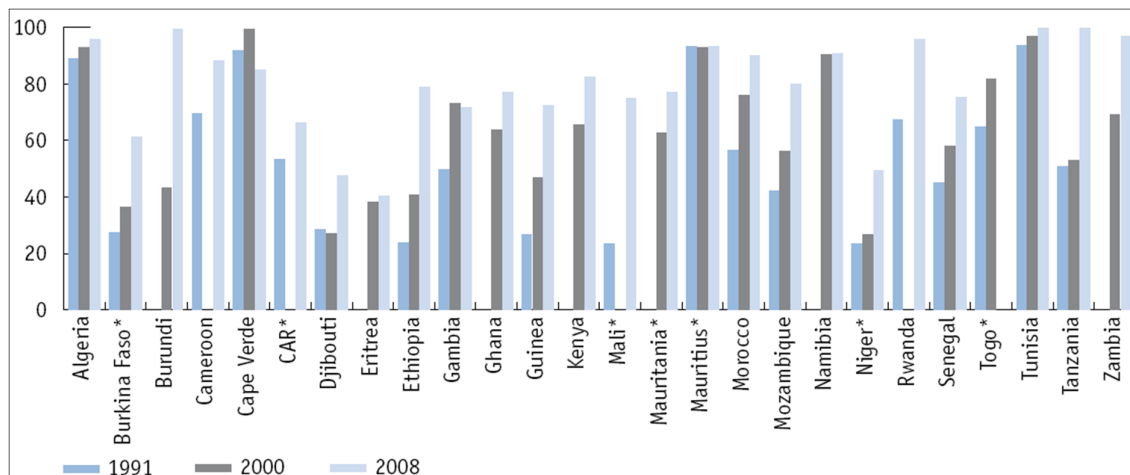
Helping countries accelerate progress toward the Millennium Development Goals for universal primary education. Over the past two years, the Bank has provided \$2.7 billion in financing from the International Development Association (IDA) for basic education in the poorest countries. We are working closely with the Global Partnership for Education (GPE)—the Bank supervises the implementation of most GPE grants, and has provided IDA co-financing in a number of countries (World Bank, 2013, P. 1).

2.4. African Continent Perspective of Accessibility and coverage

In terms of the expansion of elementary school, many African countries that are generally considered to be poor had traveled great distance in this regard and had 60-70 percent of their school-age children enrolled in elementary schools (MoE, 2002E.C, P. 8). From among these countries, according to the World Bank Report of 2013 Democratic Republic of Congo (DRC), Ethiopia, Nigeria and South Sudan are mentioned to be supported to education. The report continues saying the Bank committed US\$ 1.1 billion to education in the DRC from 2004 to

2013 to Democratic Republic of Congo for education, US\$3.76 billion for education in Ethiopia between 2001 and 2013, approved a US\$150 million commitment to Nigeria's new State Education Program Investment Project (SEPIP) and led a multi-donor trust fund project to support the development of the education sector in South Sudan (PP. 2-7). Today better outcomes are blooming in Africa because most African Countries are making progresses towards education. It is particularly encouraging that many of the countries facing the greatest challenges have made huge progress, with enrolment rates in sub-Saharan Africa going up to 76% from a base of 58% (Save the Children, 2012c, P. 1).

The 2011 MDGs Report has written; enrollment in primary education has continued to rise, reaching 89 percent in the developing world. The report continued, Nonetheless, Africa has made tremendous strides toward achieving universal primary education, increasing its net enrollment rate from 65 percent in 1999 to 83 percent in 2008. Indeed, this is the MDG where African countries have made the most progress (P. 24).



Source: MDGs Report (2011, P. 25)

Figure 2.1: Progress in Net Enrollment Rate of Primary Education for selected African Countries

2.5. Local Perspectives of Accessibility and Coverage

In the Ethiopian case, primary education and educating girls are important areas of development endeavors. The key indicator of education is the level of literacy rate. Literacy rate is used as a measure of the effectiveness of the primary education system, which is often seen as a proxy measure of social progress and economic achievement (AACG, 2002 E.C. P. 18). Considerable progress has been made through school construction by reducing the distance between schools and pupils' homes (ESDP V, 2015, P. 15). Save the Children in Ethiopia built

the capacity of government sectors on disabilities and thanks to its advocacy efforts the government has now adopted a guideline to provide education to children with disabilities in inclusive settings (Save the Children 2014, P. 3). According to the 2015 program for literacy improvement in Ethiopia also Save the Children has increased school attendance as well as reading levels (Save the Children 2012b, P. 9). In The 2013 UNICEF BTS guide report, the Ethiopian Government and partners developed an assessment process in advance of emergencies to assist in micro-planning for universal primary education (UPE), Rapid Assessment of Learning Spaces (RALS) mapping and strengthening of Education Management Information System (EMIS). All learning spaces, including schools and non-formal learning spaces, of the target regional states were mapped (P. 71). In Ethiopia's GTP (2010) for education and training, the ESDP IV had set goals stated as producing democratic, efficient and effective, Knowledgeable, inspired and creative citizens who contribute to the realization Ethiopia's vision of being a middle income economy (MoFED, 2010, P. 86). The Ethiopia MDGs Report (2012), indicating the MDG 2 of Achieving Universal Primary Education quantified the number of primary schools increased from 16,513 in 2004/05 to 29,482 in 2011/12 while the Net number of students enrolled in primary schools rose from 3.8 million in 1995/96 to 14 million in 2006/07, and reached 16.9 million in 2011/12 (P. 11). The report also adds the NER for primary education (grade 1 – 8) increased from 77.5% in 2005/06 to 85.4% in 2011/12 (Summary Section, Goal 2).

Besides the international governmental and non-governmental organizations fighting for education at global level, there are also other homegrown (Local NGOs) and foreign associations that have been contributing for education. They have been working in different cities and towns throughout Ethiopia and among them few of them are working by opening their branch offices in AA (Table 2A).

Table2. A: Local and Foreign Charity NGOs for Children Education Sector in AA

No	Name of the Institution	Major Services	Location
1	Abebech Gobena Yehetsanat Enkbekabena Limat Dirijit (AGOHELD)	Orphanage, boarding school, foster families etc.	Arada, Gulele and Addis Ketema Sub-Cities
2	Almaz Ashene Children and Family Support Organisation (ACFSO)	Orphanage; foster families; food, clothing, Education etc.	Gulele Sub-City
3	Action For Self Reliance Organization (AFSR)	Drop-in Centre, food, education and healthcare support	Nifas Silk-Lafto Sub-City
4	Arat Kilo Child Care & Community Development (AKCCCD)	Education, health service, and recreation facilities etc.	Arada Sub-City
5	Bego Fekadegnoch Le Beteseb Ediget	Foster care, food, clothing, education, healthcare, and psychosocial support	Kirkos, Nifas Silk-Lafto, Akaki Kaliti Sub-Cities
6	Centro Italiano Aiutiali Infanzia (CIAI)	Shelter, educational support and income generating activities	Four Sub-Cities
7	Cheshire Services Ethiopia	Provision of practical skill and vocational trainings and educational material support etc.	Kolfe-Keranyo, Addis Ketema, Gulele and Arada Sub-cities
8	Children Aid Ethiopia (CHAD-ET)	Drop in Centre, education, healthcare and psychosocial services	Addis Ketema Sub-city
9	Ethiopian Catholic Church Secretariat (ECS)	Orphanage, educational, health and livelihood support	All Sub-Cities
No	Name of the Institution	Major Services	Location
10	Ethiopian Evangelical Church Mekane Yesus – Central Ethiopian Synod (EECMY-CES)	Provide shelter through drop-in centers and day care; facilitate foster families; and provide support to meet basic needs	Nine Sub-Cities
11	Ethiopian Orthodox Church Child & Family Affairs Organization (EOC-CFAO)	Educational materials, psychosocial support and family empowerment	Yeka Sub-City

Source: The African Child Policy Forum (2008, PP. 14 – 41)

2.5.1. Access and Coverage Indicators of Education In Addis Ababa City

Access measures the proportion of children who have got right to entry to school and the total population of the official school admission age. Whereas, coverage measures the number of

children in school with the total size of the school age population. It is used for assessing how far a country/region has succeeded in bringing to school all those who have the right to attend (A.A BoFED, 2013, P. 19).

2.5.2. Primary Education

Primary education in Ethiopia is categorized under general education, the education level starting from grade 1 and ending at grade 8 and it constitutes two cycles: first cycle (grade 1 – 4) and second cycle (grade 5 – 8). The expected age enrolled in primary education is from age 7 to age 14 (AAEB, 202013/14, P. 13).

2.5.3. Number of Primary Schools in Addis Ababa

As can be seen from the following table 2.1, the number of primary schools has increased from 730 in 2003E.C (2010/11) to 814 in 2007E.C (2014/15) which counts to 10.3% increment within consecutive five years. Addis Ababa City Education Bureau justifies this on its Education Statistics Annual Abstract of 2013/14 the increment is because of new schools built by government and private sectors in different Woredas whereas still the shortage of primary schools in different expansion areas and periphery of the administration. Nevertheless, the stakeholders like the community, and the NGOs have given great attention in support and establishment of new schools which highly exuberant in assuring access to respond the expansion of demand in getting educational opportunities (AAEB, 2014/15, P. 13).

Table 2.1: Number and Ownership of primary Schools from 2003 – 2007EC.

Year	Number of Primary Schools in Addis Ababa			
	Gov't	Public	Private & Other	Total
2003	117	105	508	730
2004	115	105	547	767
2005	213	2	553	768
2006	214	2	579	795
2007	217	2	595	814

Source: Education Statistics Annual Abstract 2006E.C & 2007E.C, City Government of Addis Ababa Education Bureau

2.5.4. Access to primary Education

Access is defined as the extent to which the “school-age” population able to access the first grade of a particular level or cycle of education. The most commonly used indicators to measure this aspect of the education sector are the Apparent Intake Rate and the Net Intake Rate (AAEB, 2013/14, P. 14).

I. Apparent Intake Rate (AIR)

AIR is the total number of new entrants in grade one of primary education, regardless of age, expressed as a percentage of the population at the official primary school-entrance age. It can be calculated by dividing the number of new entrants in grade one, irrespective of age, by the population of official school-entrance age (7 years old in our case) (AAEB, 2014/15, P. 14).

$$\text{AIR} = \frac{\text{New entrants to Grade 1 (all ages)}}{\text{Population of the Official admission Age (7 years)}} * 100\% \dots \dots \dots 2.1$$

Table 2.2: AIR from year 2003 – 2007EC.

Year	Grade one Enrollment (All Ages)	School Age Population (Age 7)	Apparent Intake Rate (AIR)
2003	65911	51334	128.40%
2004	65889	52175	126.30%
2005	71893	53285	134.90%
2006	72210	54417	132.70%
2007	72275	57013	126.77%

Source: Education Statistics Annual Abstract 2006E.C & 2007E.C, City Government of Addis Ababa Education Bureau

From table 2.2, the apparent Intake Rate in 2003E.C. was 128.40% and in 2005E.C. it was 134.90% which shows high participation of new entrants in grade 1 as well as it facilitates the achievement of education sector MDGs i.e. Universal primary education (UPE) and Education for All (EFA) objectives and targets. However inversely it is observed decreasing in 2007EC. A high Apparent Intake Rate indicates a high degree of access to primary education (UNESCO, 2009). Besides, these Show that there are students who are age of above or below 7 years old in grade one (AAEB, 2014/15, P. 14).

II. Net Intake Rate (NIR)

NIR is the proportion of new entrants in grade 1, who are 7 years old and the total population of seven years old. It is a key parameter used for projecting school enrollment; it measures the extent of access of the population of school admission age (AAEB, 2014/15, P. 15).

$$\text{NIR} = \frac{\text{Grade 1 pupils of official admission age}}{\text{Population of the official admission age}} * 100\% \dots \dots \dots 2.2$$

Table 2.3: NIR from year 2003 – 2007EC.

Year	Grade 1 Enrollment (Age 7)	School age population (Age 7)	Net Intake Rate (NIR)
2003	18982	51334	36.90%
2004	25320	52175	48.80%
2005	26088	53285	48.95%
2006	33761	54417	62.04%
2007	38250	57013	67.09%

Source: Education Statistics Annual Abstract 2006E.C & 2007E.C, City Government of Addis Ababa Education Bureau

NIR from year 2003E.C. to 2007E.C. has shown not meaningful improvement. Actually this failure to achieve the target set could happen due to the early starting of the Children at the age of 6 to grade 1. In Addis Ababa city about 33.67% (18323) of the grade one new entrants are at the age of 6 or below in year 2006E.C. This is the exceptional factors for Addis Ababa that decline the implementation status of NIR in accordance to education bureau ESDP IV, GTP, and MDGs (UPE and EFA). Hence, they are early starters and they will be grade two when they are age of 7. Hence, the lower the NIR may not necessarily indicate completely the presence of out of school children in the Addis Ababa context (AAEB, 2014/15, P. 15).

III. Gross Enrolment Rate (GER)

GER is total enrolment in a specific level of education, regardless of age, expressed as a percentage of the eligible official school-age population corresponding to the same level of education in a given school year or it is calculated by dividing the number of pupils (or students) enrolled in a given level of education regardless of age by the population of the age-group which officially corresponds to the given level of education. In Ethiopia, the school age population for the primary education is 7-14 years (AAEB, 2014/15, P.16).

$$GER = \frac{\text{Pupils in primary (grade 1 – 8)}}{\text{School age population for primary (age 7 – 14)}} * 100\% \dots \dots \dots 2.3$$

Table 2.4: GER Grade 1 – 8 from 2003 EC to 2007 EC of Addis Ababa City

Year	Enrollment	School age Population (Age 7-14)	Gross Enrollment Rate (GER)
2003	484517	450444	107.60%
2004	487344	496938	98.00%
2005	544303	518384	105.00%
2006	546516	530358	103.05%
2007	505619	349016	144.87%

Source: Education Statistics Annual Abstract 2006E.C & 2007E.C, City Government of

Addis Ababa Education Bureau

As can be observed from table 2.4, the GER of primary level grade 1 – 8 including Alternative Basic Education (ABE enrolment) is fluctuating over the last five years. The GER for year 2007 E.C was 144.87% that implies a much declined participation of pupils with official age group or not. The rate result closest to 100% in the 2004 E.C on the other hand indicates normal because the amount of under aged and over aged student population is less than the population of student that are at official school age which is the target to be achieved. The rates of GER exceeding 100% is unavoidable circumstances in real situation (AAEB, 2014/15, P.17). Similarly in the FDRE ESDP V, it is stated; rates of more than 100% are technically impossible but arise due to imprecise population figures and challenges in measurement of student age at the point of entry (e.g. lack of uniform birth registration) (MoE, 2015, P. 15).

IV. Net Enrollment Rate (NER)

This is enrollment of the official age group for a given level of education expressed as a percentage of the corresponding population. It is calculated by dividing the number of pupils enrolled who are of the official age-group for a given level of education by the population for the same age-group (AAEB, 2014/15, P. 19).

$$\text{NER} = \frac{\text{Pupils of primary school age who are enrolled in grade 1 – 8}}{\text{School age population for primary (age 7 – 14)}} * 100\% \dots \dots \dots 2.4$$

Table 2.5: NER Grade 1 – 8 from 2003 EC to 2007 EC of Addis Ababa City

Year	Enrollment (Age 7-14)	School Age Population (Age 7-14)	Net Enrollment Rate (NER)
2003	331109	450444	73.40%
2004	371184	496938	74.20%
2005	381003	518384	73.50%
2006	399470	530358	75.32%
2007	329745	349016	94.48%

Source: Education Statistics Annual Abstract 2007E.C, City Government of Addis Ababa Education Bureau

As pointed in table 2.5 above, the NER at primary in 2003 E.C. was 73.40% and in the 2007 it was 94.48%, an increment by 21.08%. This goes with continual increment of population projection and enrollment in every year. The reason why NER is below 100% is that it excluded under aged pupils who are enrolled in primary at age 6 and those age 13 and 14 who are attaining in grade nine and ten (AAEB, 2014/15, P. 19).

V. Pupil Section Ratio

In primary school standards number of students in a class is set to be 1:50. Hence, construction of new schools has been done every year to meet this standard (AAEB, 2014/15, P. 36).

VI. Pupil Teacher Ratio

Average number of pupils (students) per teacher at a specific level of education in a given school-year and is used to measure the level of human resources input in terms of number of teachers in relation to the size of the pupil population (UNESCO, 2009, P. 25).

Calculation method is by dividing the total number of pupils enrolled at the specified level of education by the number of teachers at the same level.

$$PTR = \frac{\text{Total student population (in grade 1 – 8)}}{\text{Total teachers population teaching in the same grade levels}} \dots \dots \dots 2.5$$

According to UNESCO (2009), a high pupil-teacher ratio suggests that each teacher has to be responsible for a large number of pupils. In other words, the higher the pupil/teacher ratio, the lower is the relative access of pupils to teachers. It is generally assumed that a low pupil-teacher ratio signifies smaller classes, which enables the teacher to pay more attention to individual students, which may in the long run result in a better performance of the pupils (P. 32).

VII. Adult Literacy

In recent years, adult literacy has come to be seen as one of the fundamental tools necessary for successful economic performance in industrialized societies. Literacy is no longer defined merely in terms of a basic threshold of reading ability. As society becomes more complex and low-skill jobs continue to disappear, the concern about adults' ability to use written information to function in society continues to rise. For the purpose of this indicator, 'literacy' is defined as the ability to understand and employ printed information in daily activities; at home, at work, and in the community to achieve one's goals and to develop one's knowledge and potential (Matheson, et al – 1996, P.69).

The Government of Ethiopia in the first GTP (2010) has introduced adult education as one of the Central "Strategic Pillars" to increase potentials for the implementation of government policies, strategies and programs (MoFED, 2010, P.25). On the other hand, The ESDP IV of the FDRE MoE stated that a literate population is a precondition for any nation to become competitive within a global economy and without a significant increase in the adult literacy rate Ethiopia will not be able to achieve a middle-level income status within a foreseeable time (MoE, 2010, P. 13). The FDRE MoE (2002E.C) defining limited access quantified, 1.9 million

or only 20% of the school-age children had the opportunity to attend first to six-grade education in Ethiopia. Even by African standards said the MOE, in terms of expansion of educational opportunity, our country had extremely lagged behind. (P. 9).

VIII. Previous Attempts

Realizing the positive role that education plays in the development of a society and reducing poverty, the Ethiopian government has adopted a new Education and Training Policy (ETP) in 1994 E.C. The document outlined the mission and goals of the new education system of Ethiopia to achieve the present and future national economic and social development goals. The policy focuses on increasing access to educational opportunities with enhanced equity, quality and relevance. This was the basis for the multi-year Educational Sector Development Program (ESDP) that started in 1997/98 E.C. with the long-term goal of achieving universal primary education by the year 2015 (MoFED, 2002 E.C. P. 89).

According to MoFED, the following are the summary of the assessments of Educational Sector Development Program (ESDP):

- Coverage of primary education as measured by enrollment in grades 1-8, showed a rapid expansion during the first four years of the implementation of ESDPI. The enrollment in primary grades increased from 4,468,294 in 1996/7 to 7,401,473 in 2000/1, (in the fourth year of the implementation of ESDPI) against a target of 7 million students for the end of the ESDPI period. This constitutes annual rate of growth of 13.4% in enrollment during the four-year period under review.
- During the same four-year period, gross enrollment rate (GER) for first cycle (1-4) primary increased from 54.8% to 83.0%; for second cycle (5-8) primary moved up from 17.9% to 30.8%; and for the complete (1- 8) primary moved up from 34.7% to 57.4%. (P. 89)

CHAPTER THREE

PHYSICAL AND SOCIO ECONOMIC BACKGROUND OF THE STUDY AREA

3.1. Historical Backgrounds

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

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

3.2. Geographical and administrative division of Yeka

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

3.3. Topography or Relief Patterns

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

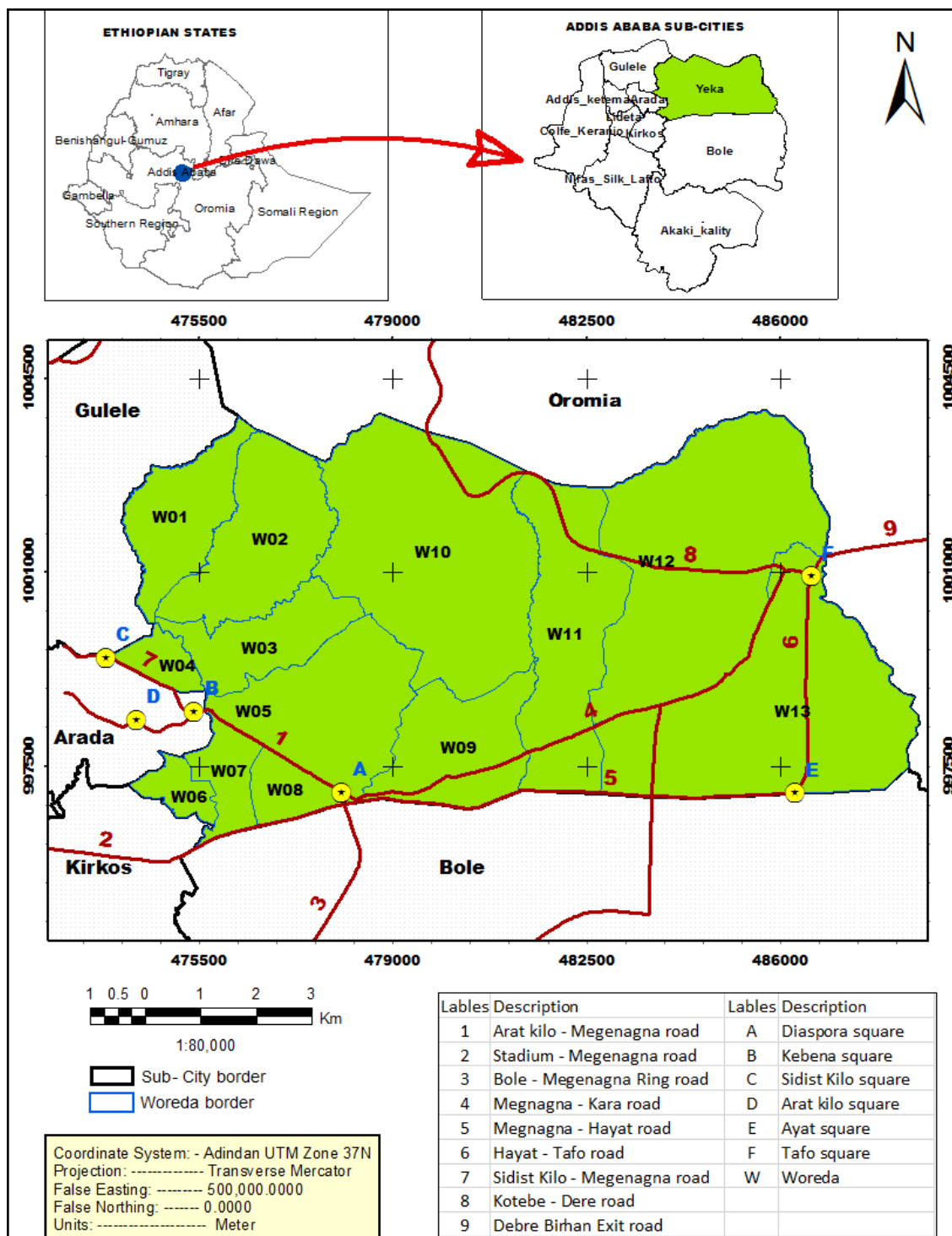


Figure 3.1: Location Map of Yeka Sub-City

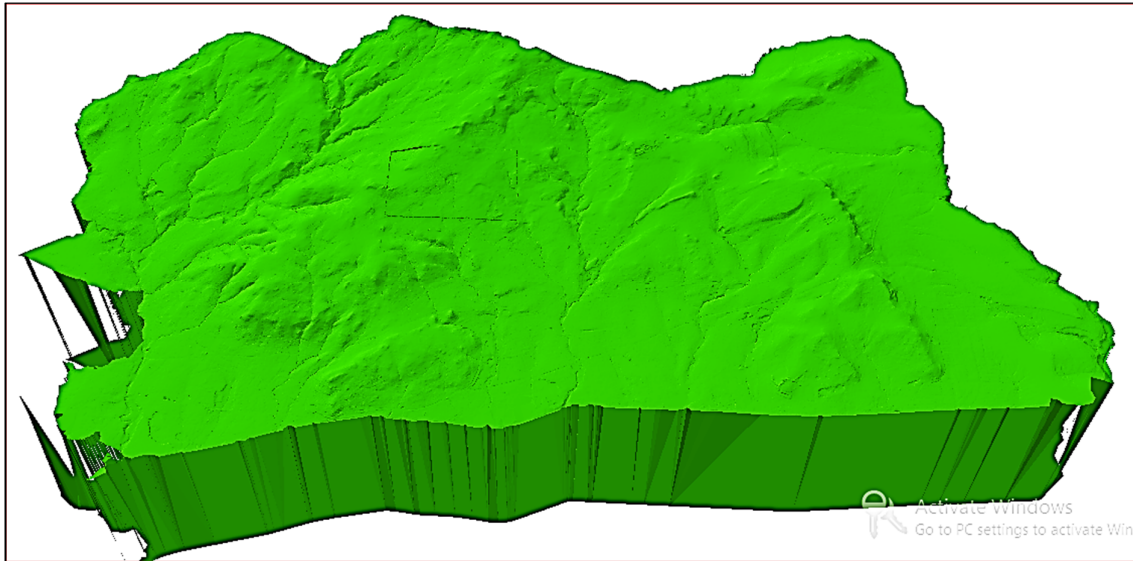


Figure 3.2: 3D diagrammatic surface representation of Yeka Sub-City

3.4. Land Area and Population of Yeka

The land area covered by Yeka Sub City is 8213.11 hectares and this constitutes 15.8 % of the total land area of the city which makes Yeka in 3rd place in land area covered from the 10 sub cities next to Bole and Akaki Kality. According to population projection values of 2016 made by CSA, the total population within this sub-city is 424,217 which is 12.66 % of the entire population of the city (i.e. 3,352,000). This intern tells us approximately 52 people live in the Sub-City per hectare. From the total population of Yeka 196,452 are male while 227,765 are female (Atlas of Yeka, 2014, P. 24).

3.5. Land Use Classes of Yeka Sub-City

Several land use types are recognized in irregularly mixed appearance with one another through the whole study area. Before school facility allocation is made, it is important to identify each and every parts of the area under study and for what purpose it is used because it helps to isolate where the demand (request) for the school exists and where there is not, where the demand is high and where it is low etc. According to Addis Ababa City Administration Integrated Land Information Center of 2014, there are about 23 number of land use types identified in Yeka Sub-City in general as can be described as follows.

3.5.1. Administration

Beside the main city administration, the Sub-City has two hierarchically structured administrations one at sub-city level the second at woreda levels. The first one is Yeka Sub-

City administration that serves as the center for woreda administration and responsible for the main city government whereas the second one is prepared for each woreda in the Sub-City that closely governs the issues of population under it and responsible for the Sub-City administration.

3.5.2. Commercial

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

3.5.3. Cultural and Social Welfare

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

3.5.4. Education

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

3.5.5. Field Crop

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

3.5.6. Health

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

3.5.7. Infrastructures and Utilities

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

3.5.8. Manufacturing and Storage

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

3.5.9. Mixed Residential

These land use types are settlements used for commercial purposes besides their usage for residences. Such kinds of houses are built on the ages following specific patterns of asphalt and other roads commonly accessible for population flow. There is no difference between mixed residential and residential types of land use except the former is built mostly following road ages and thus it is another source from which demands for primary school age population are raised.

3.5.10. Municipal Services

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

3.5.11. Open Space

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

3.5.12. Plantation

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

3.5.13. Recreation

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

3.5.14. Religious Institution

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

3.5.15. Residential

This type of land use works for only residential use. Southern, westerns and central most parts of the Sub-City is occupied by the population houses. Residential takes the highest of all other land uses area cover. It is where demand of student population for school facilities is believed to grow. It is also the place in which most of existing primary schools especially those possessed by private ownership are hosted. Residential areas are also assumed to be clues around which new sites for additional schools (candidate sites) proposed to be established. 2469.44ha (30.07%) the land use is enclosed for only residential purpose.

3.5.16. River

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

3.5.17. Riverine

Riverine is stream which drain or not drain to river and resembles (is related to) river but not always flown by water. It is characterized by wet and moisturized land. It is an inland or Coastal area comprising both land and water.

3.5.18. Road Network

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

Table 3.1: Type and lengths of roads existing in Yeka Sub-City

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

Source: Yeka Sub-City ILIO and aerial photograph of the area under study captured in 2011

3.5.19. Special Use

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

3.5.20. Transport Terminal

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

3.5.21. Under Construction

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

3.5.22. Vegetable Farm

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

3.5.23. Mixed Forest

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

Table 3.2: The Land Use Land Cover Types and Their Respective area coverage

No	Land use Type	Area (Hectares)	Area (%)
1	Administration	277.59	3.38
2	Commercial	72.72	0.89
3	Cultural & Social Welfare	35.23	0.43
4	Education	175.46	2.14
5	Field crop	1433.54	17.45
6	Health	19.47	0.24
7	Infrastructure and utilities	4.33	0.05
8	Manufacturing & Storage	134.10	1.63
9	Mixed Residential	93.82	1.14
10	Municipal Services	30.35	0.37
11	Open space	461.66	5.62
12	Plantation	1395.72	16.99
13	Recreation	9.16	0.11
14	Religious Institution	133.52	1.63
15	Residential	2469.44	30.07
16	River	159.24	1.94
17	Riverine	2.34	0.03
18	Road network	715.41	8.71
19	Special use	31.32	0.38
20	Transport terminal	2.47	0.03
21	Under Construction	189.42	2.31
22	Vegetable farm	8.55	0.10
23	Mixed forest	358.20	4.36
Total		8213.04	100

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

In general, it can be easily identified that which land use types are related to population from which request for school facilities arise and which are the facilities (services) answer the needs of the population. According to the description made on the land use types and the above table, the sum total of residential and mixed residential (2563.26ha or 31.21% or approximately 1/3) of the total land area coverage of land uses supposed to hold primary school age population requiring school facilities. Generalizations for student population from the given land use types are on the following basis:

- I. The researcher apart from the obtained data has gone through the area of study and made observations before identification is done
- II. The Mosaicked high resolution aerial photo of the study area was viewed in relation with the obtained data from the Municipals of the City and the Sub-city
- III. The population distributions (the geographical location of school services follow certain patterns of the residential areas)

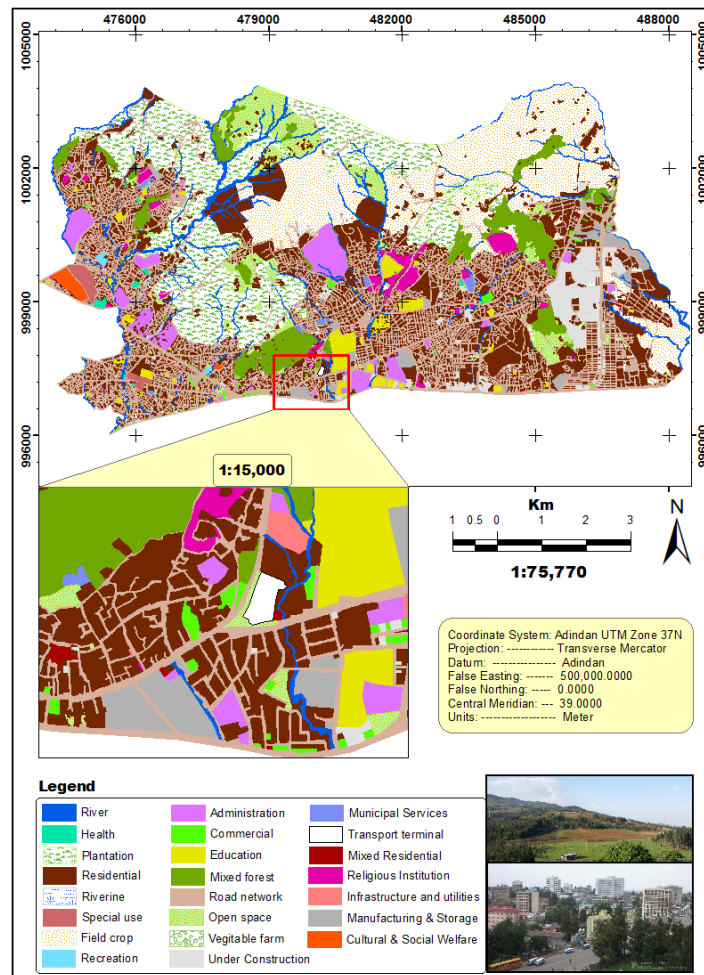


Figure 3.3: Land use Map of Yeka Sub-City

3.6. Primary School Details of Yeka Sub-City

3.6.1. Spatial Details

There are several problems that hold back to reach at the exact evidence to get the spatial information of the schools in the area. Some of the obstacles are; failure of the established schools to work continually and entry of new schools after registrations are made at city levels, increasing and decreasing of the serving schools grade levels (i.e. from KG to Primary, Primary to Secondary and vice versa), Changing of private schools from place to place etc. Three main sources of spatial data are used during in this paper work. These are Addis Ababa City Government Integrated Land information center, Yeka Sub-City Integrated Land Information Office and Ethiopian Central Statistics Agency (CSA). However all the data are different among each other and due to this, the only alternative was to go to the schools that are not common to the three sources. Woreda Administration Education Offices are the best sources for spatially lost schools that are working. Thus about half way of the number of schools are collected by the researcher. Because of this spatial information that are in municipalities hands have difference when compared with the facts that are currently on the ground in the 2008 E.C. Numerically 73 primary schools are obtained from the main Addis Ababa City Municipal center, whereas Yeka Sub-City Integrated Land information office and CSA respectively have about 84 and 73 schools at hand that includes all ownerships (i.e. Government, Private, NGOs and others). The correspondent numbers of the City Government and CSA have internally many differences in location. Finally after identifying all similarities and differences, current spatial data collection has been made and 127 primary schools are obtained that are working in the 2008 academic year of Ethiopia.

3.6.2. The Socio-Economic Details

The three important sources for the socio economic data are at City level, at Sub-City level and at Woreda levels in the Sub-City. General information for the schools in the City are prepared and obtained from Addis Ababa Education Bureau (AAEB). Secondly, data at the Sub-City level are received from Yeka Sub-City Education Office and thirdly information are gathered from all woredas' Education Offices of the entire Yeka Sub-City that have close and direct interaction with the schools working under them. Similar situations in the spatial data are perceived on the attribute parts of the school eventhough the flow of information is hierarchical such that woreda education offices are responsible for sub-city education office and sub-city education office intern is responsible for the core city education bureau (i.e. AAEB).

CHAPTER FOUR

RESEARCH DESIGN, DATA AND METHODOLOGY

4.1. Chapter Introduction

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

4.2. RESEARCH DESIGN

The conceptual structure or the design of the research project that the researcher followed to conduct the research became important issue to be clearly defined to visualize the whole image of the work. Preparing research design highly contributes by showing over all highlights of methods towards result findings. Therefore, before commencement of the research techniques it is decided to prepare tracks of the research by assembling all the requirements for the problem solving objective (Fig. 4.1).

4.2.1. Approaches to the Research

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

4.2.2. Research Type

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

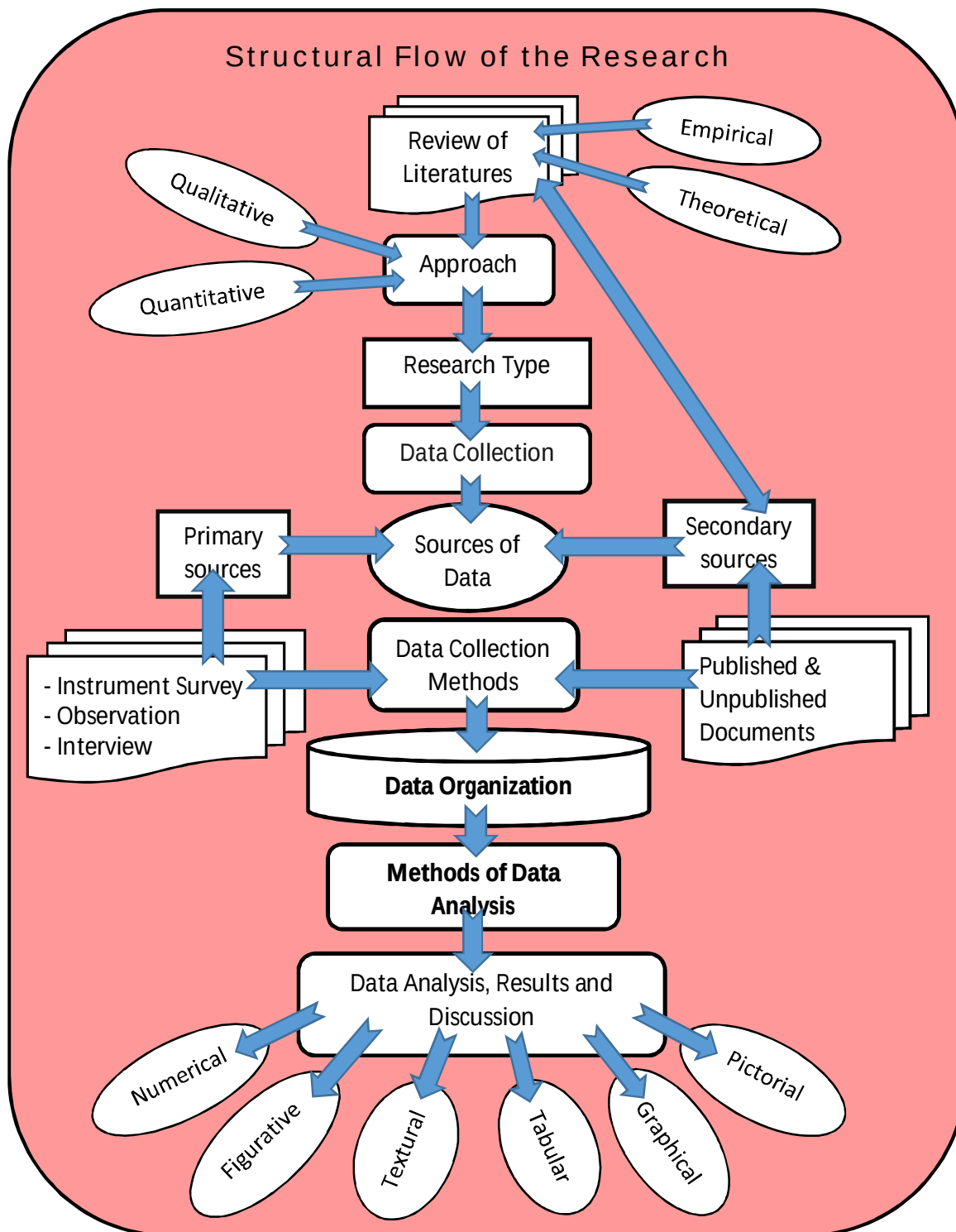


Figure 4.1: The Structure of the Research: from Literatures and the Author

4.3. DATA

4.3.1. Softwares

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

4.3.2. Equipments and Tools

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

4.3.3. Sources of Data

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

4.3.4. Data Collection Methods

Data gathering procedure includes different techniques that are applied formally and informally in order to achieve all documents for the study. There are two major data collection methods used:

4.3.4.1. Instrumental Survey

Primary data of the schools were collected by the researcher by going to the desired schools. It was done by means some equipments. The primary data are as can be displayed in the following table.

Table 4.1: Primary data, their source and uses in the study

Data	Source	Format	Uses	Year
GPS Coordinates of Schools	Schools understudy	.dxf	Identifying the Sub-City Locations of school	2015
Road network	Aerial Photograph of Yeka (2011)	GRID	Modify existing road network	2015
Residential area	Aerial Photographs of Yeka (2011)	GRID	To modify residential areas	2015
Photographs	School understudy	.jpg	Show school placements	2015

4.3.4.2. Interview with Organizations

The interview method was used to collect **secondary data**. Simple questionnaire comprising of both close and open ended questions was prepared to contact and make conversations with relevant workers in organizations to identify and collect valuable data and materials as shown in the following table.

Table 4.2: Secondary data, their source and uses in the entire study

Data	Source	Format	Uses	Year
Administrative maps of AA & Yeka	AACA ILIC	.shp	For defining the study location	2013
Parcel Maps Of Yeka Sub-City	Yeka ILIO	.shp	Distinguish residential parcels from the others	2014
Demographic data	CSA	.dbf	Know Subject population	2016
Existing Schools	AACA, Yeka ILIO & CSA	.shp	After assessment of their existence on the ground directly taken for use	2015
Road network map	Yeka Sub-City ILIO	.shp	Input Data for Building a Network	2014
Land use Map of Yeka Sub-City	Yeka Sub-City ILIO	.shp	Separate residential areas and further details	2014
Yeka Sub-City ATLAS	AACA ILIC	Print out	Get some written evidences of study area	2014
Education Statistics Annual Abstract	AAEB	Print out	Evidences of primary education at City & Sub-city	2005-2007EC
Yeka Schools' Information	Educ. Offices of Yeka	Print out	For details of primary schools in the Sub-City	2015

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

I. Maps

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

II. Demography

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

III. GPS Data

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

IV. Spatial Location of Existing Schools

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

V. Road Data

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

prepared the network for the sub-city with less accuracy and quality naming the road types as All-weather Roads, Dry weather Roads and Trails.

VI. Land Use Data

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

VII. Yeka Sub-City ATLAS

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

VIII. Education Statistics Annual Abstract

One of the publications and reports prepared by Addis Ababa City Bureau of Education is the Education Statistics Annual Abstract (ESAA) on the academic institutions under its government especially of the range from KG up to Secondary education. Therefore this paper work is prepared in part on basis of the information attributed in these published reports whereas in part data and reports from woreda and sub-city education offices are also used in combination.

4.4. METHODOLOGY

4.4.1. Data Adjustments (Preparation) Methods

Two major activities are undertaken in this subtopic. Firstly adjustments for errors, irregularities and absence. Secondly preparation of the refined data for the requirements (preconditions) of the analysis part. Therefore, data editions like corrections, modifications,

deletions, substitutions etc. were made deeply during data preprocessing. These task of data preparation is categorized into two phases as follows.

4.4.1.1. Phase One

Comprehensive effort is made in comparing and crosschecking information and evidences on school data from the three origins AACA, Yeka ILIO and CSA. Schools common in both attribute and spatial reference from all of the sources are selected and reserved and those with no spatial reference frame particularly that are observed from CSA data are omitted. Some schools are still existing at data levels but they are not practically seen on the ground. In addition to these sources of data, lastly both spatial and socio economic information are gathered physically going to where the schools are located in the whole study area. The outcomes of the effort came up with missing schools on the data sources because of their newly introduction to the school market and services which is realized mostly on private sector. Beside this, during instrumental data gathering it could be recognized that there are also some inappropriate location of schools particularly those owned privately. Most of private owners of schools have lack of their own places for only training purpose, they use houses and land properties owned by other citizens in the society whose land use classes are used for residential purpose by means of contract in the form of rent. Such schools have no firm ground to stay and serve for years at the same location and thus make positional change from place to place. In The 2008E.C. academic year, such kinds of problems are also resolved on the data before the research is conducted.

4.4.1.2. Phase Two

This stage works on readjustments and changes of the road network data and the land use of the study area. Raw network data that are originally received from the sources cannot be directly applied as an input for the analysis. Therefore it was obligatory to change from the original file format to the format type supposed to use. ArcGIS Network Analyst uses the centerline street network to find its analysis result. But Yeka Sub-City local road network data were available in only area shapefiles that bound the areas covered by it. Hence primarily the centerlines of this network data are traced from the existing data by means of editing tools in ArcMap and further modifications and additional road network parts are also added. After all editing activities are finished Yeka Road network Topology (i.e. goedatabase Topology) is built. The topology is controlled by some rules incorporated in it for further refinements of interconnections of all the lines participated in it. If any line in the topology violates one of the

rules involved, it is displayed in one of the three errors attributed to any kinds of topological structures and that are; Area errors, Line errors and point errors if the topology is built from the combination of all area, line and point features. Fig. 4.2 and 4.3 shows the work flow of Topology building and the output Yeka street topology respectively.

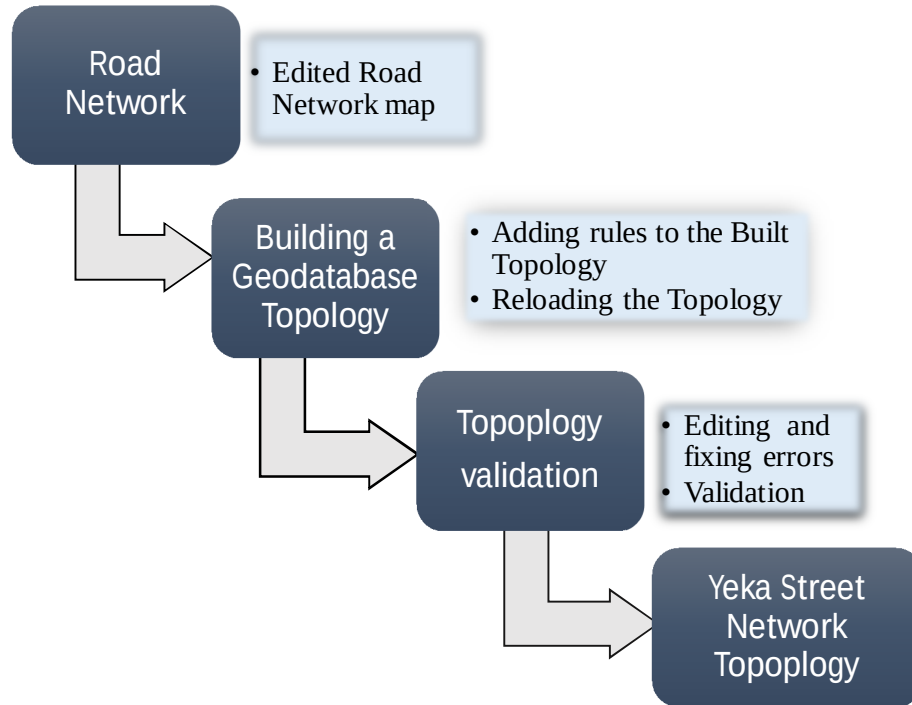


Figure 4.2: Geodatabase Topology Building Workflow

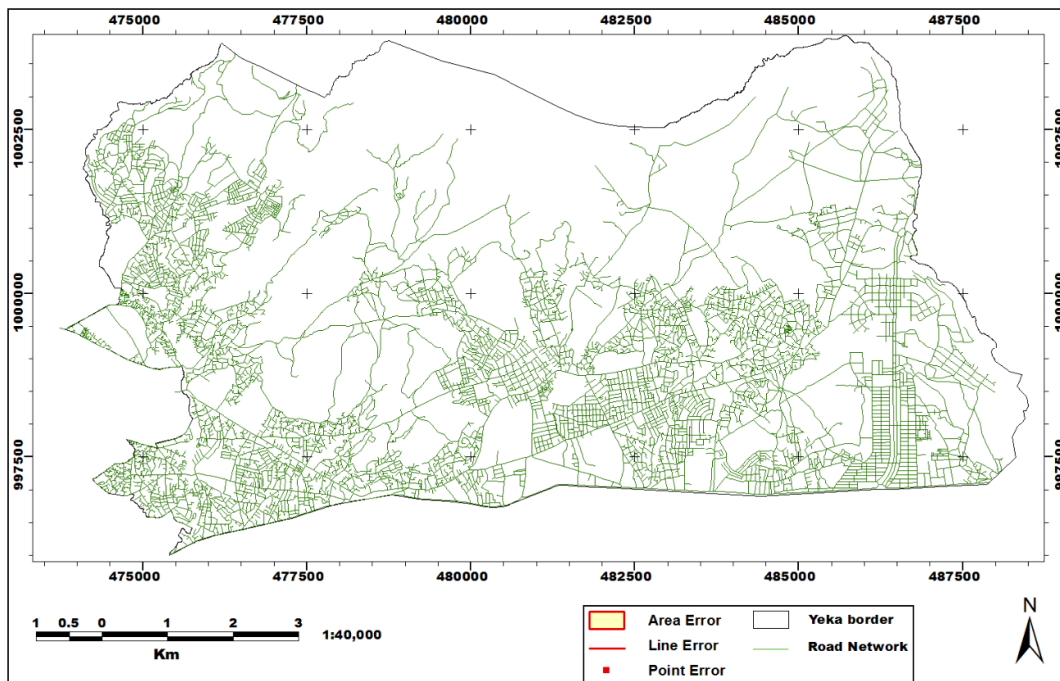


Figure 4.3: Street Network Topology of Yeka Sub-City

Note: - In Fig.4.3 in the legend content, the three error symbols are not seen in the map because the StreetNet_Topology is free from any type of error

The street Network is topologically pure in its connectivity and the next step is to build a network dataset which is used directly as an input for the analysis part. And the network dataset is the pillar on which the analysis is made. Network can be created either from only involved line features (i.e. street data) or including both points and areas in a similar fashion made in the topology. There are some elements that are simultaneously created with network dataset. But the importance of the elements depend on many factors such as traffic flow, over passes, tunnels, complexity of the roads and their hierarchy etc. These elements are junctions, edges, turns, restrictions, stops, barriers and centers. But under this study only the former three are dealt (Junctions, Edges and Turns). Fig. 4.4 and Fig. 4.5 show the work flow of Yeka network dataset and the output network dataset respectively.

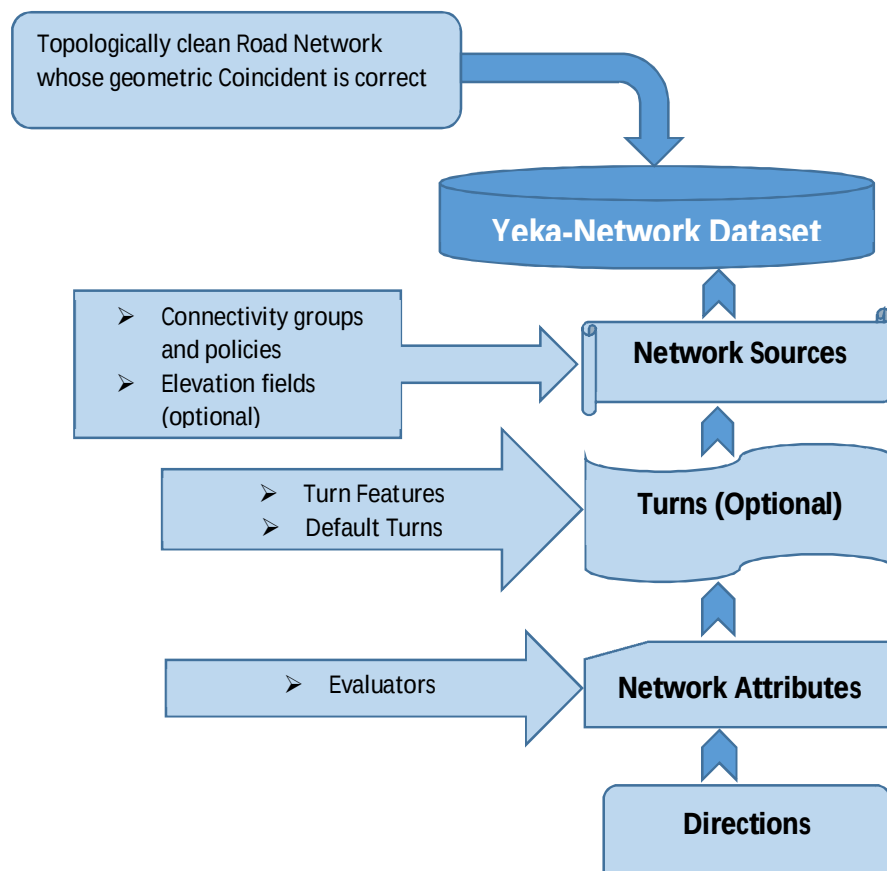


Figure 4.4: Network Dataset Building Workflow

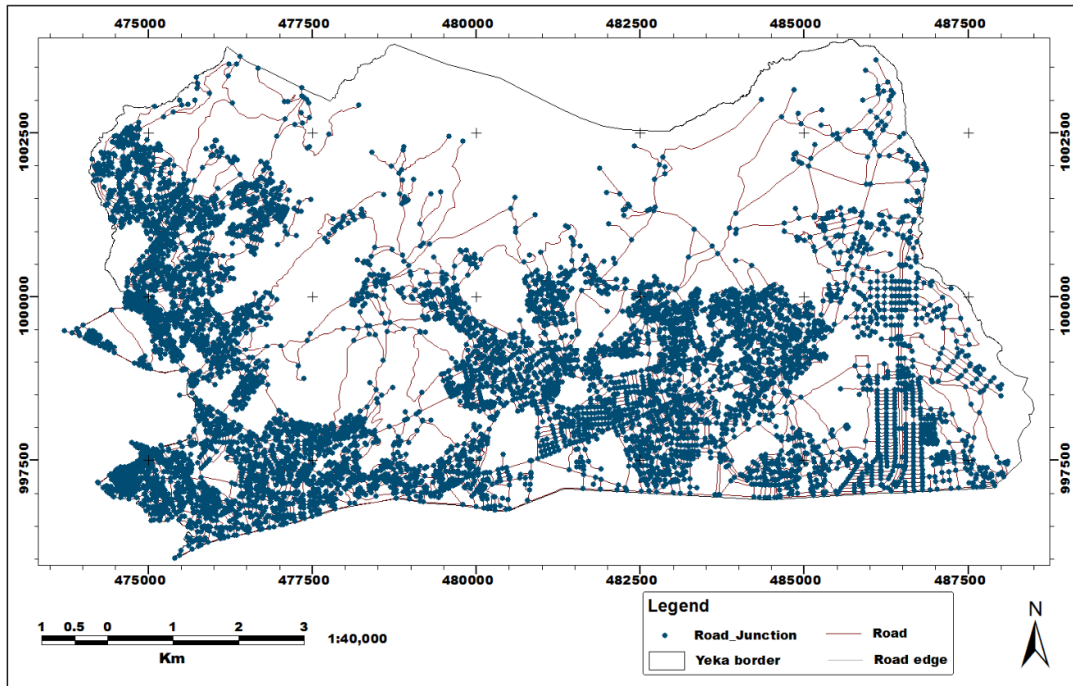


Figure 4.5: Yeka Sub-City Network Dataset

4.4.2. Methods of Data Analysis

4.4.2.1. Location-Allocation of Primary Schools

The ArcGIS location allocation analysis layer offers only six problem types to answer specific kinds of questions which are minimize impedance, maximize coverage, minimize facilities, maximize attendance, maximize market share and target market share. In this case it is tried to undergo the former one (or Minimize Impedance problem type). Three important input datasets are required for location allocation analysis to work see Fig. 4.6.

A. Demand Points

These are points that represent student population whom the school facilities are believed to give services. Demand points are originally portions of land use that resulted from the combination of residential and mixed residential land use classes where almost all population of the sub-city use them for the residential purposes. After identifying all the land use land cover types of the study area, land parcels that shield areas for human residences are extracted by ArcGIS system tools and converted to identity points each representing each parcel.

B. Existing Schools

As explained in detail in Chapter Two, all the Primary schools currently working in the area that are well-known serving for grade level from One up to Eight (Grade 1 – 8) comprising all ownership (i.e. government, Private, Missionary, Churches and Mosques etc.) have been recognized. The schools are also attributed by names, reference coordinates, specific woreda in which they relatively exist, ownership and Grade levels. In addition to this, the enrollment each school made in the 2007EC received from Addis Ababa City Government Education Bureau (ESAA) is considered as Capacity for the school. This is assumed as one determining factor to know the degree at which the requirement for additional schools in the locality when compared with the demand points.

C. Existing Road Network Dataset

The road network dataset is developed from both the local and structural roads through the entire Sub-City. First and foremost the network dataset is very important for the network analyst tools to work on the problem types under it (i.e. for new route, service area, closest facility, OD cost matrix and new vehicle routing problem types including New Location Allocation).

4.4.2.2. Service Area Using Network Analysis

This is a technique that develop distinction area for the school facility service and the student population that want school services around its locality. Similar to the location allocation analysis part, it uses the formerly built road network dataset and current school locations based on which boundaries of each individual school service are generated. It also uses the impedance cutoff value but in this case known by Default Breaks. It is plural because it is likely to set default break values of more than one but different in magnitude from the service point to examine variation of accessibility. However to create service area demand points are not compulsory in such a way that unevenly shaped polygons around the facility are generated from the service based on the nature of the geometric pattern of road network.

Candidate site selection

It is here where potential sites for introducing new additional school facilities are proposed. At this point one can decide where demand nodes are strong and where it is the reverse, where are demand points that are beyond the impedance cutoff (Default breaks) so that they are unreachable (hardly reachable). Therefore once the candidate sites are roughly suggested wherever there are tendencies, the above analyses are revised. The candidate sites that meets

all the criteria fully or partially are selected on the basis of the input data and the density of demand points through the study area. But while establishing this new facility sites, already existing facilities of the same purpose (primary schools in this case) that are in the area of interest should not be neglected.

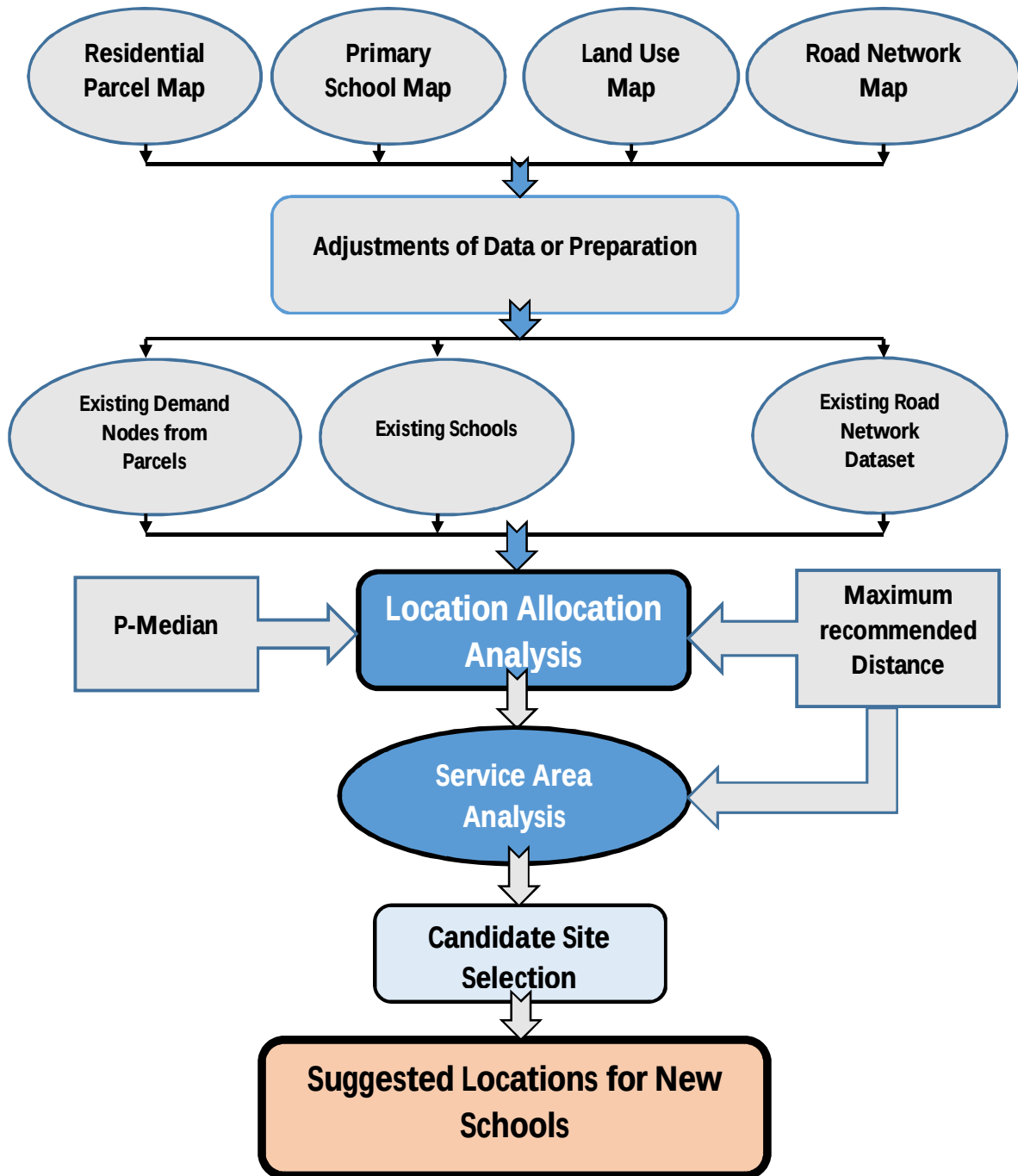


Figure 4.6: Overview of the methodology Workflow I by the Author

4.4.2.3. Finding Optimum School Locations Using Spatial Analysis

Further analysis is made from the suggested school locations result from the Location allocation and service area analysis as input using the ArcGIS Spatial Analyst extension tool. This is done because in the former methods only rough suggestions are given regarding locations that are recommended to be candidate. In addition to this, the capacity of existing schools with the student population size is also determined from the result obtained before proceeding with this portion. So the main purpose to use spatial analysis is examining the recommended and relocating or validating suitable areas with respect to the existing conditions.

The inputs used in this part of analysis method are different from the ones used for Location allocation except for existing primary schools and population data used as demand points. But the way these two common inputs are used is different from the above. Therefore six requirements are recognized in order to conduct the analysis as described below.

A. Elevation Data

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

B. Existing Noise

There are community sites considered noises because of their emission of troubling sounds to teaching-learning school environment. According to Ethiopian Context, from among noisy things that highly affect school environment, Entertainment centers of different types and Religious sites are included in this analysis. The data used for this purpose are originally received from the ILIO Office of Yeka Sub-City. Therefore locations farthest from such noisy places are considered suitable for Schooling.

C. Existing Primary Schools

These are schools that are working currently and also used in the location allocation analysis part. The level of interested sites for schooling purpose increases as one go backward from existing schools. Areas that fulfill another criteria but failed to fit this criterion are supposed not suitable. Thus, locations with farthest Euclidean (straight line) distance from the location of the working school are well-thought the most suitable.

D. Suggested Sites

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

E. Existing Population

Existing population is the collection of peoples or residents from which students are outspread. This is similar to the demand points of the location allocation part of analysis. Detailed discussion is made on this part of land use land cover classes in the previous chapter. In This case because schools are established to serve best the society at nearest locality, locations far away from population area are not comfortable while the reverse is true where schools are opened nearest to population are the most preferable.

F. Land Use Map

The land use map used in this analysis is different in format from that used in Fig. 3.3 is reclassified and transformed to raster dataset. The result reduces the number of land cover classes from 23 to only 6 as seen in Fig. 4.7. This is because in the science of remote sensing classes grouped together show almost similar reflectance patterns in imaging process. The reduced land use land cover classes are therefore, Built up (Combines 16 classes) with 4393.80ha of total area, Agricultural land (Combines 2 classes) within 1442.08ha, Barren land which amounts 461.66ha, Vegetation cover of 1395.72ha, Water (Combines 2 classes) within 161.59ha and Mixed Forest cover of 358.20ha (Table 4.3).

Table 4.3: Categories of land use Land cover classes of Yeka Sub-City

Cate gory	No	Classes	Cate gory	No	Classes	Categ ory	No	Classes
Built up	1	Administration	Built up	9	Municipal Services	Agricultural land	17	Field Crop
	2	Commercial		10	Recreation		18	Vegetable farm
	3	Culture & Social welfare		11	Religious Institution	Barren	19	Barren land
	4	Education		12	Residential	Veget ation	20	Plantation
	5	Health		13	Road network	Water	21	River
	6	Infra & Utilities		14	Special Use		22	Riverine
	7	Manufacturing & Storage		15	Transport Terminal	Forest	23	Mixed Forest
	8	Mixid residential		16	Under construction			

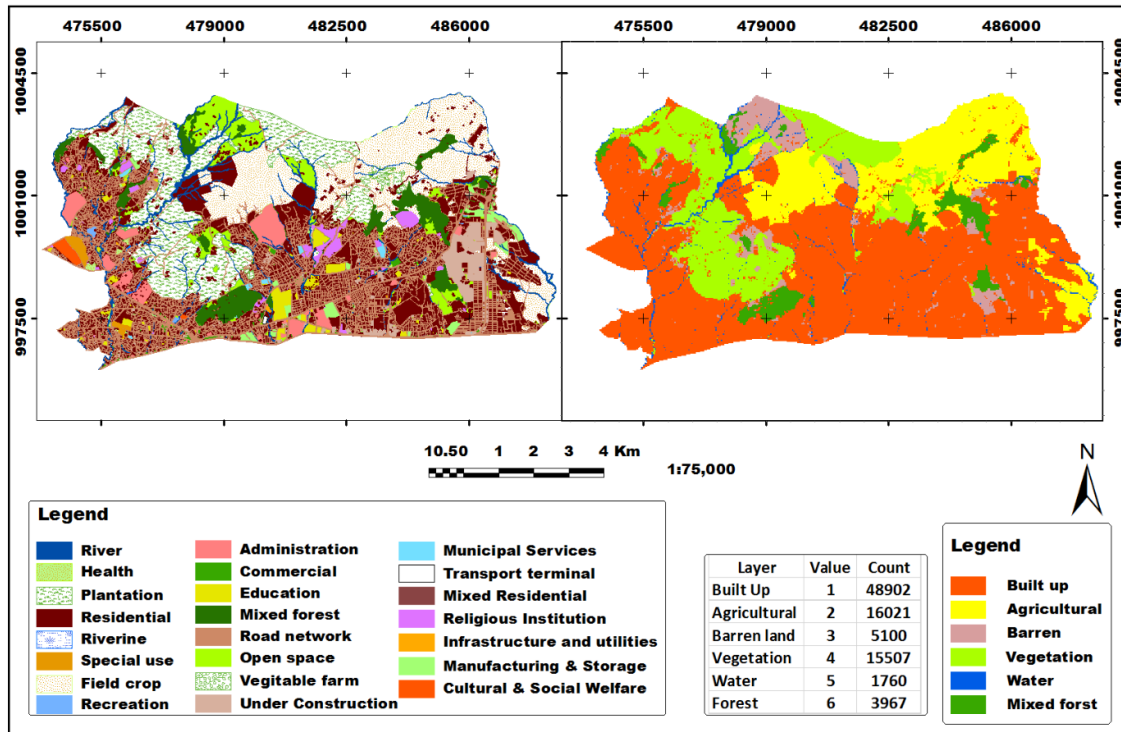


Figure 4.7: Land Use Land Cover Map of Yeka Sub-City

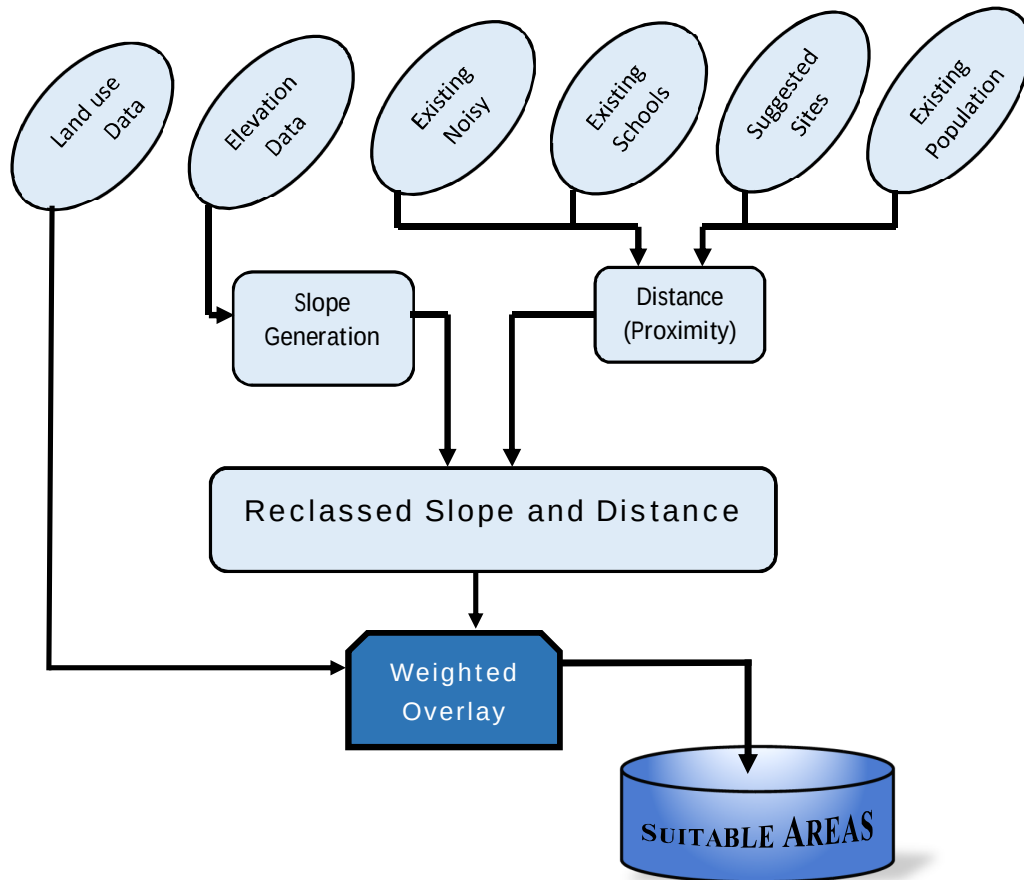


Figure 4.8: Overview of the Methodology Workflow II by the Author

CHAPTER FIVE

DATA ANALYSIS, RESULTS AND DISCUSSION

5.1. Chapter Introduction

The chapter tried to deal with the data in order to answer the research questions formulated earlier starting from approximate assumptions up to the most reliable solutions that even stakeholders can apply to action. Relevant data analyses using the predefined methodology and consecutive techniques of location allocation and spatial analysis are employed. Descriptions of the results in the form of information are briefly laid. Discussions are provided to meet the purpose and objectives set briefly at the start of the study. Finally the intended and refined best output of the research that is the most suitable school sites are extracted. These are sites for schools that in combination with the existing schools can steadily serve the demanding communities. The past and present experiences of the sites are discussed and their future destiny is also predicted.

5.1.1. Accessibility and Coverage of Primary Schools in Yeka

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

5.1.1.1. Approximations From Evidences

Based on the current facts, there are 127 schools in Yeka Sub-City whose total area is 8213.11 hectares and when evenly distributed 1 school must have coverage of 64.70 hectares through the whole area regardless of any restriction. However the schools are constructed in built up portion which only cover 4393.80ha (Fig. 4.7) and reduces the area to approximately 34.60 hectares coverage per each school. As quantified in statistics of 2014/15 academic year by Yeka Education Office, 62552 regular students were enrolled in all ages from grade 1 – 8. This number of student population is outstretched from residential parcels of 41113 (spatial parcel map data from Yeka ILIO of 2014 with modification). Distributing this number of students, approximately 1 student from 2/3 of each compound and 2 from 1/3 must have attended the school nearest to it. Based on statistics of enrollment per each school for the same year (2014/15) prepared by AAEB, there were 69146 both regular and evening class students

enrolled in 131 primary schools in Yeka Sub-City which means 528 students per each school if evenly distributed without any restriction. From this basis, in the next 2015/16, the 60095 number of students were enrolled in 127 primary schools in the sub-city which indicates about 474 students per each school. So when compared with capacities per each school in the former year, 2014/15 in relation with enrollment and the 41113 residential plots from which demand for school is supplied, accessibility and coverage are reached within existing schools without any requirement. But the problem for these assumptions to come true is lack of even distribution of schools in the Sub-City. This intern caused another problem to access and coverage of the schools due to many reasons among which some are irregular land scape of Yeka, Plan less developments of schools especially those owned privately, uneven residential areas of school population and the community, uneven access to transportation network or road access, capacity and type difference among the schools etc.

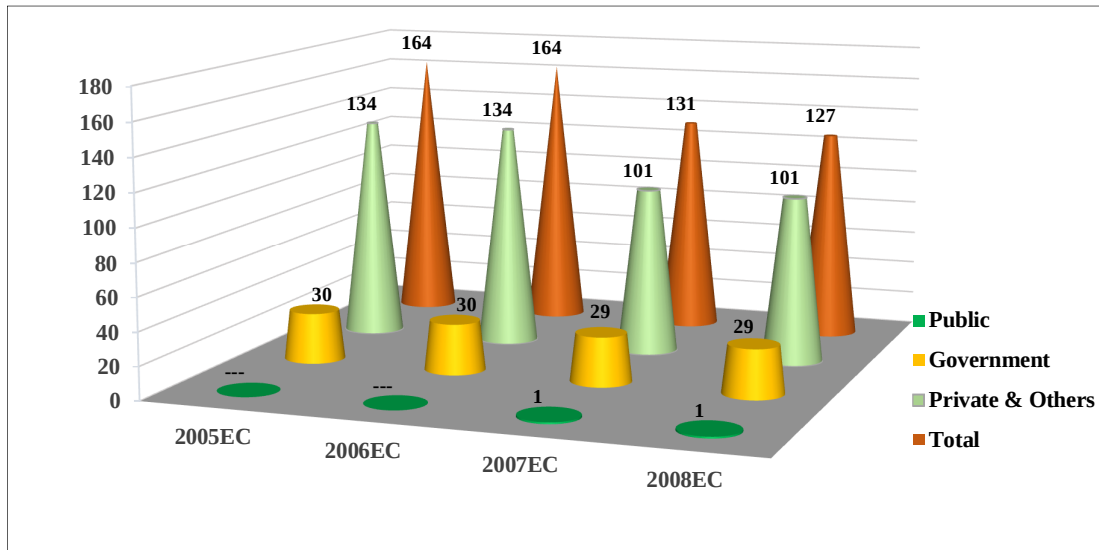


Figure 5.1. School Data of Yeka Sub-City in four Consecutive Years

Source: Education Statistics Annual Abstract (2005, 2006 & 2007EC) and the Researcher

Fig. 5.2 below shows output of density of schools in Yeka Sub-City based on the search radius of 2.50 km laid by ESDP. From this fact, road network is one of the most influential factor that determined the distribution. In the figure, from the five classes of roads, asphalted portion is sampled to see how the road affects access and coverage of facilities. Therefore, it is clear that all schools are densely built where there is ease of access of sufficient road network is available and in reverse the facilities are rarely found at areas where the network is available in low range. Similar situations happen to the schools in terms of residential areas,

where they are dense in bottlenecked sites by residents to share better market attraction and vice versa because human activities grow being interlocked with basic needs.

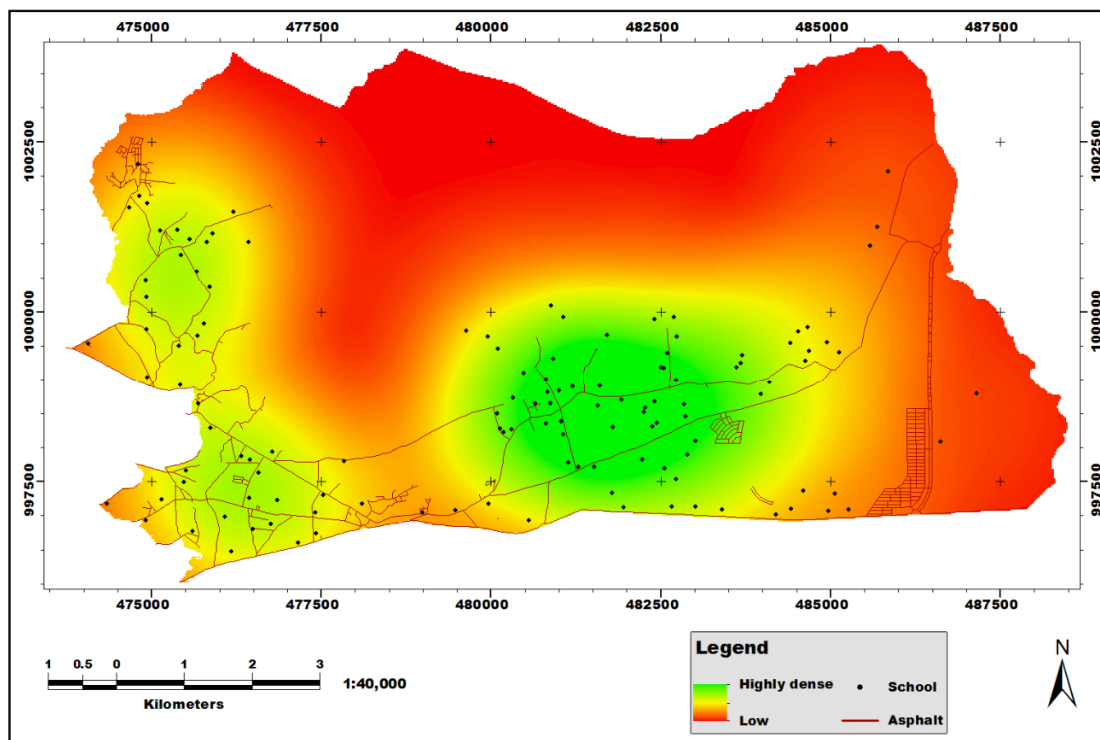


Figure 5.2: Distribution Pattern Map of Primary Schools in Terms of Road

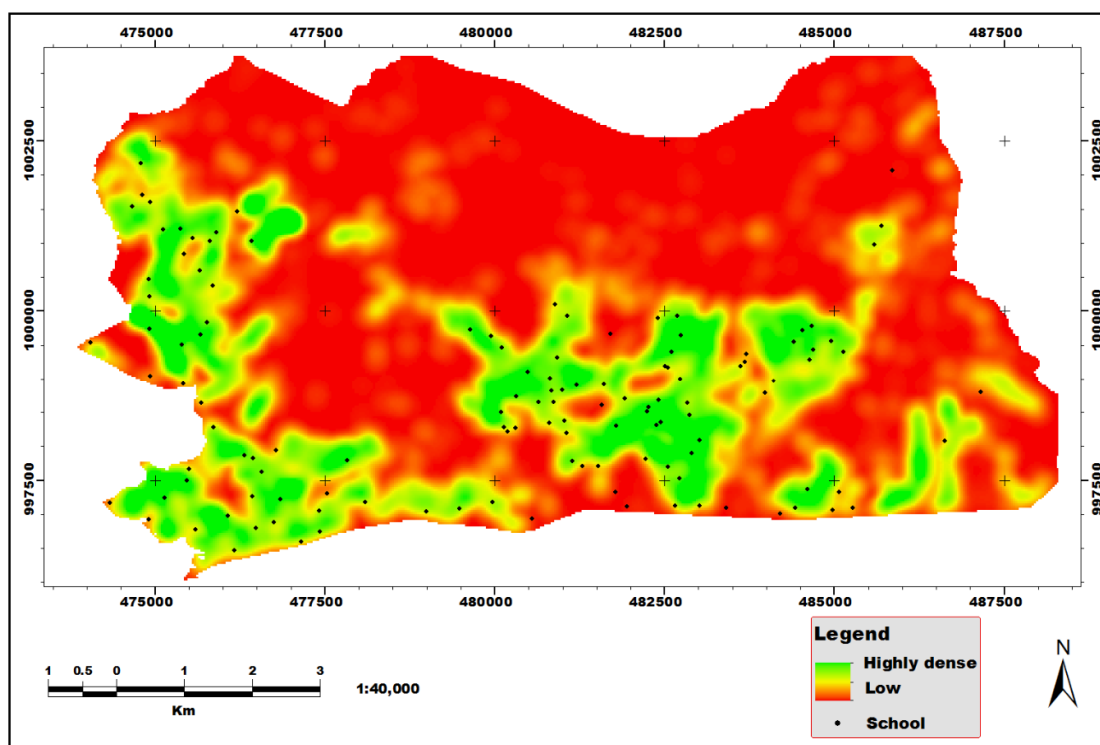


Figure 5.3. Distribution Pattern Map of Primary Schools in Terms of Population

5.1.1.2. Approximations From Education Indicators

Education Statistics Annual Abstract (ESAA) is prepared by AAEB per year for all Educational institutions from pre-primary to preparatory (i.e. KG or ECCE, Primary, IFAL, ABE, Secondary and Preparatory,). The details of Yeka primary level data for all modes of training are thus collected from ESAAs of three consecutive years (2005EC, 2006EC and 2007 EC). In addition to this further materials and data are also collected from Yeka Sub-City Education Office as described below.

Apparent Intake Rate (AIR)

The AIR values are computed using equation number 2.1 described in chapter two.

Table 5.1: AIR of Yeka Sub-City from year 2005 – 2008EC.

Year	Grade 1 Enrollment (All Ages)	School Age Population (Age 7)	Apparent Intake Rate (AIR)
2005	NA	NA	-----
2006	NA	NA	-----
2007	9002	7132	126.22%
2008	11360	10749	105.68%

Source: Yeka Sub-City Education Office and the Researcher

Note: NA = Not Available

Net Intake Rate (NIR)

The NIR values are computed using equation number 2.2 described in chapter two.

Table 5.2: NIR of Yeka Sub-City from year 2005 – 2008EC.

Year	Grade 1 Enrollment (Age 7)	School age population (Age 7)	Net Intake Rate (NIR)
2005	NA	NA	-----
2006	NA	NA	-----
2007	5638	7132	79.05%
2008	8505	10749	79.12%

Source: Yeka Sub-City Education Office and the Researcher

Note: NA = Not Available

Apart from the description made above, education indicators out lined in ESAA of AAEB are also used to approximate the accessibility and coverage level of the schools understudy. Among these are Apparent Intake Rate (AIR) and Net Intake Rate (NIR). By the year 2014/15 and 2015/16 AIR is measured 126.22% and 105.68% respectively in Yeka from grade 1 - 8. The high value of 126.22% in the year 2014/15 indicates the high participation of all aged student population. But the corresponding value in 2015/16 was 105.68% with 20.54% difference in the former year which tells there is less entrants. The NIR of both years 79.05% in 2014/15 and 79.12% in 2015/16 however is similar telling approximately equal and moderate number of school age student participation.

Gross Enrollment Rate (GER)

The GER values are computed using equation number 2.3 described in chapter two.

Table 5.3: GER of Yeka Student Population Data (From 2005 – 2008 E.C)

Academic year (E.C)	Yeka Sub-City				
	Enrollment	School Age (Age 7 – 14)	Under aged (Age 6 and below)	Over aged (Age 15 and Above)	GER (%)
2005	NA	NA	NA	NA	NA
2006	68089	NA	NA	NA	NA
2007	62552	56007	1740	4805	111.69%
2008	60095	52315	1472	6308	114.87%

Source: Yeka Sub-City Education Office and the Researcher

Note in Table 5.3:

- Cells that are filled with **NA** represent **Not Available**
- The enrolment value of year 2006EC is obtained from the AAEBESAA of the 2006 EC
- The enrollment data for 2007 and 2008EC are obtained from Yeka Sub-city Education Office and the figures only show enrollment for regular students of all private, government and other schools and do not include the evening students.

Net Intake Rate (NER)

The NER values are computed using equation number 2.4 described in chapter two.

Table 5.4: NER of Yeka Student Population Data (From 2005 – 2008 E.C)

Academic year (E.C)	Yeka Sub-City				
	Enrollment (Age 7 - 14)	School Age (Age 7 – 14)	Under aged (Age 6 & below)	Over aged Students (Age 15 & Above)	NER
2005	NA	NA	NA	NA	NA
2006	NA	NA	NA	NA	NA
2007	32098	56007	1740	4805	57.3%
2008	25728	52315	1472	6308	49.18%

Source: Yeka Sub-City Education Office and the Researcher

Note: NA = Not Available

Other indicators considered in this study case are Gross Enrollment Rate (GER) and Net Enrollment Rate (NER). The GER in 2014/15 is 111.69% and in 2015/16 is 114.87% from grade 1 – 8. From this, even though it is not considerable difference, GER in the later year shows there is a slight decline (by 3.18%) of pupils with official age group resulting in enrollment rise of over aged and under aged students. On the other hand, NER in 2014/15 is 57.30% and in 2015/16 it is 49.18% for the total primary grades. NER in the 2015/16 shows 8.12% less enrollment of official school age population than the previous year. Therefore the values computed for GER and NER when compared do not clash against each other. Finally it is seen that from the enrollment evidences, student population who had school access at official

school age (grade 1 at age 7 according to Ethiopian primary school structure in terms of age) is at poor level or near 50% leaving behind the rest of 50% for under aged (grade 1 at age 6 and below) and Over aged (grade 1 at age 8 and above).

5.2. DATA ANALYSIS AND RESULTS

Data analysis in combination with the results are consequently and clearly provided in this section. The predefined methodologies (Fig. 4.6 and Fig.4.8) are followed for location allocation analysis and finding optimum school sites in spatial analysis respectively to solve locational problems of schools in Yeka Sub-City.

5.2.1. Location Allocation Analysis Results Of Primary Schools In Yeka

Of the problems to be studied with the help of ArcGIS network analysis, location allocation is undergone through the study area of the whole Yeka Sub-City and overview of the results tells different aspects of accessibility and coverage made above. The analysis investigated the state of demand-facility interrelationship in terms of distance in five scenarios (0.5km, 1.5km, 2.5km, 3.5km, 4.5km distances) and comparison of results are organized to solve location and access problems in order to meet the objectives set at the very beginning of the study. In addition to this, service area analyses for each school are made in the same way as location allocation using distance variables. The main intention of the researcher to use service area analysis beside the Location allocation is to address that the school supply coverage is best described using service area analysis while accessibility is preferably interpreted using location allocation analysis.

5.2.1.1. Distance Based Analysis

Distance is a cost attribute used as impedance for the network analysis settings. Two of the impedance cut off values are 0.5km and 1.5km which are below the allowable search radius 2.5km set by ESDP while the rest two are 3.5 and 4.5 which are above the radius. On this basis the 0.5km impedance cost is set between the demand nodes and school services. Then solving for this resulted 27396 demand nodes allocated (66.64%) within the given limit from the school facilities. Similar progress is followed to the rest distance variables and 39701 nodes at 1.5km, 40508 at 2.5km, 40991 at 3.5km and 41108 at 4.5km are located to the nearest schools.

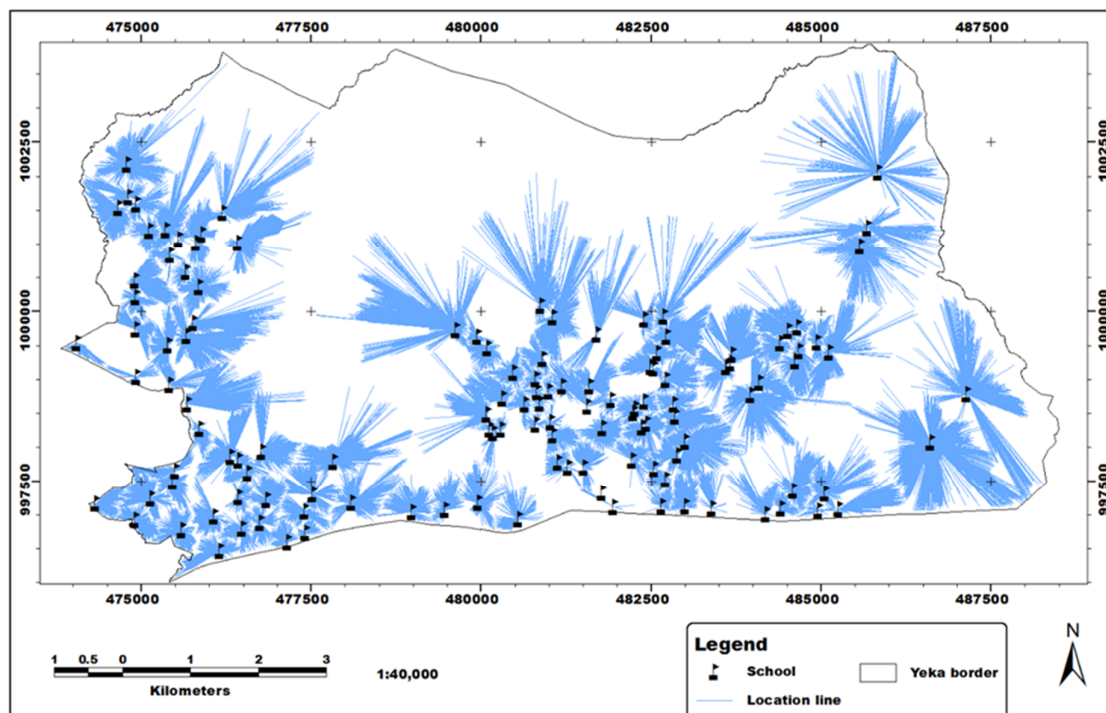


Figure 5.4. LA Analysis Result at 2.5 Km Impedance Cut Off

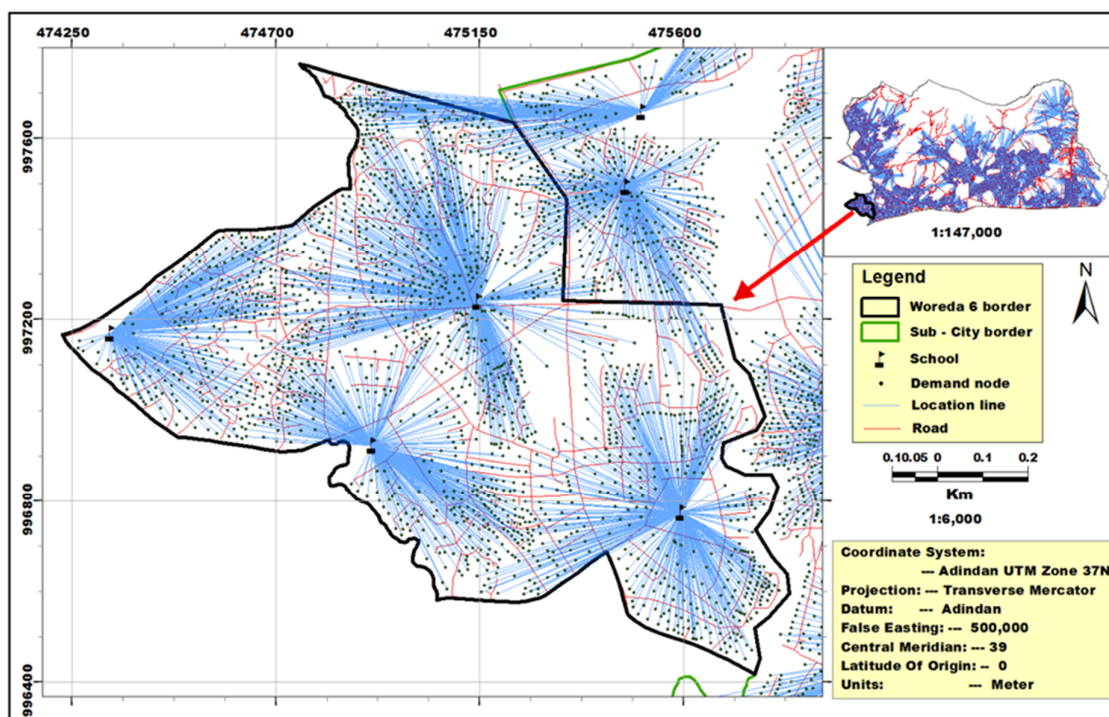


Figure 5.5: Detailed LA Analysis Result at 2.5km Impedance Cut Off

From the above (Fig.5.4), each line in blue color with hidden demand node at one of its end and symbolized school node at another shows the gap between the service and the demand

node (student home) that attend the service. The lines are at different lengths and those with short lengths describe that the students are close to the services while the longer distances show students are far from the services. It is also observed that nodes with long lines are frequently seen in the central, Northern and Eastern part of the area where primary school provision is low. The reverse is true where the schools are abundant and as a result the students can get their school near to them. Longer lines show longer distances taken by students along roads from the area to school sites that are in the 2.5km limit. Students beyond this limit are left unallocated to the facility. Therefore based on these in Fig. 5.6, the central and northern parts of the sub-city population because they are beyond the set limit, they are left unallocated nodes. This in turn implies that there is need for new schools to be built in these area.

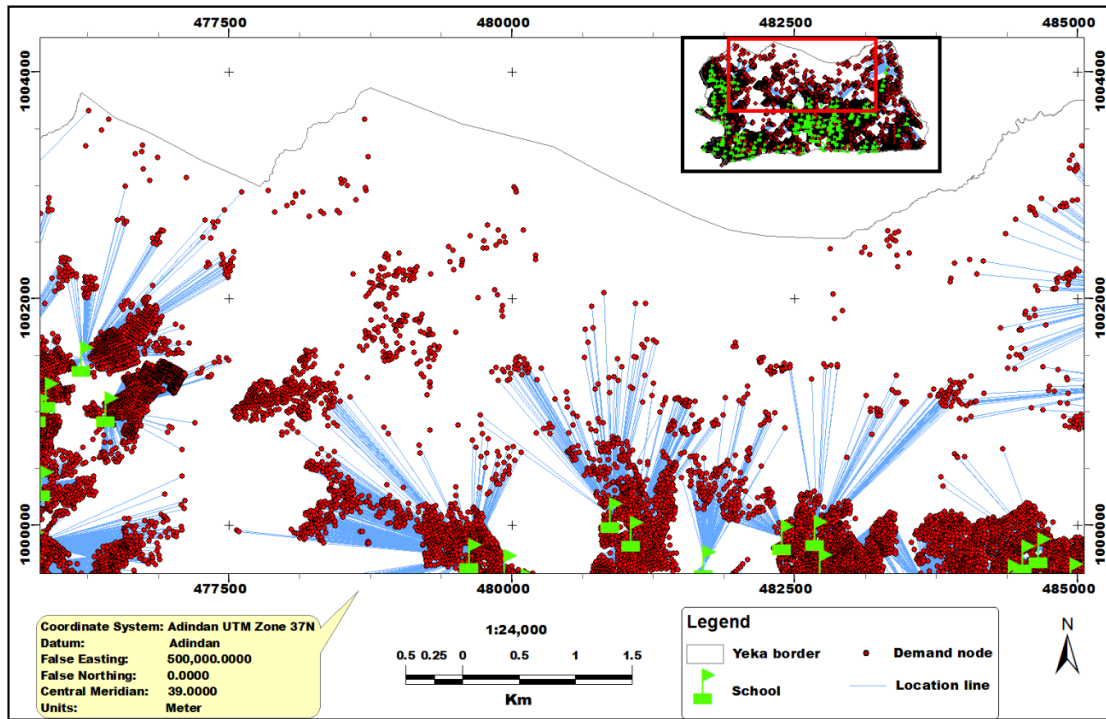


Figure 5.6: LA Analysis Result at 2.5km Impedance Cut off and Scarcity Area

5.2.2. Service Area Analysis

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

5.2.2.1. Distance Based Service Area

In this phase of generating service areas for the facilities, the cost attribute employed is distance. Five scenarios are laid here the same way made for the distance based analysis of location allocation in the above by taking the nationally recommended distance of 2.5 km into consideration. Based on this, 0.5 km for the first, 1.5km for the second, 2.5km for the third, 3.5km for the fourth and 4.5km for the fifth scenario are selected to generate the results. In the 0.5km service area, 26711 population parcels are included from the total that amounts 64.97%. Therefore, it tells that above 3/5 of population can access the existing 127 schools in a walking distance along the preferable road network (road that takes to proximate school destination). Secondly, a 1.5km distance scenario is used and after solving for the problem the result implies there are 39546 (96.19%) population nodes are enclosed in it. The remaining 1567 nodes are left over to the third distance scenario where the median value 2.5km is used as the default break (impedance) value. Then solving for 2.5km outstretched service area, 40267 (97.94%) population nodes are bounded and only 846 nodes are not trapped to the service area that expands 2.5km away from the facility along the existing road network.

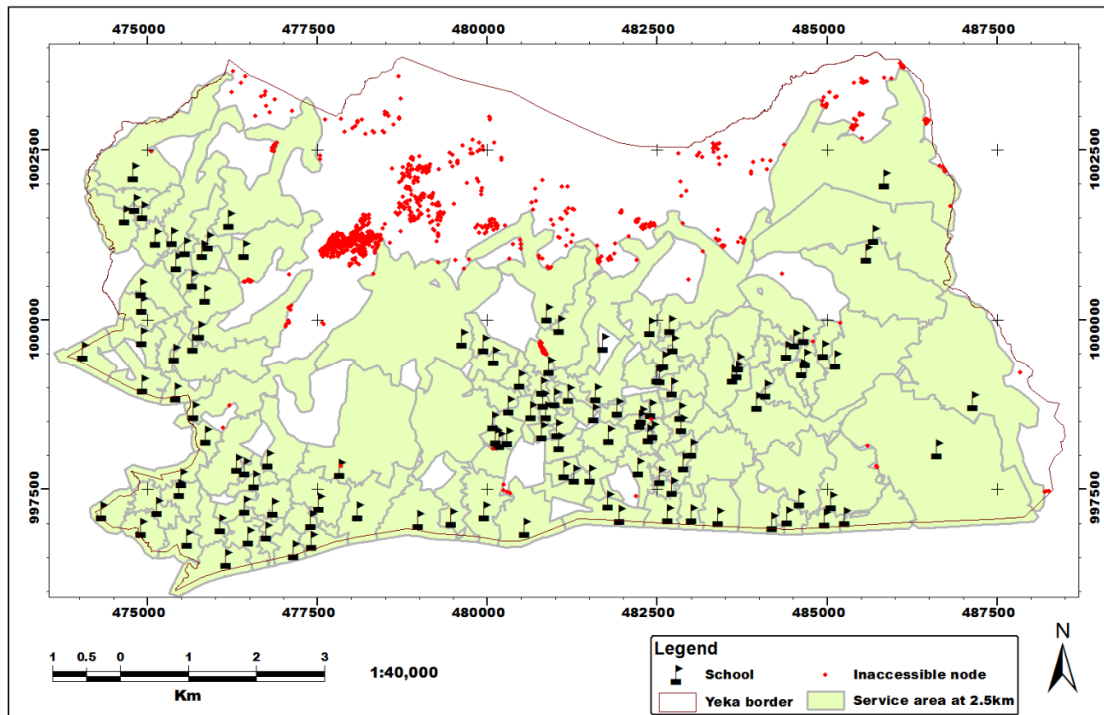


Figure 5.7: SA Analysis Result at 2.5km Break value and Scarcity Area

The main objective of analyzing these situations are, to find areas that are left unreachable by nearest primary schools in Yeka Sub-City and as a result to introduce additional primary

schools in the scarcity area. Finally the results from the two analyses each in five distance scenarios are generalized as follows in table 5.5.

Table. 5.5: Summary of LA and SA Analyses Results in Terms of Distance

COST ATTRIBUTE	COST VALUE	LOCATION ALLOCATION			SERVICE AREA		
		Located Nodes	Percent (%)	Unallocated Nodes	Located Nodes	Percent (%)	Unallocated Nodes
DISTANCE (KM)	0.5	27396	66.64	13717	26711	64.97	14402
	1.5	39701	96.57	1410	39546	96.19	1567
	2.5	40508	98.53	604	40267	97.94	846
	3.5	40991	99.70	122	40683	98.95	430
	4.5	41108	99.99	5	40745	99.10	368

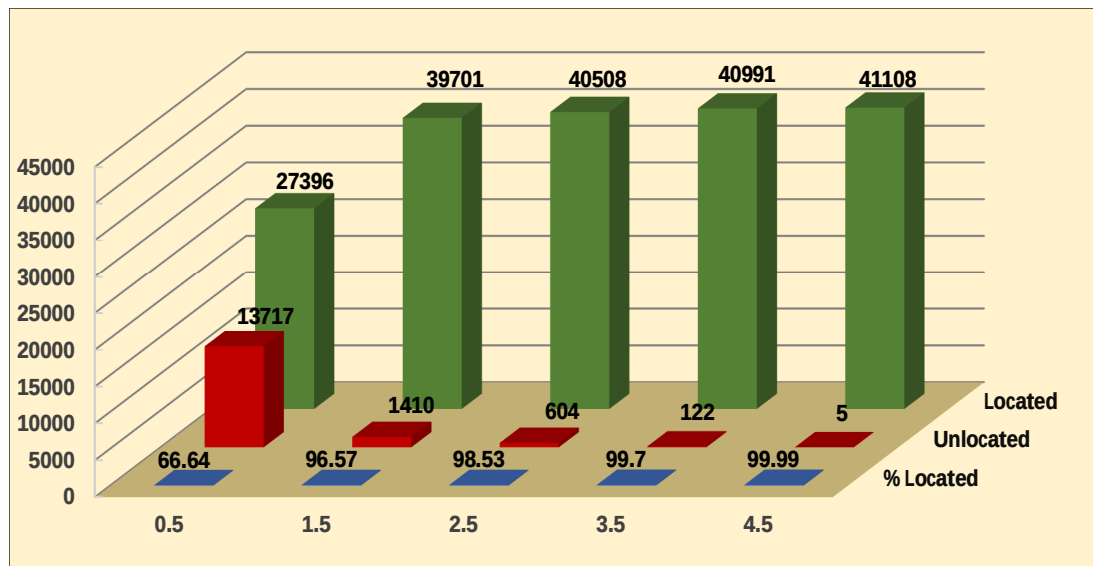


Figure 5.8: Graphical Representation of LA distance based Analysis

Candidate Site Selection For New Schools

From the LA and SA analysis in 2.5km impedance value, 604 and 846 student nodes respectively are far from school (out of range). Because of this, to reach these population by school access another additional schools must be constructed in their area. So on the basis of scarcity maps shown through Fig. 5.4, 5.6, 5.7 and Table 5.5 judgments, candidate locations are proposed for new schools.

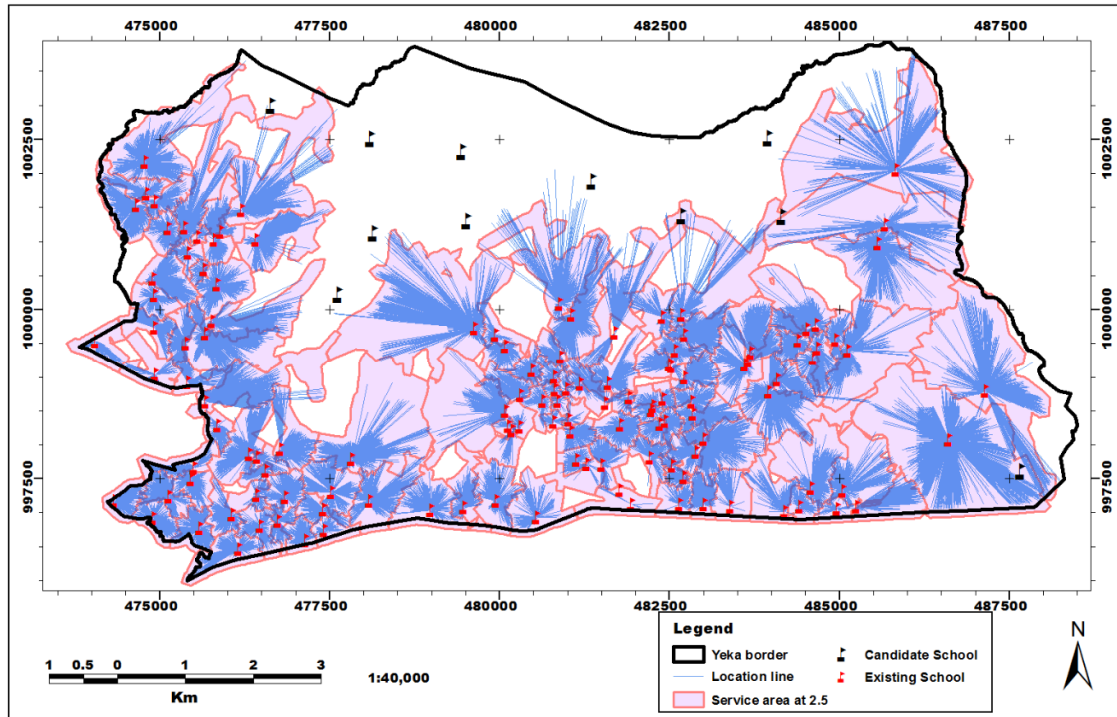


Figure 5.9: Location Map of Candidate Sites as a Result of LA and SA

On the above figure the school sites symbolized in black color are planned to be at points where they are built and believed to give service to the remaining population that are beyond the distance from the existing ones in red. 13 spots are projected to be school places but this does not mean that at all points, schools should be constructed. As can be seen they are known by candidate sites such that the most optimal ones that essentially serve the demand nodes should be selected from them. On the basis of the school capacity as indicated under the sub-title 5.1 for the year 2015/16 per each school which is 493 in size and the remaining population (unallocated nodes) from the LA and SA outputs at 2.5km impedance value which are respectively 604 and 846 in Table 5.5, 2 candidates are proposed again to be reselected (Chosen) from among the potential sites. The two chosen sites are known only after resolving the LA analysis in the same way that has been performed at 2.5km impedance cut off for the existing schools. But in this case candidate sites are loaded to the facilities tool option in the network analyst window of ArcGIS.

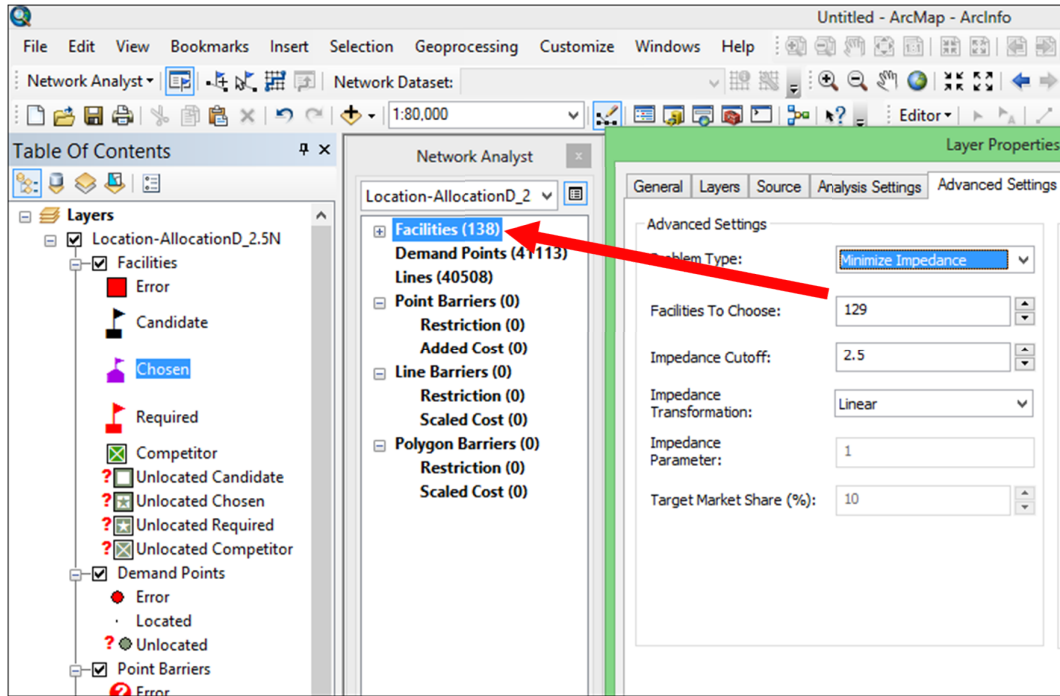


Figure 5.10: Layer Properties Window of the Network Analyst

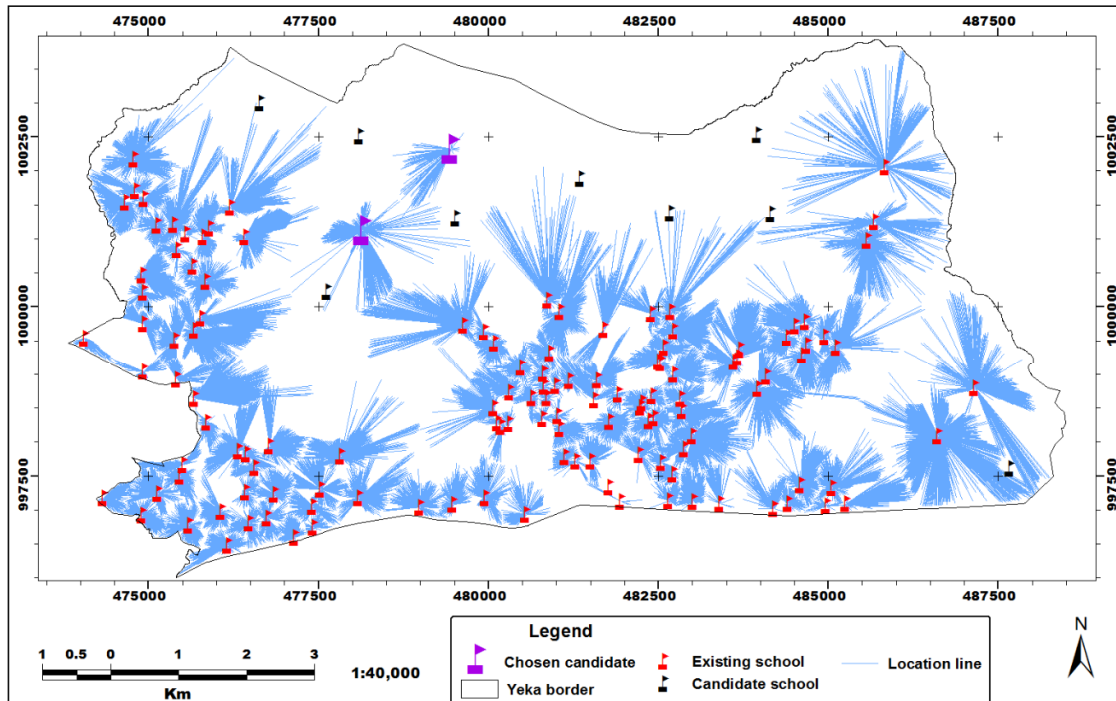


Figure 5.11: Final Chosen sites for New Schooling Purpose

5.2.3. Optimizing School Sites Using Spatial Analysis

The chosen sites as a result of LA and SA might be disallowed if they are evaluated in terms of suitability due to elevation (slope) factors, land use land cover factors, noise factors and

population factors etc. Therefore studying from these aspects is compulsory to either validate or relocate the sites. The mechanisms used for solving this problem is provided by spatial analyst extension of ArcGIS.

5.2.3.1.First Stage

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

5.2.3.2.Second Stage

Surface slope is divided mostly into four common ranges based on the steepness of the surface which are flat (0^0 - 5^0), Rolling or gentle (5^0 - 25^0), mountainous (25^0 - 50^0) and escarpment ($\geq 50^0$). But for the matter of ease of analysis in this study, terrain slope is reclassified into constant intervals of five 1 (0^0 - 17^0), 2 (18^0 - 35^0), 3 (36^0 - 53^0), 4 (54^0 - 71^0), and 5 (72^0 - 90^0). Intervals that are at high degree values show mountainous or escarpment areas and are not comfortable to build schools. Because of this, areas of such slope values are not selected. On the other hand areas from zero to gentle slope will be the most suitable. This implies suitability increment is the reverse of slope increment. Straight line distance between the listed input datasets are already prepared. Reclassification is made by giving similar intervals (scale values) of slope for each (Fig.12).

Existing Noises (Entertainment centers and Religious sites) and Existing Schools are places that negatively influence the course of finding the suitable areas for schools. Therefore, areas that will be comfortable for Schooling purpose are pushed away from this sites. Linear straight line distances from these sites that are maximum shall be in line with scale values that are high and very high and vice versa (Fig 5.13 and Fig. 5.14). Therefore the scale values as for slopes shall not be reversed during reclassification.

Suggested sites and existing population sites on the other hand positively influence the search work for suitable schooling areas. This is because proposed sites and population attracts school services to be near to them therefore, the reclassified scale values and old values of their

respective distances will be opposite to each other (the scale values are reversed in the way it is done for slope) see Fig. 5.15 and Fig. 5.16.

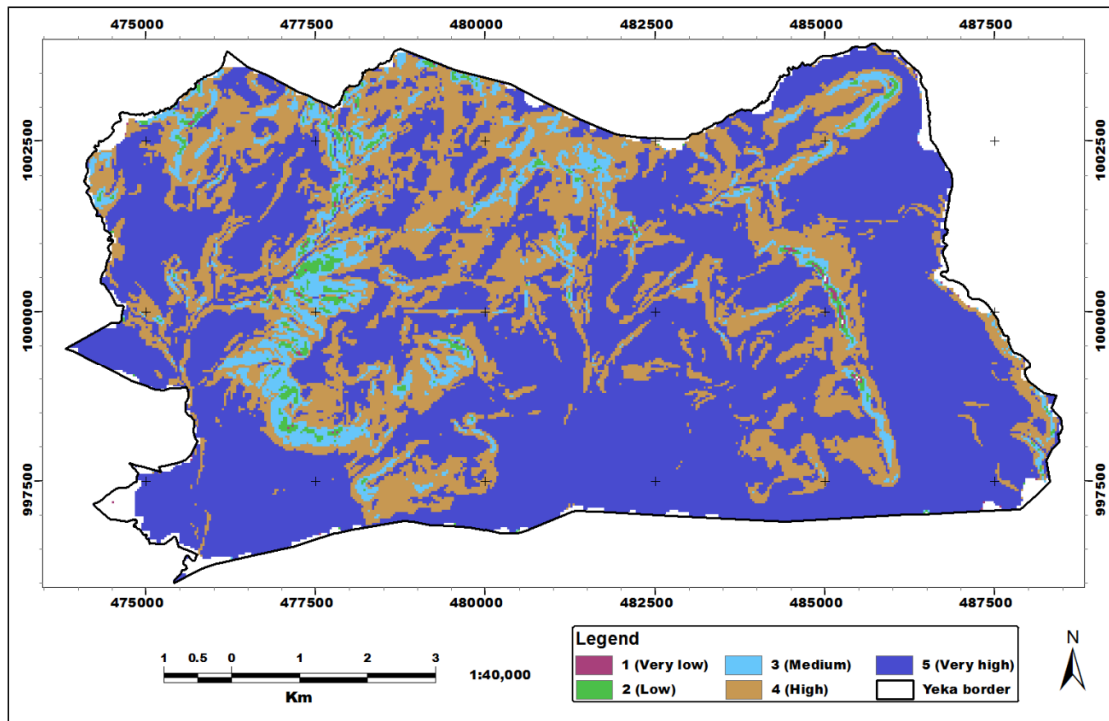


Figure 5.12: Reclassified Slope in Terms of Suitability

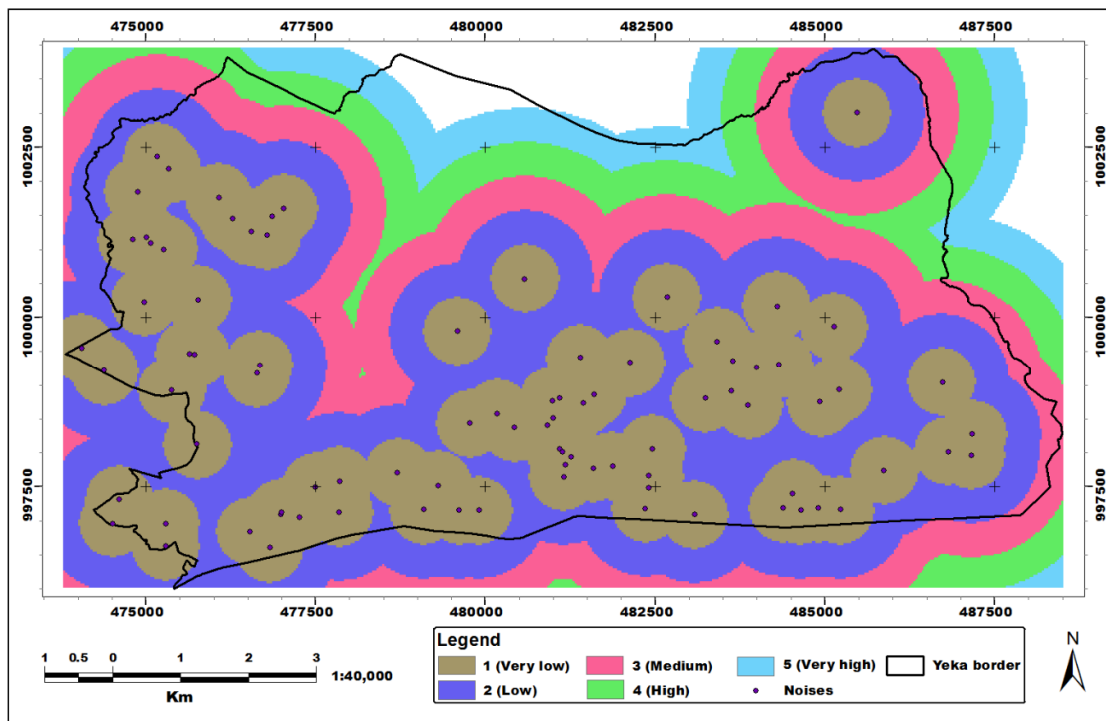


Figure 5.13: Reclassified Distance from Noises in Terms of Suitability

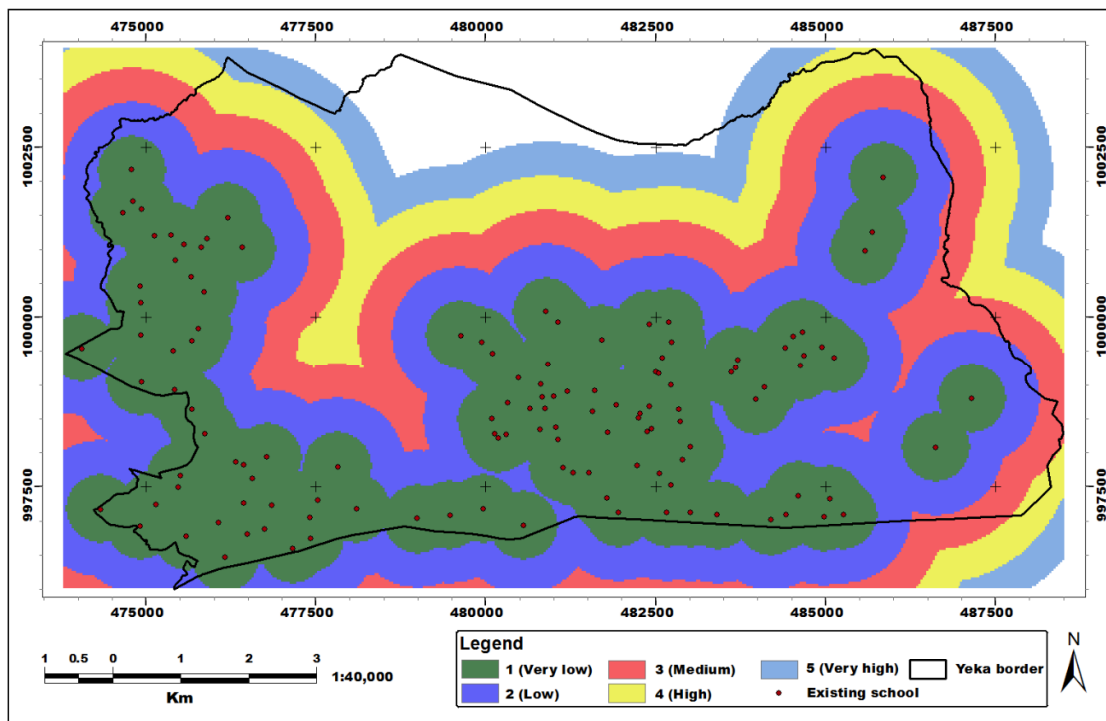


Figure 5.14: Reclassified Distance from Existing Schools in Terms of Suitability

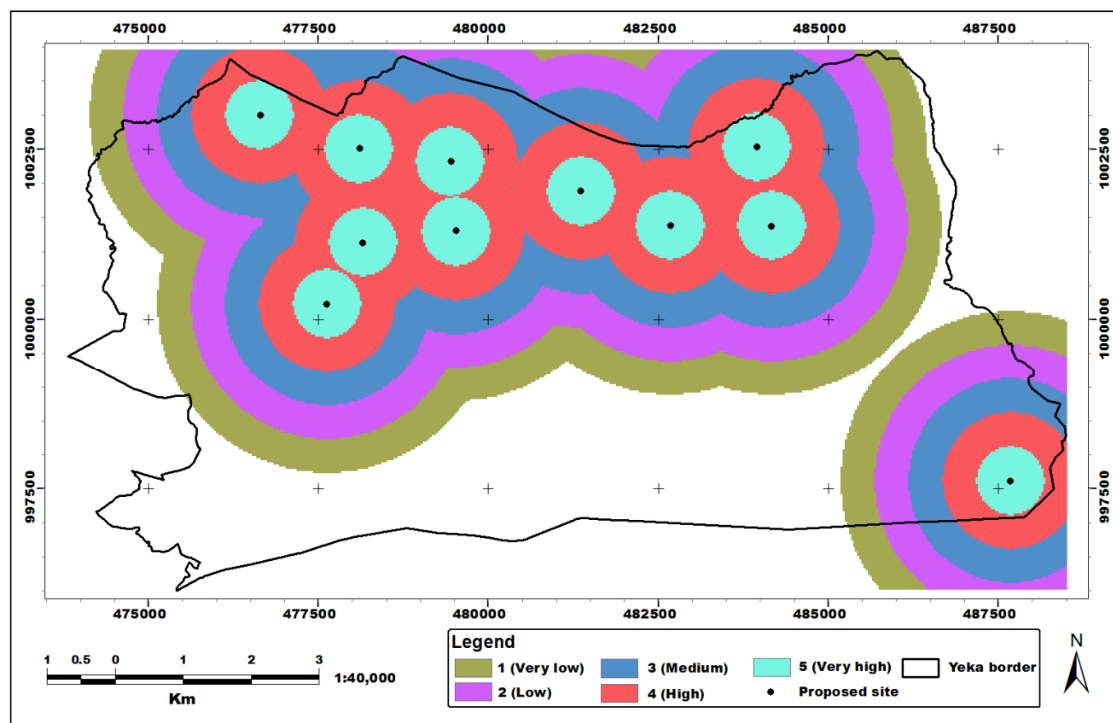


Figure 5.15: Reclassified Distance from Proposed Sites in Terms of Suitability

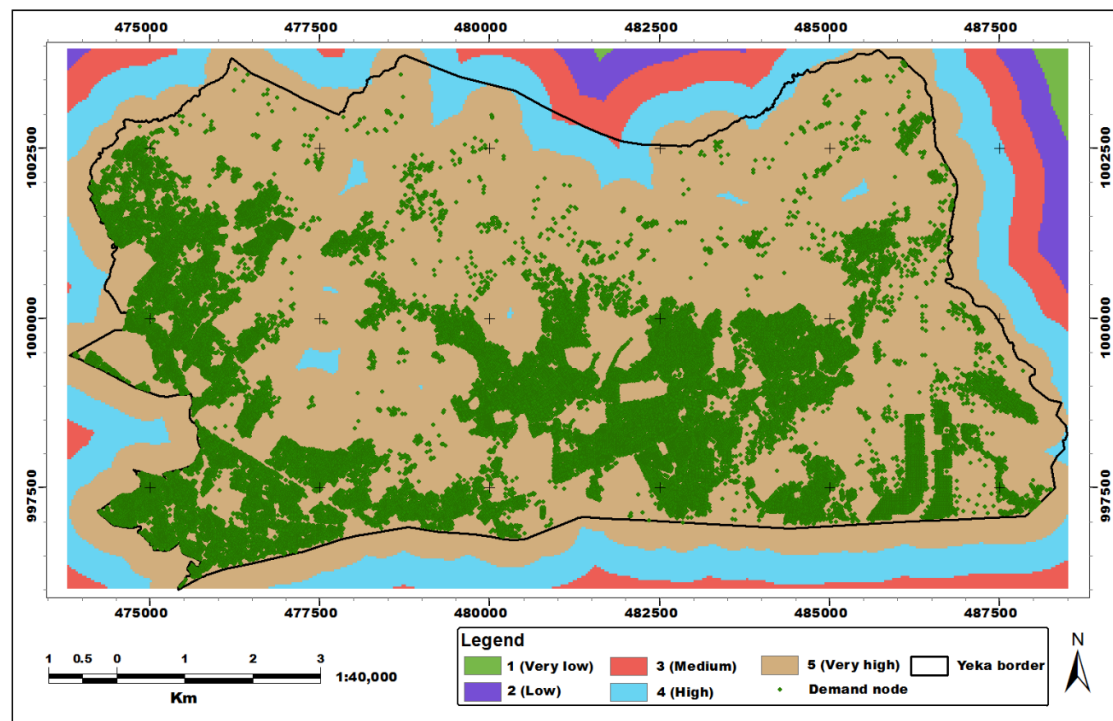


Figure 5.16: Reclassified Distance from Population in terms of Suitability

5.2.3.3. Weighted Overlay

Overlay of several raster inputs using a common measurement scale and weights of each according to its percentage influence is prepared (Table 5.6). The reclassified results obtained above are all combined through the weighted overlay toolset from spatial analyst tools (Fig. 5.17). In addition to this the land use land cover map shown in Fig. 4.5 is also supplemented. Each land Cover class influence the suitable areas differently from the other and due to this, the land cover classes are also given scale values. Based on this, for this study, Built up Area is given a value of - 1, Agricultural – 4, open Space – 5, Vegetation – 3, Mixed Forest – 2, and water is restricted because water bodies are not suitable to build schools. Land use is given a weight of 10%.

Table 5.6: Details of raster datasets in weighted overlay

Dataset	Wt (%)	Reclass Scales	Overlay Scale	Suitability Level	Remark
Slope	10	1	5	Very high	
		2	4	High	
		3	3	Medium	Restricted
		4	2	Low	Restricted
		5	1	Very Low	Restricted
Distance to proposed sites	30	1	5	Very high	
		2	4	High	
		3	3	Medium	
		4	2	Low	
		5	1	Very Low	
Distance to population	30	1	5	Very high	
		2	4	High	
		3	3	Medium	
		4	2	Low	
		5	1	Very Low	
Distance from School	10	1	1	Very Low	
		2	2	Low	
		3	3	Medium	
		4	4	High	
		5	5	Very High	
Distance from Noises	10	1	1	Very Low	
		2	2	Low	
		3	3	Medium	
		4	4	High	
		5	5	Very High	

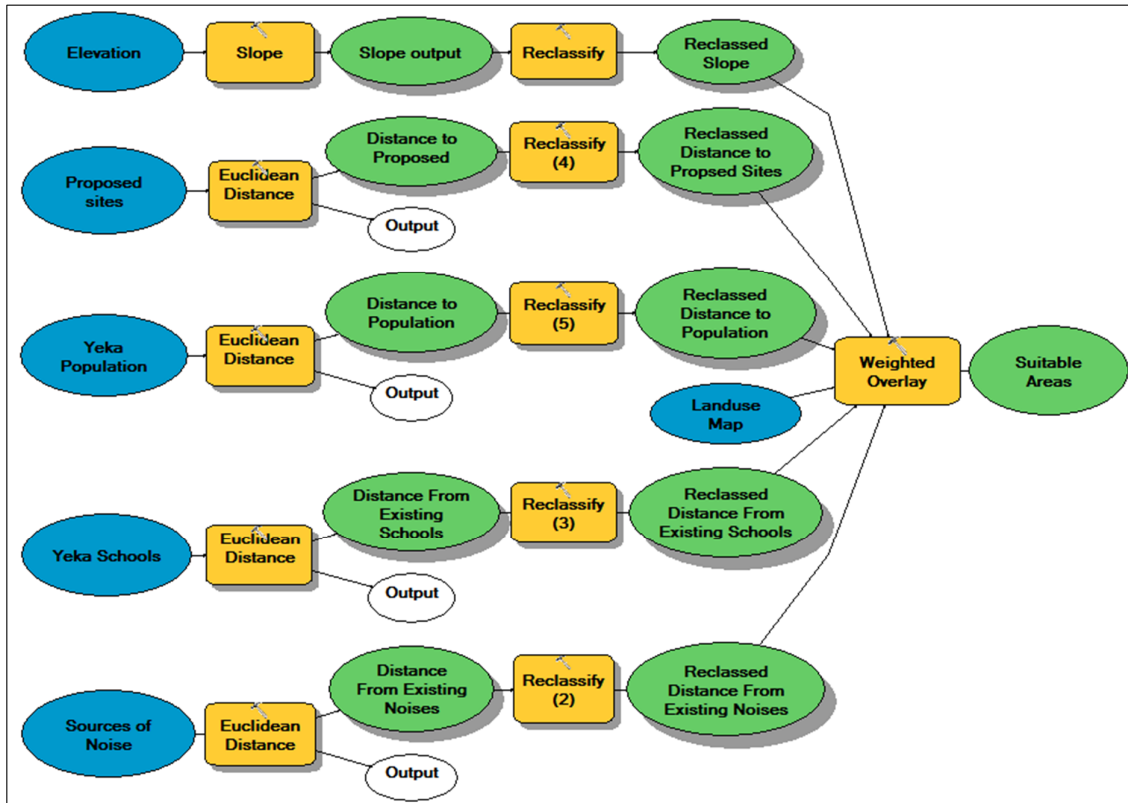


Figure 5.17: Model Builder Work Flow of The spatial Analysis

5.3. DISCUSSION

5.3.3. The Location Allocation (LA) and Service Area (SA) Analyses

The main objective of conducting the research is to find results on how to balance distribution of the primary schools and how to establish the school services near to the population (customer) environment. Various factors are investigated in order to achieve the intended goals and objectives set for this study. It is seen through Fig. 5.2 & Fig. 5.3 that distribution is not uniform and instead they followed dense patterns of road networks and residential areas. Due to these reasons, on these figures school services are very dense or closely built in southern and western edges of the sub-city while the northern, central and eastern parts where peoples live sparsely are very rare or none. The development of these services should of course follow these dimensions but it does not mean that population groups that are dispersed do not share the service opportunities. Students from these society are attending their education by covering distances that are beyond the customary in the District of Yeka. This distance variation could be observed from the LA and SA analyses results (Fig. 5.6 and Fig. 5.7) so that there are student population that are yet moving for more than 2.5km from their home to reach school destination

whereas there are other areas where schools are established within less than 100 meters apart from each other particularly the Southern and Western edges of the Sub-City. These mainly affected students in lower grades at their official primary school age (children that inter grade 1 at age 7 and grade 2 at age 8 etc.). These intern is against Ethiopia's role to achieve the UPE and Adult Literacy because of the fact that both children and Adults refrain from attending their education at the right time due to distance cost. Justification for this is from the education indicators determined in tables 5.1 – 5.4. GER and NER computed 114.87%, 49.18% respectively for the 2015/16 academic year. The GER percentage value is above 100% showing high enrollment of students whose ages are not at their official age and the very low value of NER showing low enrollment of students at their official age. ESDP has set 2.5km distance to be the minimum allowable cost value that is recommended to exist between two school facilities nearest to each other. But from the current situation where the limit is not currently practical in the Sub-City, schools are unevenly distributed. The first part of analyses compares results drawn from LA and SA of the same basic data set in five distance scenarios that is 0.5km, 1.5km, 2.5km, 3.5km and 4.5km variables between school services and demand points in Yeka Sub-City. From this, above half (27396 nodes in LA and 26711nodes in SA analysis) are allocated to the facilities from the 41113 total demand nodes within 500 meters (Table 5.5.). The limit value (i.e. 2.5km) is used and the result provided 40508 points are allocated which equals to 98.53%. This implies the services can be taken as enough supply for the demand from the population of the Sub-City. In addition they are found close to one another and demand nodes at high density. But the un-allocated demand nodes 604 and 846 for LA and SA respectively are outside this limit. The main intention therefore is to make this population accessible to primary school services within this limit or standard distance. The Last 4.5km search radius reduced the un-allocated points to 5 and 368 For LA and SA respectively. This is achieved after increment of the distance approximately by two folds of the limit. Based on this, the area in which un-allocated population beyond the limit distance lives is identified as Scarcity area.

5.3.4. The Spatial Analysis

While some solution sites are more stable (Fig. 5.18) than others, the results show that almost all locations can be shown to be “optimal” for the school facility location. The optimality of a set of sites obtained from LA analysis only pertains to a general set of zonal demand data and not necessarily to the true underlying demand structure. When optimality is discussed,

therefore in relation to the solution of LA analysis using combined data, it has a limited sense. Thus it has a clear implications for the use of spatial analysis technique to find the most reliable sites for school depending on the optimized sites by LA and SA analyses.

The purpose of using the p-median problem type in LA in this study is to maximize primary school coverage in the focus area so that the walking distance for each student attending school is minimized. This possibly be achieved using Euclidean distances, or network distances as explained in Abdel-Latif's study in 2007. Abdel-Latif in his research has used the former one but in this study however the Euclidean distance method is used because of its simplicity and beside it helps to find the minimum possible distance and maximize efficiency in solving allocation of demand to facility problem in the vicinity area as to Abdel-Latif explanation.

5.3.5. The Final Selected Suitable Areas

These are areas that are free from the limiting factors listed above (i.e. slope is safe for constructing houses, land use type is the most preferable for school, distance from noises, distance from existing school, distance from population and distance from suggested sites is the most suitable). This is achieved after each raster output is further reclassified into common measurement scale values in order to let each participant factor have equal influence in creating the most suitable areas. For this study case, as can be observed from the consecutive figured maps displayed above a common measurement scale of 5 is assigned for all participating inputs. Combination of the factors by means of overlay analysis resulted the final output aimed to be acquired. The result is thus affianced or suitable areas for school buildings as displayed below in Fig. 5.18.

5.3.6. Vulnerability of the Final Selected Sites from Flood Hazard Aspect

Vulnerability of a particular area to flood of course depend highly on the topographic nature of the terrain. It is broadly discussed in the background chapter of the study area that the topographic surface of Yeka Sub-City is characterized by slopes at various degree of steepness. The focus area of the solution on the other hand is found on almost upper plateau part of the Sub-City where the rain drops rapidly rundown the surface. The flow accumulation probability is very low. Thus it can possibly be decided that almost all parts of the Sub-City is not susceptible to flood hazard. In contrast to this, some neighboring sub-cities like Bole and Kirkos are found on low and flat landscape where the probability of flood incidence is high. Thus Flood hazard risk assessment for Yeka Sub-City is not given any consideration in this study.

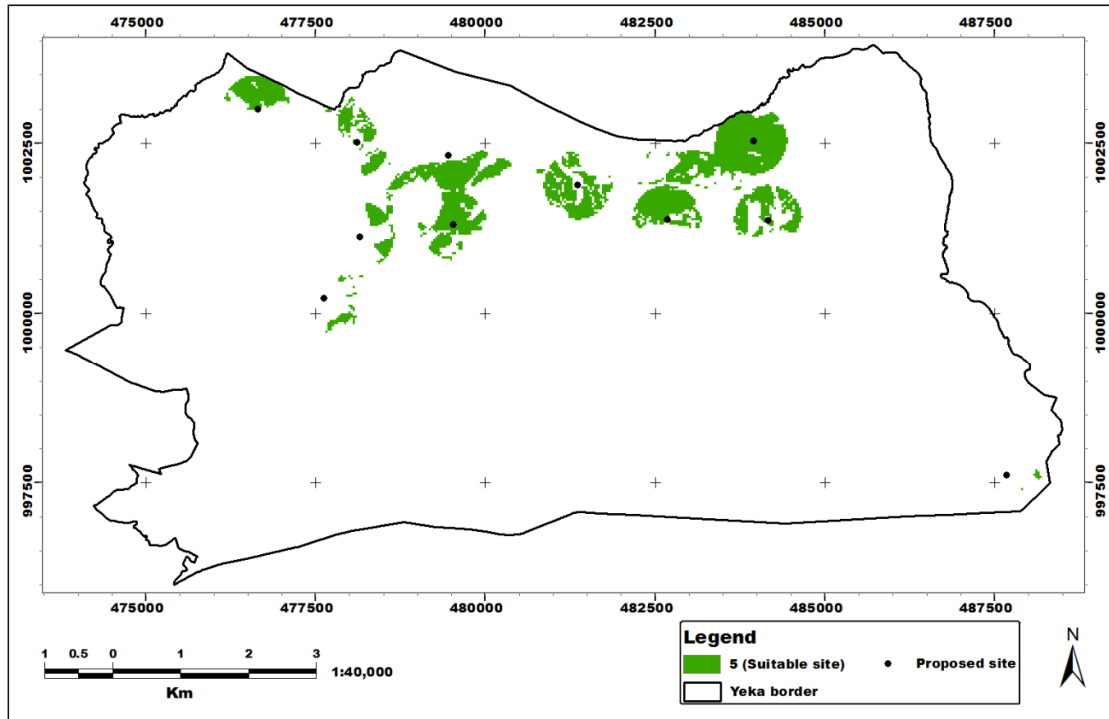


Figure 5.18: The Final Result Output of the Suitable Areas for New Schooling

5.3.7. The Selected Areas in the Past Time

It is clear that Addis Ababa is the outgrowing city from the central area of foundation which lies in sub-cities located at the center. Yeka is one of the recently emerging sub-cities of the City which covers northern most part of Addis Ababa. Therefore it is easy to have imagination of the past background of the Sub-City. Urbanization as seen from the emerging situation of the City is taking place through an increase in the number of urban places. This takes place by conquering rural territories and changing the life standards to urban. The current visual surface of the Sub-City particularly the selected area to be suitable for development of the schools because of scarcity, shows the area was very rural few years before now. There were no infrastructures as per plan, no transportation means except the traditional, No utilities like electricity and manmade water pipes and tanks.

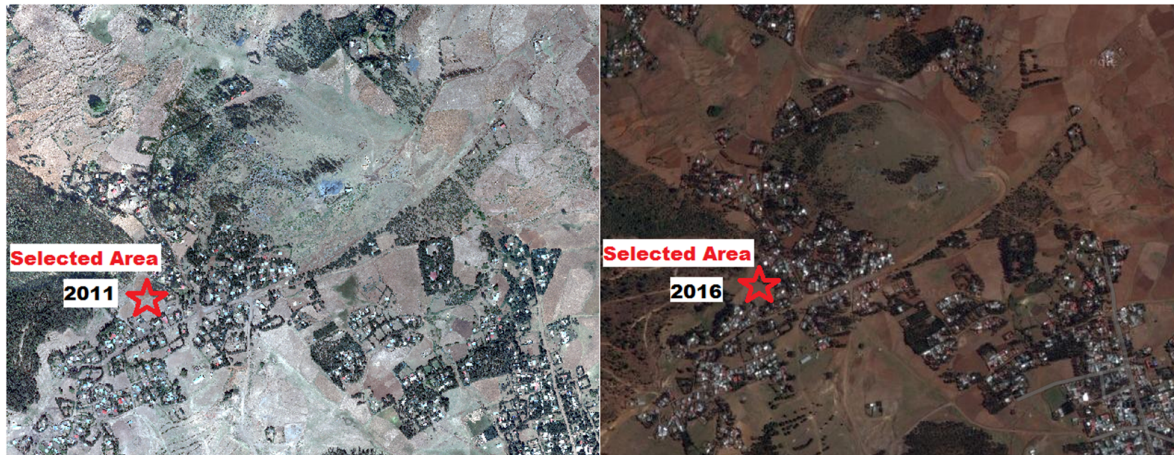


Figure 5.19: The past experience of the selected area in terms of the present time

5.3.8. The Selected Areas in the Current time

Nowadays little area is covered by people leaving in settlement being too far from urbanized area of Yeka. Due to this the life style of most of these people is dependent on agriculture. Rural lifestyle is revealed from the environment. No more services like school, water and health, limited road infrastructures with no transportation facility and utilities such as electricity and telecom service. But Number of inhabitants in the settlement that need supply of these services is increasing.

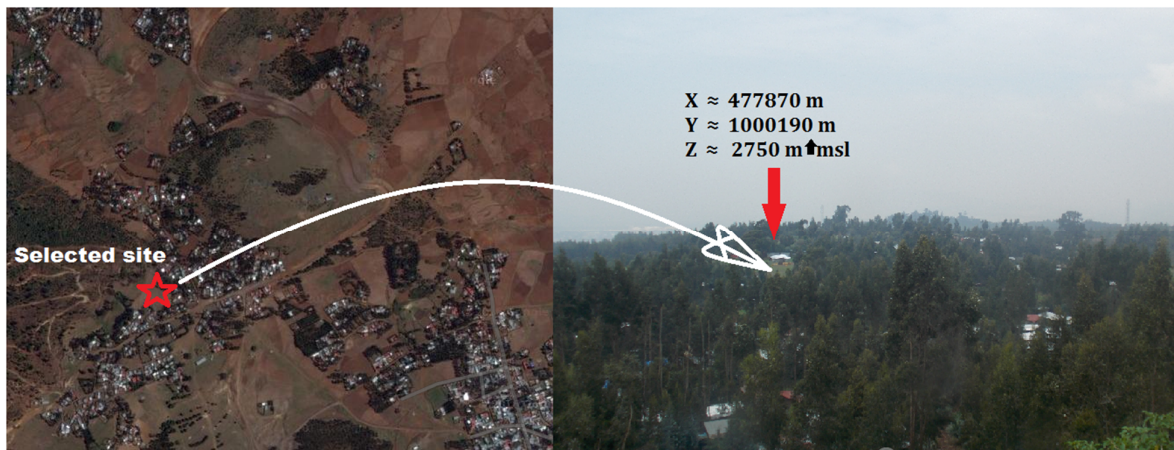


Figure 5.20: Sampled Selected Site Approximate Location vertical and Horizontal View

5.3.9. The Selected Areas From Future Point of View

The area is going to be developed in infrastructure especially road according to the structural road plan prepared at City level. In addition to this, a site is selected for construction of a condominium houses for city residents. This intern increase value of the land and therefore the future chance of existing free spaces to be covered by different economic activities will be high.



Figure 5.21: Selected Site with Road Infrastructure Viewed Vertically and Horizontally

In the research work the author combined two Location finding methods to identify the best location of new primary schools services. The first approach is combined LA and SA modeling analysis which is used to identify candidate sites and highlight approximate or chosen location from the candidate sites for new schools in the underprivileged area, while the second approach is spatial analysis technique of optimizing and relocating the chosen candidate sites in the first approach as well as examining the existing ones for predicting the future. Of course there might be several techniques of introducing such services and other social common goods in the community. But the researcher found these techniques easily help towards finding better result in the problem solving procedures. For instance the study conducted by Abdel-Latif (2007) comprises Multi-criteria Modeling for identification of the candidate sites for principal schools in an urban area and the second approach to identify the optimum sites among the candidate sites chosen in the first approach is location allocation modeling. The weakness in this research is the methodology could not be able to locate the demand population to the school services on the basis of the capacity of the services and interests of the demands whereas the methodology used by Abdel-Latif is the distance calculations depend on the proximity of nodes to actual demand points as per the researcher's description.

Apart from the drawbacks indicated, application of the research methodology is not only used for establishment of primary school services but also for distribution and evaluation of other related urban public services such as hospitals, public healthcare centers, warehouses, market centers and other public goods etc.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1. Chapter Introduction

It is now the state where the researcher has met lots of findings as a result of series of consecutive and different methodical testings of input data of primary school services and student population existing in Yeka Sub-City. The results from LA analysis and supplementary analyses of SA and Spatial analyst therefore brought the outputs to reach at the goals and objectives of the research based on which the following conclusions and recommendations are developed.

6.2. Conclusion

LA and SA analyses result indicated in Fig. 5.6, Fig. 5.7 and Table 5.5, and series of suitability analyses show that within distance cost of 2.5km more than 97% of the school population are accessible to school services currently existing in Yeka. There is no planned mode of school distributions in the demanding environment of the community so that schools are highly concentrated at infrastructure and utility filled areas where as rare number of schools are seen in other areas of population. This situation intern caused some parts of the population remain unreachable while the others are bounded by high potential of coverage and accessibility.

Additional School facilities are required in the northern parts of Yeka Sub-City whose cost attribute values (distance and time) are beyond the recommended. Area that around the proposed site locally known as Danse or Wello Sefer is partially populated and needs developments of infrastructures, utilities and social services such as health, water, public transport along with school requirements.

From evidences seen on the geographical location of schools, annexed Photographs at the end (Appendix 2, **a** and **b**), and random conversation the researcher made with school community, there is no firm separation of schools from sources of noises recognized in Ethiopian educational standard. Therefore city government is responsible to facilitate religious primary schools that provide regular education by providing separate area for schooling and on behalf, taking the nearest extra land portions owned by Religion Centers.

Because it is urban, where there is dense population within specific area, it is difficult to keep most locations of the current school services away from noises. Activities would have been done before the land is occupied with other dominating land use types.

It is apparently that GIS analysis has shown how much is miss-planning of primary school locations along the populated community (Figure 5.3). This can effectively help MoE decision makers to take an immediate action towards distribution of primary schools and the urgent needs for either establishing new schools or relocation of others to provide complete services and easy accessibility to the community. And Therefore GIS based LA and Spatial analysis are the best methods of finding locations that are most suitable for new school sites and other related public services. Governments can consider such scientific studies before the area is developed to districts, towns and cities etc.

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

6.3. Recommendations

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

- ❖ Potential sites for school purpose should necessarily be reserved before they are occupied inconsiderably. The spatial data of land use that has been used in the study has no reserved places for schooling purposes. Land use map of Yeka Sub-City (Table 3.2 & Fig. 3.3) is received from the Sub-City Municipal office. According to these data, there is no spatial land kept for school expansion so that Yeka land planners and relevant bodies shall take considerations on how to deal with such matters for the future fast growing urban population
- ❖ Data organization of Yeka Education Office is hardly strong such that it is recommendable to pertinent individuals that school data shall be prepared and organized properly and consistently. Educational Reports, magazines, brochures and booklets such as ESAA and Education Coverage, Access and Quality (ECAQ) that are prepared by AA City Education Bureau shall also be at Yeka and Woreda office levels in detail.
- ❖ Studies that are conducted related to education are significant and contributing to both the government and the academic community with their findings and problem solving ideas and supports. Because of this, evidences and materials for research shall be open to experts in unlimited manner in the Sub-City Education Bureau.

- ❖ Because AA Education Bureau is at the highest responsibility from the existing educational bureaus in the city, educational issues that are to be dealt at city level must be handled by the Bureau. Regulations set by the city government on how to locate and construct primary schools shall be implemented in accordance with the rules and regulations vested on the paper.
- ❖ Road is one of the basic infrastructures that highly affect both the population density and destiny. Therefore the AACRA shall take special care in expanding the roads on the basis of standard quality and grade levels to keep the normal and even value of the land.
- ❖ Remarkable amount of land portions are owned excessively by delegations such as Embassies, Governmental and Non-Governmental Organizations (NGOs) in the Sub-City. While most of private schools are educating students for future Ethiopia on small plots of land totally occupied by narrow classes that were originally built for residential purposes (Appendix 2, c, d & h). Therefore it is recommended that AACG shall deal with the basic needs of these schools community.
- ❖ Yeka Sub-City Administration shall prepare a ground for regular distribution of services, Infrastructures and control the irregular population resident areas and human life activities and as a result the land value throughout the entire Sub-City will be balanced. Administrations at all levels shall make pre and post customer and facility link studies before establishment of the so called public service centers either for governmental or private services.
- ❖ Government and Private sector of education shall work together closely to achieve stable facility and demand environment. The current situation tells private sector is the major and powerful branch among the participants toward development of Education (Table 2.1 & Fig. 5.1). But it is impossible to confidently say private schools are properly designed and located. On the 2014/2015, ESAA, it is specified that in the standard of primary school, number of students in a class is set to be 50 and construction of new schools is based on this standard. But the fact observed during the study time is different from this. So private and other education sectors must take part in the responsibility of uniform and standard distribution of School services in the Sub-City.

APPENDICES

Appendix 1: More Analysis Results

I. Table 01: Containing Results Indicating LA & SA Distance and Time Attributes

Cost Attribute	Cost value	LOCATION ALLOCATION			SERVICE AREA		
		Located Nodes	Percent (%)	Unallocated Nodes	Located Nodes	Percent (%)	Unallocated Nodes
Time (minute)	5	17607	42.83	23506	17017	41.39	24096
	15	38523	93.70	2590	38284	93.12	2829
	25	40175	97.72	937	39929	97.12	1184
	35	40529	98.58	584	40171	97.71	942
	45	40905	99.49	208	40480	98.46	633
Distance (km)	0.5	27396	66.64	13717	26711	64.97	14402
	1.5	39701	96.57	1410	39546	96.19	1567
	2.5	40508	98.53	604	40267	97.94	846
	3.5	40991	99.70	122	40683	98.95	430
	4.5	41108	99.99	5	40745	99.10	368

II. Figurative outputs of consecutive LA distance based analysis in Table I

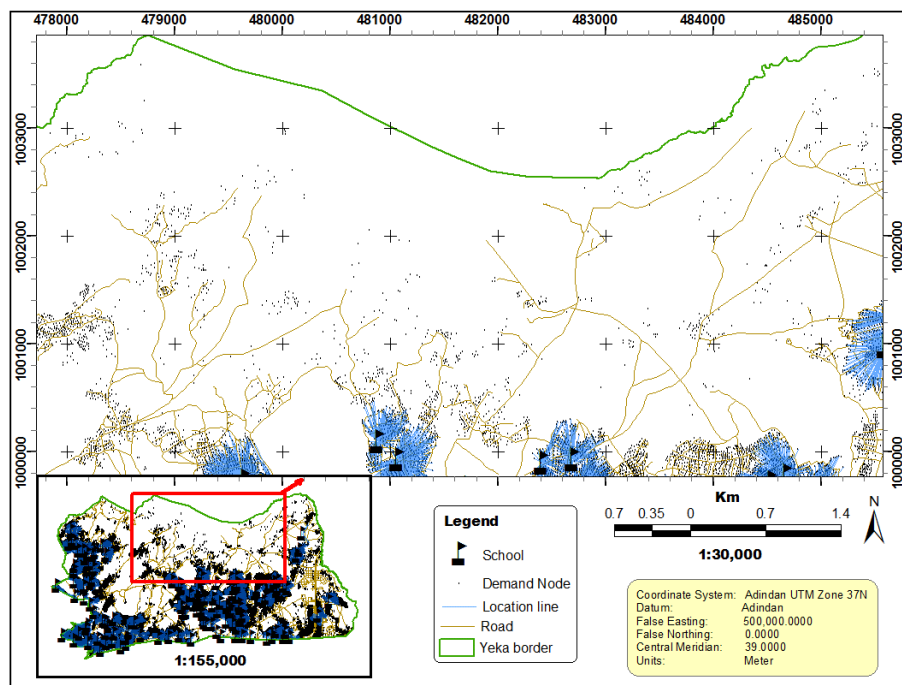


Fig. 01: LA Lines at 0.5km Distance from Demand nodes to School near the Scarcity Area

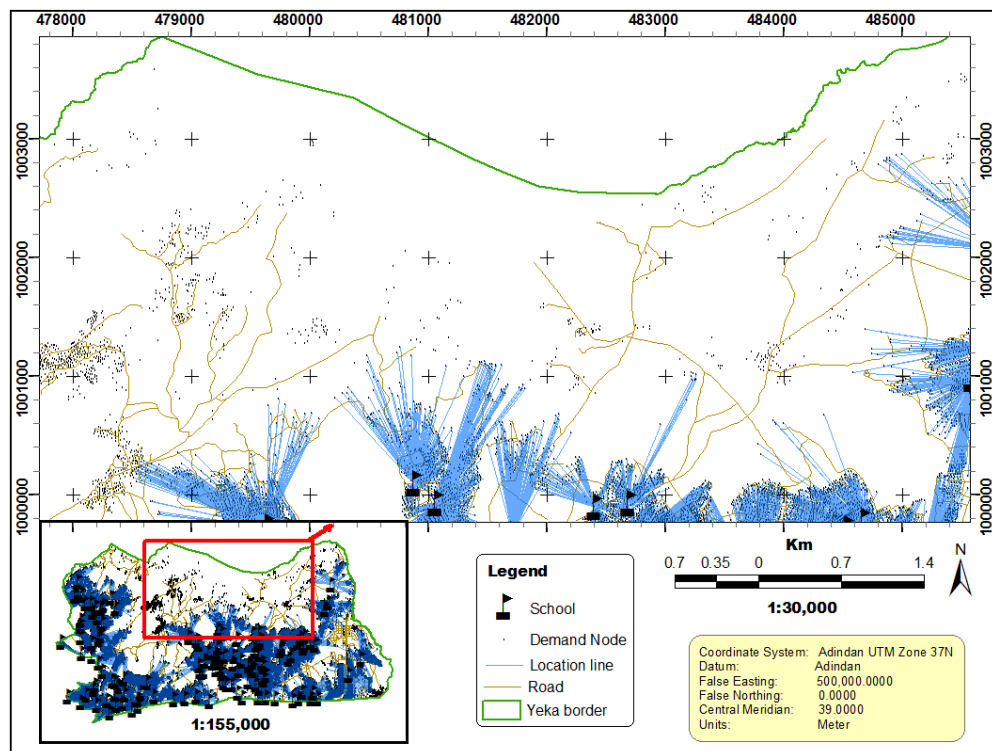


Fig. 02: LA Lines at 1.5km Distance from Demand nodes to School near the Scarcity Area

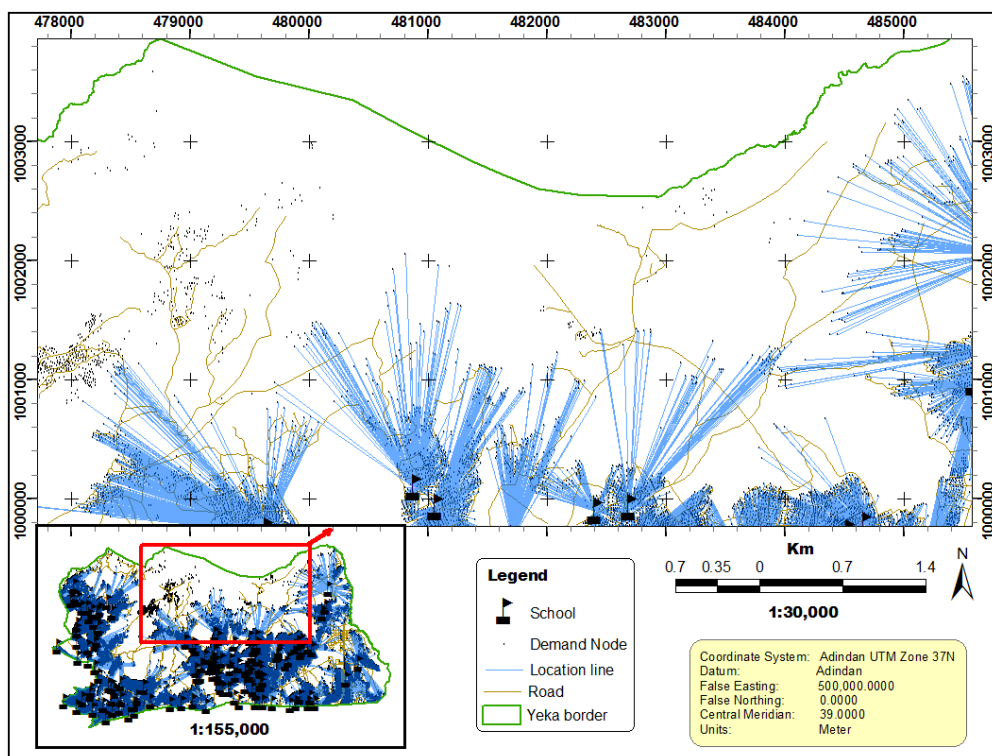


Fig. 03: LA Lines at 2.5km Distance from Demand nodes to School near the Scarcity Area

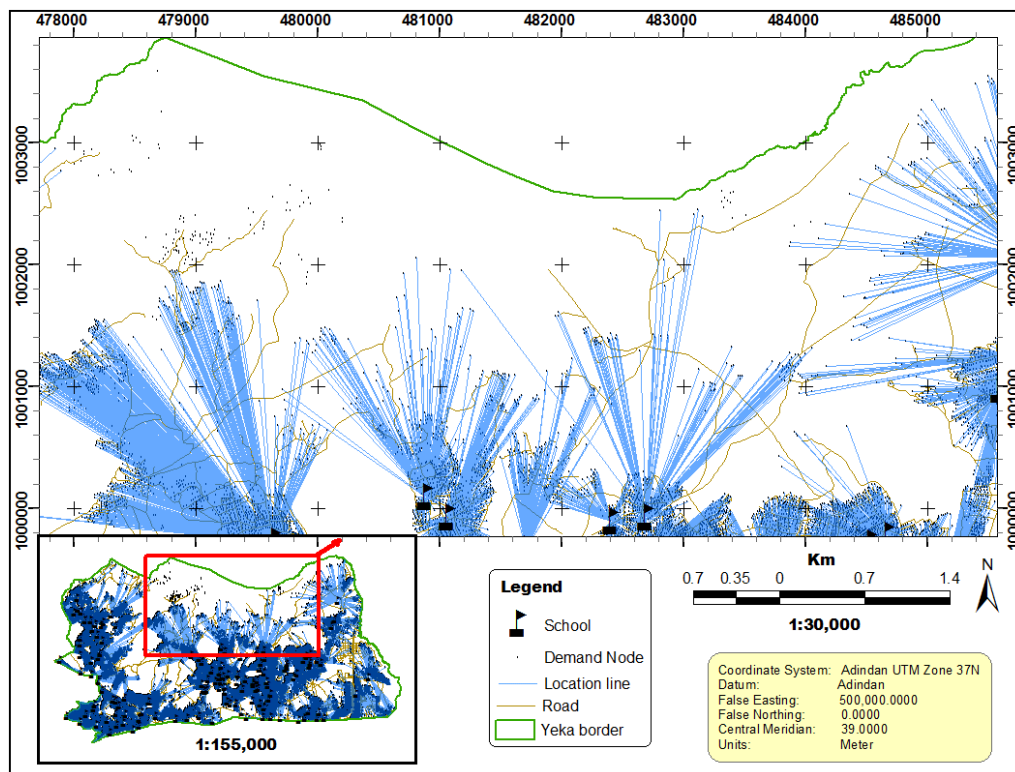


Fig. 04: LA Lines at 3.5km Distance from Demand nodes to School near the Scarcity Area

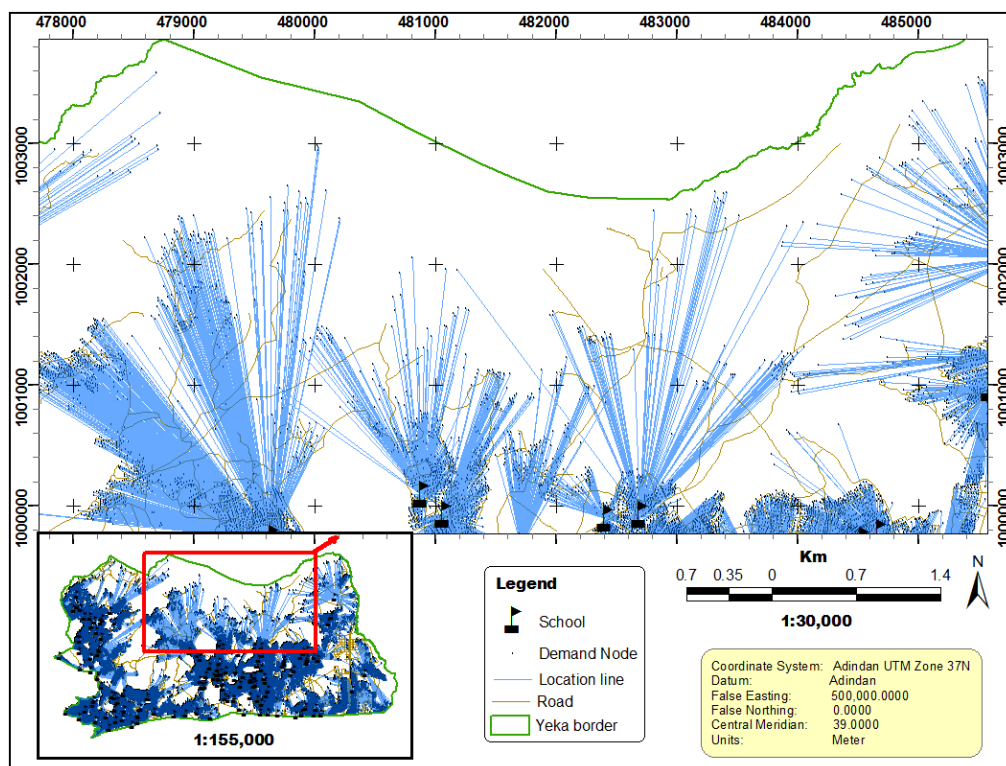


Fig. 05: LA Lines at 4.5km Distance from Demand nodes to School near the Scarcity Area

III. Figurative outputs of consecutive SA distance based analysis in table I

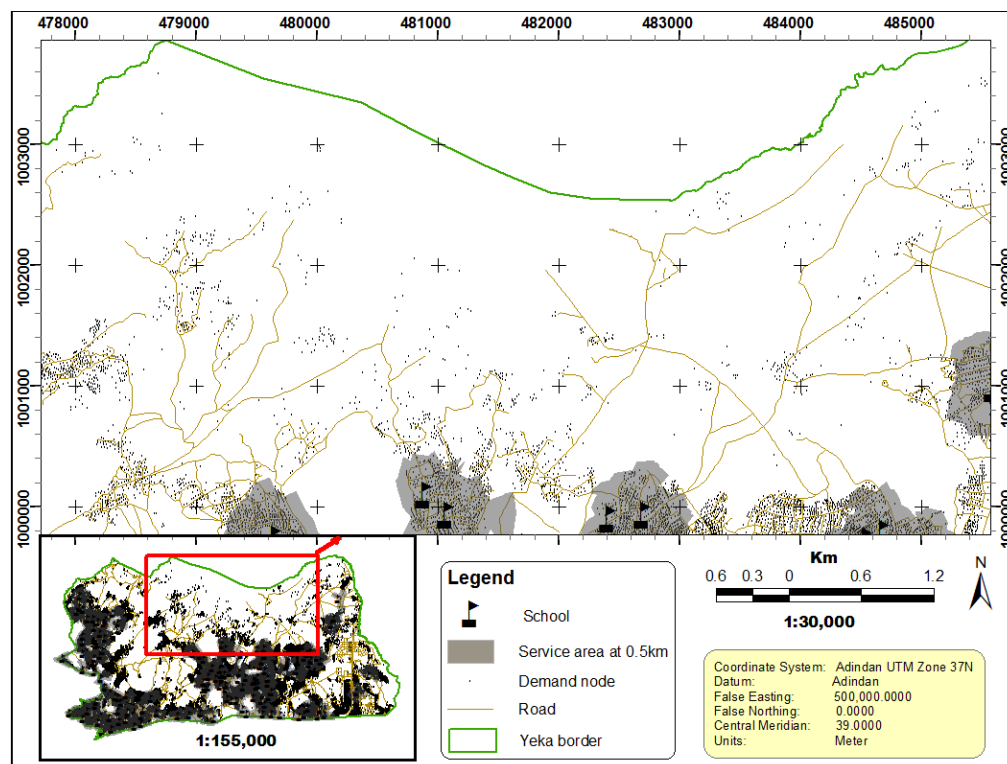


Fig. 06: SA Polygon at 0.5km Distance from School to Demand nodes near the Scarcity Area

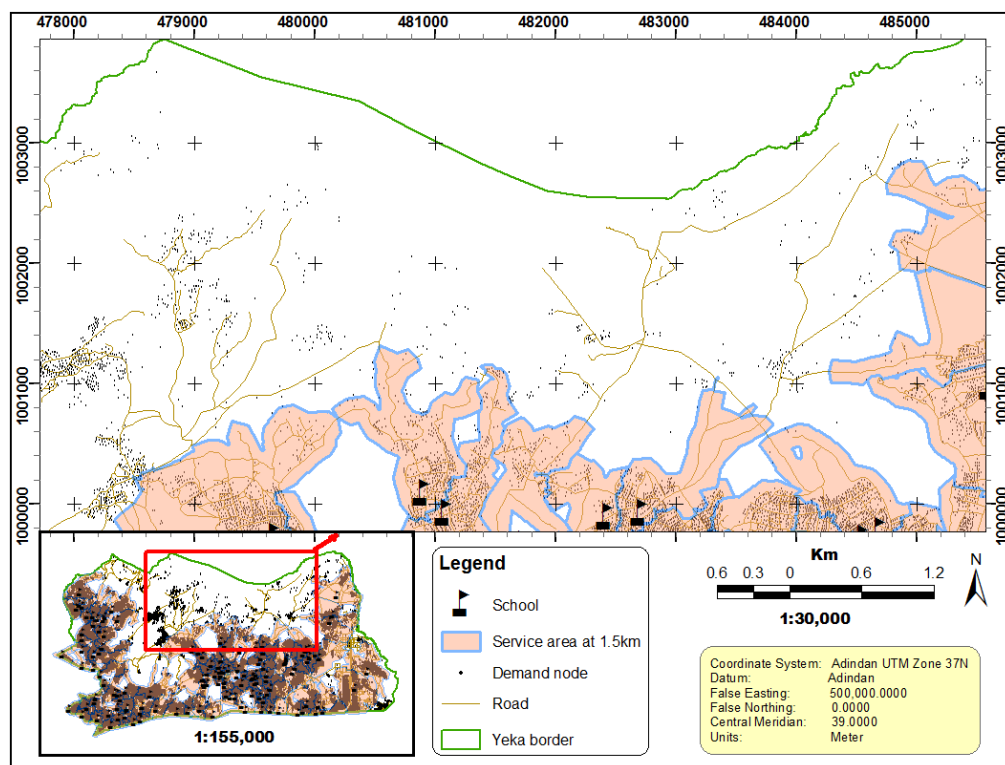


Fig. 07: SA Polygons at 1.5km Distance from School to Demand nodes near the Scarcity Area

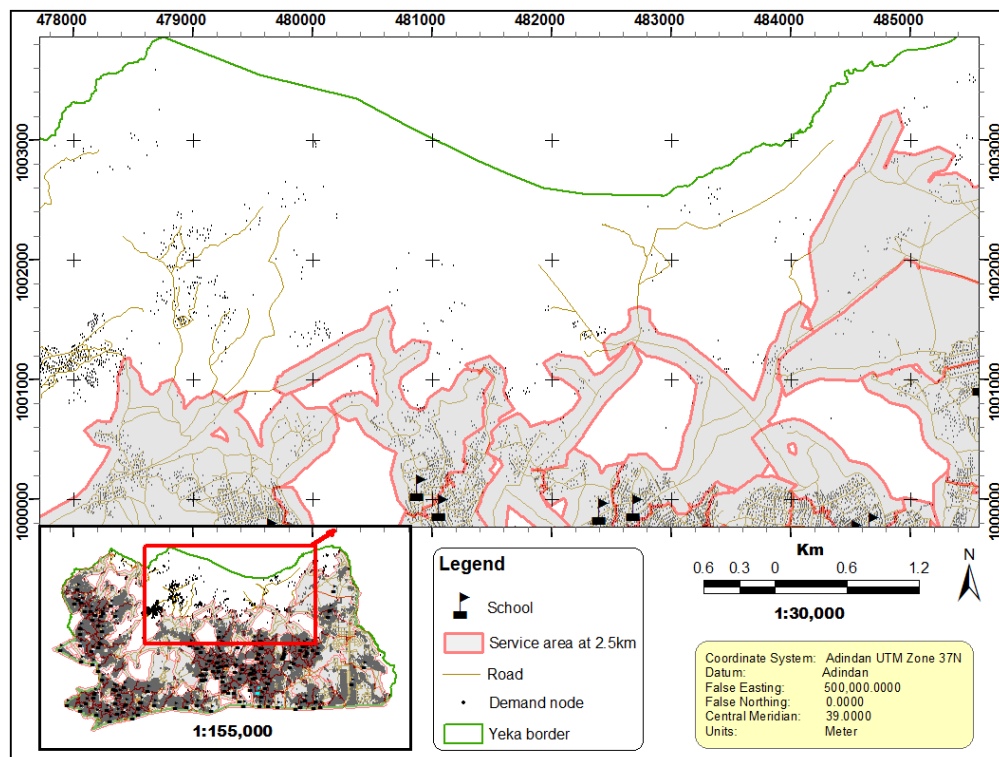


Fig. 08: SA Polygon at 2.5km Distance from School to Demand nodes near the Scarcity Area

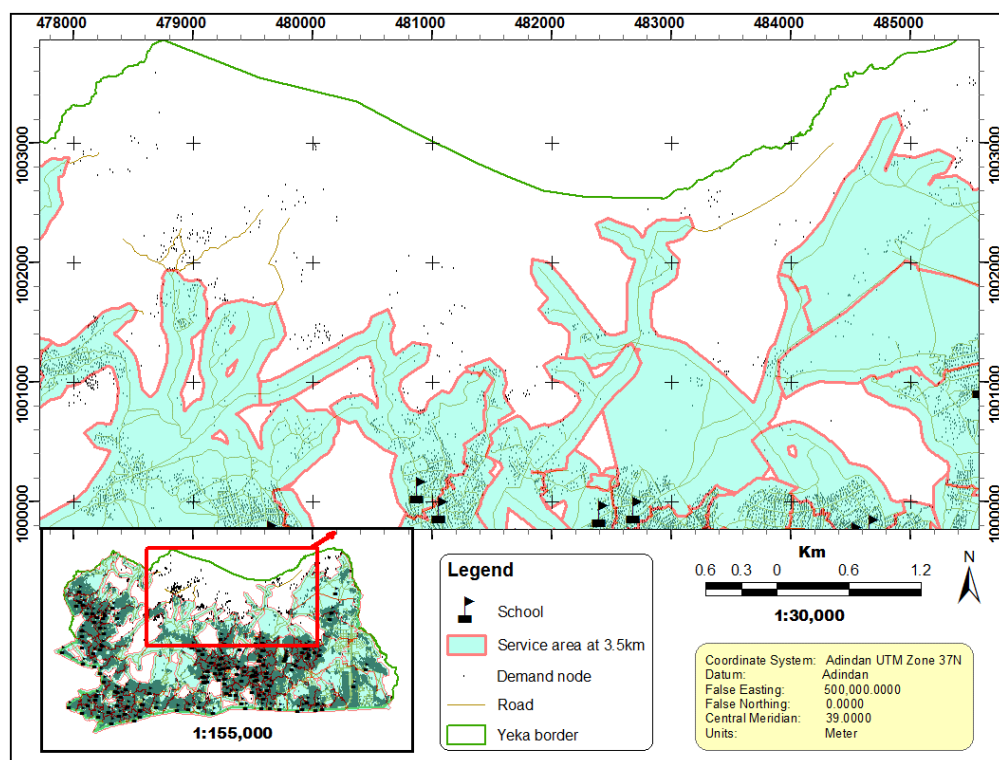


Fig. 09: SA Polygon at 3.5km Distance from School to Demand nodes near the Scarcity Area

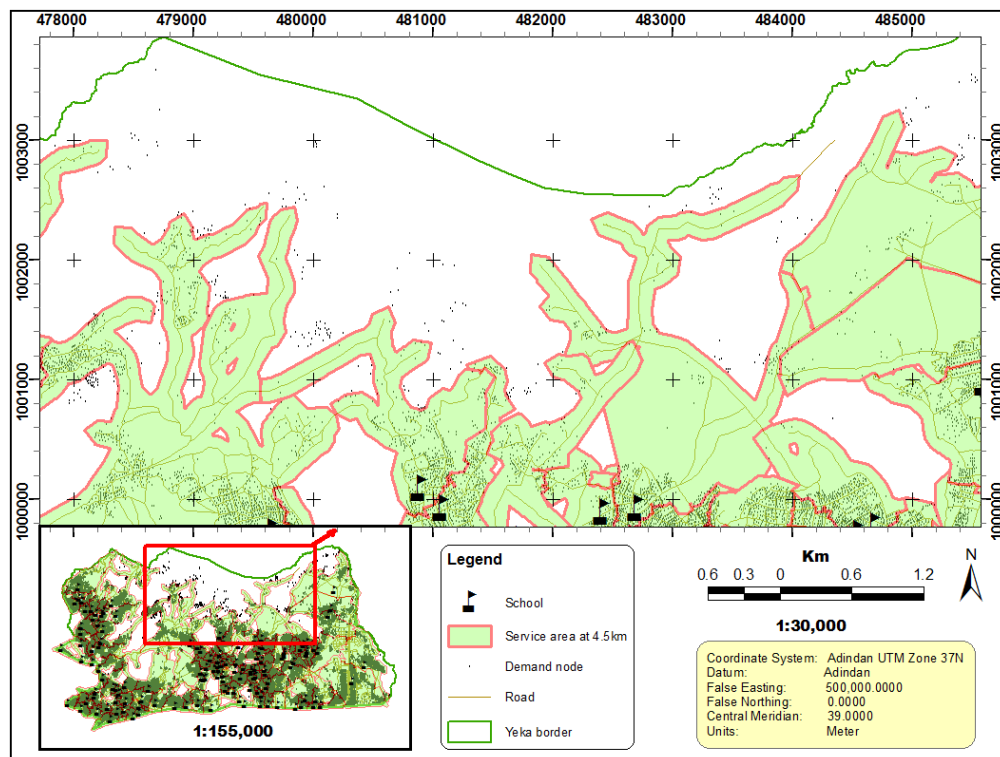
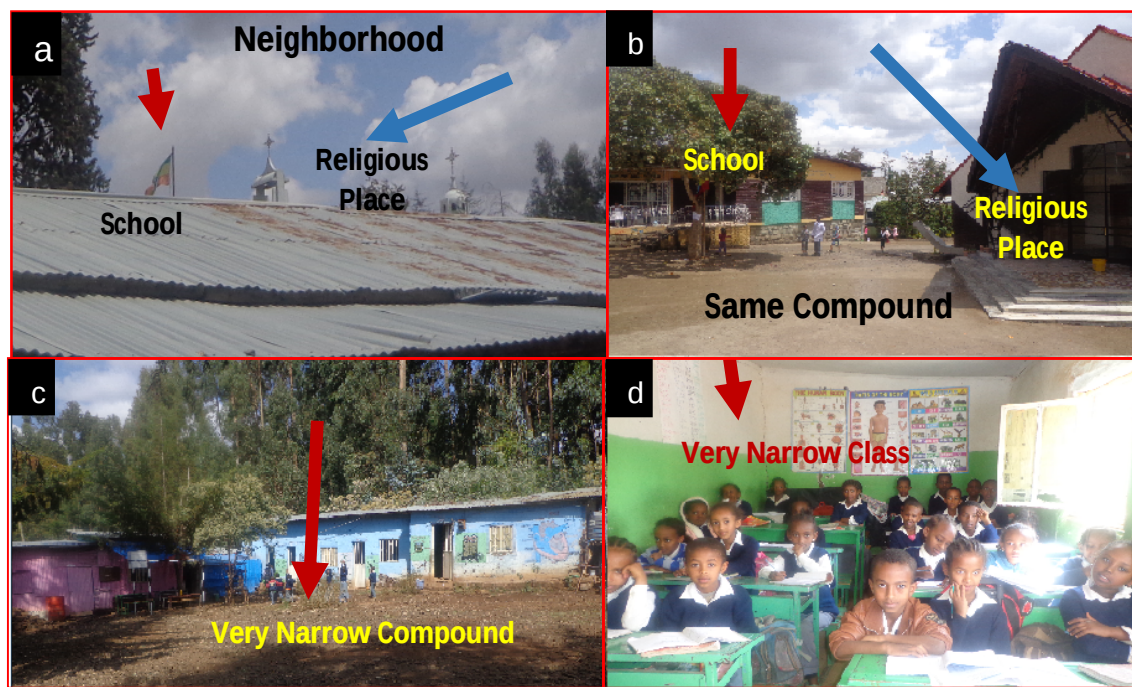


Fig. 10: SA Polygon at 4.5km Distance from School to Demand nodes near the Scarcity Area

Appendix 2: From Picture Gallery





Appendix 3: Citation and Reference information

Referencing style used: American Psychological Association (APA)

Source: Published materials listed in bibliographies

Table 2: Shortened and contrasted Words used in both **text** and **reference list** in APA style

Symbol	Full word	Description	Example
P.	Page	Specify page number in text and reference list	P. 60
n.d	No date	Used wherever year of publication is not specified	Good Child (n.d)

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