ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

GEOMATICS ENGINEERING PROGRAM

ANALYSIS OF SPATIAL DISTRIBUTION AND ACCESSIBILITY OF PRIMARY AND SECONDARY SCHOOLS IN BISHOFTU TOWN, ETHIOPIA

THESIS

SUBMITTED TO THE SCHOOL OF CIVIL ENGINEERING AND ARCHTECTURE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN GEODESY AND GEOMATICS ENGINEERING

BY

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in the thesis entitled "**Analysis of Spatial Distribution and Accessibility of Primary and Secondary Schools in Bishoftu Town, Ethiopia**" in partial fulfillment of the requirements for the award of the degree of Master of science in Geodesy and Geomatics Engineering is an authentic record of my own work carried out from February to December 2017 under supervision of **Dr. Tulu Besha**, Ethiopian Space Science and Technology Institute(ESSTI); and **Mr. Dejene Tesema**, Adama Science and Technology University (ASTU).

The matter embodied in this thesis has not been submitted by me for the award of any other degree or diploma. All relevant resources of information used in this thesis have been duly acknowledged.

Leta Getahun _____ _____

Name Signature Date

This is to certify that the above statement made by the candidate is correct to the best of our knowledge and believe. This thesis has been submitted for examination with our approval.

_____ _____ _____

Major Advisor Signature Date

_____ _____ _____

Co-Advisor Signature Date

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Approved by Board of Examiners

Chairman, department Graduate Committee	Signature
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LIST ACRONYMS

ANNI:	Average nearest Neighbor Index
EPRDF:	Ethiopian People's Revolutionary Democratic Front
ESR:	Education Sector Review
FBO:	Faith based organization
GIS:	Geographic Information System
GOPS:	Government Owned Primary Schools
GOSS:	Government Owned Secondary Schools
GPS:	Global Positioning System
KG:	Kinder Garden
LQ:	Location Quaint
NGO:	Non-Governmental organization
NNA:	Nearest Neighbor Analysis
NNR:	Nearest Neighbor ration
OUPI:	Oromia urban plan institute
POPS:	Private Owned Primary Schools
POSS:	Private Owned Secondary Schools
RMSE:	Root Mean Square Error
RS:	Remote sensing
TVET:	Technical and Vocational Education and Training
UNESCO:	United Nations Educational, Scientific and cultural Organization

ABSTRACT

The fundamental goal of accessible educational service provision is to improve social welfare. However, presently it is unclear that how well the facilities being distributed and accessed by residents and major factors contributing to the variation of its distribution in Bishoftu Town, Ethiopia. This research examines the level of spatial distribution and the extent to which primary and secondary schools are accessible by residents of the town. Locations of schools are spatially mapped; spatial disparities, spatial concentration using location quotient, and spatial distribution patterns using Nearest Neighbor Analysis (NNA), were analyzed at kebele level and the town as the whole. Level of accessibility was analyzed through service area computed using road network of the town. The findings demonstrate that although the number of primary schools in the town is acceptable as compared with the standard set by ministry of urban development and construction, the distribution is found uneven and exhibits in clustered pattern. Moreover, 54 % of the population is identified as to travel more distances to access primary schools. On the other hand, despite inadequate quantity, distribution of the secondary school exhibits dispersed pattern. However, 38.6%of the residents are expected to travel more distance than the standard distance to access the secondary schools. This limitation in spatial distribution and accessibility of the facilities in Bishoftu town is mainly due to combined result of variation in population distribution, socio-economic, absence of regular monitoring and evaluation, and geographic variable. The study would support sustainable spatial policy and direction of spatial development with respect to sustainable urban environment.

Key words: *spatial accessibility, spatial distribution, educational facility, spatial concentration, facility planning, public service*

1. INTRODUCTION

1.1. Background of the study

Social services are services which are provided with the main aim of improving social welfare. They mainly include education, health care, police station and fire protection, and a variety of cultural and recreational services. In particular, education plays an important role in the life of every citizen and the nation at large. Burtch (2006) referred to it as a major force in economic, intellectual, social and cultural empowerment. However, the performance of schools in particular area depends on the availability of service, the number of population it serves, the location distribution of the services, socio-economic characteristics etc (Chukwuemeka, 2013;Naidoo et al., 2014). For example, lack of availability of service leads to low accessibility level for the people to access the facility. Sometimes overwhelming quantity of people to be served by one facility also leads to low service level of the facility. This low performance might influence the prosperity of life for the inhabitants.

Hence, provision of accessible educational services therefore is the foremost step to achieve sustainability in national development and living conditions in the area, as it can directly affect quality of life of targeted population (Fabiyi and Ogunyemi, 2015). Ensuring the spatial accessibility in the urban services distribution is one of the main purposes in urban land use planning through assuring equity in the use of neighborhood areas. The plan of school provision is available as one of the components to be planned in the urban planning tools of Ethiopia. As indicated in urban planning and implementation manual (MUDC, 2012), location of primary and

secondary schools should be in terms of maximum distance travel (catchment area radius) and population index.

However, due to limited effectiveness of plan implementation, urban development in the case of Ethiopia urban centers is rarely meet this standard. Moreover, developers of private schools in particular, in Bishoftu are mainly market-oriented and focus on an area where they can attract relatively residents with better income. This can affect spatial distribution of schools in the town that leads to unbalanced service provision between neighboring areas such as Kebeles and expectation for equal distributions of educational infrastructure is a major challenge (Adebola, 2011). Apparently, residents in the urban periphery, have low level of accessibility to educational facilities.

Addressing the challenges of urban public services has been and will be one of the most imperative efforts of National Government as it has been identified and underlined as among the key problem areas of urban good governance. In order to balance services in the long term urban social service planning, assessing the level of existing educational services provision and accessibility is a useful approach to acquire in-depth understanding at different level of decision making process moreover understanding underlying influential factors contributing to the existing level can be considered as a base for planning new headings.

1.2. Statement of the problem

Accessibility to education at all level helps to equip people with the potentials to overcoming the constraints to development (Denga,2000). Inequality in service provision between neighboring areas increases spatial inaccessibility of the residents to educational facilities affecting the

quality of life. Hence, understanding of the existing level of facilities distribution and accessibility has the major role in alleviating the problem.

A range of case studies have been conducted to evaluate the level of urban public amenities distribution and accessibility (Yi 2004; Inobeme & Ayanwole, 2009, Oluwadare and Julius 2011; Ogunyemi et al., 2014; Chen, 2012; Han et.al., 2012; Mohamadi et al. 2014; Zhao et.al 2016;Lorestani et.al., 2016). However, evaluation of spatial distribution and accessibility of public facilities should be considered in a broad context, encompassing specific physical location of the study area and human, socio-economic, and environmental factors associated to disparity in provision of public facilities.

Despite this acknowledged studies, contemporary researchers are telling us much we do not know and urging to explore more in the area in order to further illustrate of mutual relationship between spatial distribution and accessibility of facilities (Naidoo et al., 2014;Al-Enazi, 2016). Moreover, evaluating the distribution and accessibility of educational services in Ethiopia urban centers is uncommon. Particularly, in Bishoftu, despite of quantitative expansion of primary and secondary schools is perceived, the level of spatial distribution and accessibility of the services to residents are remained unclear.

On top of this, most of the studies conducted so far in this field of study are focusing on a particular level of the services, primary schools owned by Government which ignores the contribution of privately owned schools to spatial distribution of the services. In other cases, services area analysis was based on straight line distances from the facilities which rarely represent the reality of actual travelling distance. In addition, locations of facilities were recorded by a single point anywhere in the plot often most of the time taken outside of the plot which can

affect the distance between the facilities and the resulted spatial distribution due to inaccurate representation of facility's location. Above all, major factors associated with the resulted distribution were not well addressed.

Hence, The distribution and accessibility of schools may have detrimental effect on provision of the services that can affect educational performance and national development, and as my knowledge no study had been conducted in the case of Bishoftu town, then more should be known about current level of distribution and accessibility of schools in the town.

1.3. Purpose of the study

The purpose of this study is to examine the current level of spatial distribution and accessibility of primary and secondary schools in Bishoftu town using Geographic Information System (GIS) as a tool of analysis. Based on the result, the study sought to shade light on major challenges associated with the existing level of distribution and to improve the provision of the services for betterment in serving growing demand of people in the future by proper planning.

1.4. Objectives

General objective

The general objective of this study is to examine spatial distribution and accessibility of primary and secondary schools in Bishoftu town using GIS Techniques.

Specific Objectives

- To determine spatial concentration of the primary and secondary school
- To examine spatial pattern of the facilities
- To identify accessibility level of the facilities to residents

- To Indicate factors associated with existing pattern of spatial distribution

1.5. Research questions

- What is the level of concentration of existing primary and secondary schools in the town?
- How could the existing spatial pattern of the facilities be determined?
- To what extent that primary and secondary schools in Bishoftu are accessibility?
- What are the potential underlying factors contributing to existing distribution pattern of the facilities in the Town?

1.6. Significance and beneficiaries

The findings of this research highlight the level of provision of educational services in Bishoftu town, more specifically, spatial distribution and accessibility of primary and secondary schools in the town. This can create awareness in relation to provision of social services towards sustainable urban development. It can also help planners to recognize where there is disparity in the services that may adversely influence residents of the town. Moreover, it serves as a monitoring tool with which to guide the direction of demand of the services, to adjust course to updated information, or to plan a new heading before negative outcomes become irreversible.

Moreover, the study provides a better understanding of major factors contributing to the resulted distribution and accessibility of the services in Bishoftu town in particular and possibly serves as spring board for the country's urban centers in general. Identification of why imbalanced developments occur in unintended location can support the government to formulate sustainable spatial policies and direction of spatial development with respect to sustainable socio-economic needs and reduce disparities in accessibility of services across the town.

Most importantly, adaptive approach and techniques used in this study provide a basis for monitoring and evaluation of other social services in other urban centers in the region and country as well. Finally, it can initiate further researches on issues in line with sustainable urban services provision in Bishoftu town and the country.

1.7. Delimitation of the study

There are some demarcating lines up to which the study extends. These are time, scope of literature review, theoretical and methodological perspectives, and spatial extent which the analysis uses as inputs to produce the aimed result, and its level of generalizability.

Bishoftu town is one of fast growing urban centers in Ethiopia. The town is experiencing rapid urbanization and spatial growth since the last two decades. Urbanization is regarded as important factor contributing to imbalance developments. Hence, examining the level of spatial distribution and accessibility of educational facilities in Bishoftu would be interesting. In line with this, the existing boundary of the city as of 2016 is selected to limit the spatial extent of the study.

Relevant related literatures have been reviewed to acquire background information, strong theoretical bases, selection of appropriate methodology, identification of gaps in the literatures, and to compare the findings in the existing body of knowledge. Based on this, the review was focused on the following themes; the trend of education in Ethiopia, role of education in national development, spatial concentration of urban public facilities, concepts and measurements of accessibility, and potential of geospatial technology in facility planning. Finally, the results of this study could be generalizable to urban areas with similar problem, socio-economic status, and under same urban land-use planning system.

1.8. Limitation of the study

This study aimed at investigation primary and secondary schools in Bishoftu town. Other than Government owned schools, there are private developers, NGOs, and public. However, due to existing limitation of availability of data, time, and intended depth of analysis, schools other than Government owned are taken as Private Owned Schools. This might affect the discussion of the result.

In addition, due to limited number of secondary schools identified in Bishoftu and their concentration in only few kebeles, spatial concentration of secondary schools is analyzed with respect to the town as the whole. i.e. concentration analysis for secondary schools was not conducted at kebele level. Moreover, existing road network in the town does not cover sub-urban kebeles, thus spatial accessibility of the facilities was analyzed focusing on urban kebeles.

1.9. Thesis outline

The thesis consists of six chapters. The second chapter is a literature review where various research studies were explored on various topics such as the role of education in national developments; concepts and measures of spatial concentration, distribution and accessibility of urban public services. The third chapter describes geographic location, climate, and socio-economic characteristics of the study area, Bishoftu town. The fourth chapter will go through the research design, data, data sources, methods of data analysis applied to the study. Chapter five provides analysis and a discussion of the results.

The final chapter presents conclusions drawn from the study and recommendations for future research.

2. LITERATURE REVIEW

2.1. Education in Ethiopia

Education in Ethiopia has been dominated by the Ethiopian Orthodox Church for many centuries until secular education was adopted in the early 1900s. Successive governments in Ethiopia have tried to develop the country through basic education. For instance, during the Imperial Empire, following the Italian defeat in 1941, the country started to build up the sector. Unfortunately, because of several unanticipated problems such as shortage of teachers, textbooks, inadequate infrastructural facilities among others that emerged in the early stages of the implementation of the scheme the program failed to achieve the objectives. As a result, at early 1970s, Ethiopia had an estimated literacy rate below 10%. The government expanded the public school system and in 1971 there were 1,300 primary and secondary schools and 13,000 teachers. To improve the situation, the comprehensive study of the education system was initiated and education Sector review (ESR) completed in July 1972 recommended attaining universal primary education as quickly and inexpensively as possible, equalizing educational opportunities, and relating the entire system to the national development process.

After the beginning of the Ethiopian Revolution in 1974 during the Derg regime, the national literacy campaign began in 1975 when the government mobilized more than 60,000 students and teachers, sending them all over the country for two-year terms of service. One of the first policy changes was the right of every citizen to free education. The general idea was education for the masses and could be summarized in the slogans “Education for production, for research and for political consciousness”. Primary schooling expanded throughout the country with national

enrolment reaching 34.1%. However, there were regional disparities with more resources going to the south than to north.

By 1991, when the Derg was overthrown by the Ethiopian People's Revolutionary Democratic Front (EPRDF), infrastructure had been destroyed, there was little access to education and extreme poverty was widespread. Since this time, the EPRDF has gradually improved the educational sector leading up to the current system. The Ministry of Education (MoE) provides some indication of achievements in the five years from 2008/9 to 20012/13 that is primary school enrolment has increased substantially. Within this period the number of primary schools increased from 25,212 to 30,534 and the number of secondary schools increased from 1,197 to 1,912. Nowadays, Primary education has two cycles from age 7 to 10 years (grade 1 to 4) and from age 11 to 14 years (grade 5to 8). Secondary education has two cycles from age 15 to 16 years (grades 9 to 10) and from age 17 to18 years (grades 11 to 12) leading up to the national examinations which leads to higher institutions.

2.2. Role education in national development

Education plays an important role in the life of every citizen and the nation at large. Burtch (2006) referred to it as a major force in economic, intellectual, social and cultural empowerment. Its value in bringing about character and attitudinal change ranks as important as its ability to reshape human potentials for desired development. UNESCO reported that the growth of education is essential to the development of economy around the world. World Bank opined that the Gross Domestic Product (GDP) of a country will increase 3% yearly as the level of education increases. Education is a basic human right, and is indispensable for the achievement of other human rights. Education contributes to every Nation by building the economy, therefore limiting

poverty rate. It also enlightens the people, thereby making the citizens to abide with the norms of the society.

Psacharopoulos and Woodhall (1985) defined national development as the improvement of a country's productive capacity through changes in social attitude, values and behavior and finally, changes toward social and political equality and eradication of poverty. Earlier studies (Longe, 1999, Fabunmi and Akinwumiju, 2002, and Fabunmi, 2004) revealed a strong and positive relationship between investment in education and national development. World Bank suggests that there should be continued expansion and improvement in both primary and secondary education to prepare students for different career options in the growing economy.

Ethiopia is among countries that concur to education as an undoubted means of fulfilling national development, thereby making private individuals, government and organizations to set up educational institute at all level to meet educational yearnings and wants of the citizens; although the expectation for equal distributions of educational infrastructure is a major challenge. It is quite obvious that the objective of developing the entire citizenry cannot be achieved unless the public education facilities are evenly distributed over the country's landscape taking into consideration the local population density and land area coverage per school.

2.3. Spatial location of urban facilities

Urban public facilities are crucial resources that enhance all-round development of man and his environs. Especially, educational infrastructure is an important aspect of infrastructures that needs to be earnestly developed in the society. Education is an important part of public facilities since it provides services to the people and also impacts on individuals who do not have access to its use in the area. The selection of the location of each service depends on the specific nature

and characteristic of service; the catchments area for which the service is provided; the location area of the users /serviced population; the availability of appropriate area of land/site (topography, area). In Ethiopia, locational standards (table 2-1) for urban infrastructure provision have been set in Urban Planning and Implementation Manual to guide planning process.

Table 2-1 level, requirement and location of educational service (source: UPIM 2012; MUDC, 2012)

Level of education	Space requirement*	Radius of Catchment area	Served population
Primary Education	1.5 – 2.5 ha	≤ 2km	12000- 18,000 (A.A) 5,000- 15,000
Secondary Education	2.5-6 ha	3-5km	10,000- 15,000

*The area required for all the above pre-primary schools can exceed the above figures by taking the gross area 0.4 - 1.4 m2/inhab in high-density areas.

2.4. Spatial concentration of urban facilities

The concept of spatial concentration is used to measure the extent to which the public facilities in different parts of urban areas are in balance (Jahan & Oda, 2005). It takes population distribution in to consideration and computed value of location quotient (LQ) ratio. The location quotient is a device for comparing a percentage share of a particular facility within a part of the City with its percentage share of the total population. It helps to quantify and benchmark the degree of relative concentration of an activity in the analysis of area localization. The values of the result of spatial concentration can be categorized into above average, average, and below average. This concept has been used in different studies. For instance, in spatial analysis of urban amenities (Parry et. al, 2013); to evaluate distribution of public facilities (Jahan & Oda, 2005; Talen & Anselin,

1998); as a tool for measuring progress towards sustainable neighborhood environments (Karol & Brunner, 2009).

2.5. Spatial accessibility of urban facilities

2.5.1. Concept of accessibility

Accessibility is a concept that has taken variety of meanings in different fields of study. It is an "explanatory factor" used to support formulation, or to increase understanding on the performance of policy instruments in these fields. In transportation, for example, Litman (2003) defined accessibility as an ease of reaching the opportunities (goods, services, activities and facilities) in a given destination. Also, Baradaran & Ramjerdi (2001) defined accessibility as "a state of connectivity". In the field of geography and urban economics, accessibility refers to the relative ease of reaching a particular location or area. In social planning, accessibility refers to people's satisfactions and behaviors. Moreover, it is concerned with the local societies' attitude and focuses on psychological points of view. Accessibility, also, refers to people's ability to use services and opportunities (Litman, 2007). Accessibility can be interpreted as the amount of effort for a person to reach a destination or the number of activities which can be reached from a certain location (K.T. Geurs & J.R.Ritsema Van Eck, 2001). These all demonstrate that the concept of accessibility varies depending on its aims and the scientific field that it comes from. However, in general term, a particular location can be defined, as accessible if the effort it takes to get there is acceptable to the target group. So, the concept of accessibility incorporates not only the transport link between origin and destination and the ability for travelling by the target group, but also characteristics of the destination and the objective of the trip.

Despite the fact that accessibility has disparate differences in its operational formulation and theoretical basis, its concept has played an important role in spatial analysis of the urban environment. Spatial accessibility to social infrastructure broadly refers to the ease with which residents of a given location can reach social infrastructure. Its role includes helping understanding of the complex urban system of land value, household location choice, population density, land-use patterns, social exclusion, urban growth, and intensity of economic and social development. Therefore, accessibility can show the potential of sustainability and a dimension of the quality of life.

2.5.2. Accessibility measures

Accessibility indicators give different values that rank accessibility to facilities from high accessibility to inaccessibility. They can also be used to classify facilities in term of their peripherally and centrality locations (Schurmann & Talaat, 2002). As there is no agreement about the concept of accessibility, measuring accessibility differs from study to another depending on its aims and the nature of factors that are used to measure accessibility, which might be quantitative or qualitative factors. These factors can be time or distance of travel, available transport modes, people characteristics, activities characteristics, etc. As a result of this disparity in the causes of measurement of accessibility, a number of accessibility measures have been appeared in the different disciplines. For this reason, Geurs & Ritsema van Eck (2001) has categorized accessibility measures into three groups: infrastructure-based accessibility measures, utility-based accessibility measures, and activity-based accessibility measures.

Infrastructure-based accessibility usually used in transport studies and infrastructure planning, such as analyzing the performance of transport infrastructure such as travel speed, journey time

and congestion. This category does not concern the spatial or land use components; therefore, it considers traffic or transportation measures. Utility-based accessibility measures analyze the benefits individual derive from the land use-transport system. It measures based on the random utility theory. This measure represents evaluation for accessibility by the persons. Therefore, it is based on the assumption that persons choose activity that gives them high value of utilization compared to other valuable activities (Marki & Flokesson 1999). This measure is often used in economic studies, especially, for cost-benefit analysis. Activity-based accessibility measures take in account land-use components as well as people, transport and activities and are used to analyze the range of available opportunities with respect to their distribution in space and travel impedance between origins and destinations. Hence, Activity based accessibility measure is best suited to this study as it deals with people's access to reach the social facilities from their origin and spatial distribution of the services.

From this perspective, four interdependent components determining accessibility can be identified. They are *transport component*, *land use component*, *temporal component* and *individual component*. Transport component reflects the travel time, cost and effort to travel between origin and destination location. Land use component reflects the spatial distribution of activities at destinations (e.g. jobs, schools, shops) and the demand for those activities (e.g. workers, pupils, inhabitants). Temporal component reflects the time restrictions of individual and availability of activities at different times of the day. Individual component reflects the needs, abilities and opportunities of individuals. This argument demonstrates that accessibility can illustrate the spatial relationship between the people's demand of social infrastructures and the availability of activities, in this case schools. Activity-based accessibility measurement is best

suited to this study as it deals with people's access to reach the social facilities from their origin and spatial distribution of the services.

2.5.3. Measuring spatial accessibility

Activity-based accessibility considers cumulative opportunities measures, gravity models or potential measures, person based accessibility measures, and distance measures. All this measures have their own limitation. For instance, potential measures neglect the spatial behavior of persons; person-based measure determines the accessibility of each person, so it needs large amount of data to measure accessibility, it is difficult to use this measure at the higher level and often used at small areas. The contour measure (also called a proximity count, proximity distance, cumulative opportunities, isochronic measure) indicates the total number of destinations reachable within a given travel time or distance. This measure emphasizes the number of potential destinations or opportunities rather than their distance. In cumulative opportunity measure the cut-off value is determining arbitrarily to define the accessibility to opportunities, which leads to biased results. Distance measures are relatively distance measures are simple to calculate and interpret; requires small amount of data; used as average distance, weighted area distance or distance to the closest activity using road network distance measurement. On top of this, they assume all persons have equal access to activities. Hence, it is best suited for this study.

For the distance measures, it calculates straight line distances. This cannot give an accurate description of the reality. However, if the distance calculated is network distance, this can represent travel path of people in reality. For the contour measures, the choice of a cut-off travel distance (or time) is very crucial. The result of analysis, in terms of accessibility levels, can be

highly sensitive to this cut-off value. But the measures do not incorporate an impedance function to weigh opportunities according to their travel time or cost. For composite measures, a parameter value for the travel impedance function must be selected or estimated using recent empirical data of spatial travel behavior in the study area, and the measures are based on aggregate travel patterns. Actually, a contour measure is a specific form of the gravity-based measure, with the impedance function equal to one if the opportunity is within the travel time limit, and zero otherwise.

These measures have their own benefits and shortage in terms of analytical capability and the data requirement. The choice of the most suitable measure to be used in the study depends upon the objective of research, data availability and time available to conduct the research.

2.6. Geospatial technologies in facilities location analysis

Geospatial technologies such as Global Positioning System (GPS), Remote Sensing (RS), and Geographic Information System (GIS) are a powerful tool to collect spatial, process, and analyze spatial data. GPS is used to collect spatial data in real-time. Satellite image acquired from remote sensing satellites in different spatio-temporal scale enables the contemporary researchers to analyze spatially referenced data and pinpoint the challenges and propose solutions. GIS technology is appropriate for a variety of usages including resource management, delivering better services distribution, and making reliable decisions. In addition, GIS technology has been implemented in service management for displaying large volumes of diverse data pertinent to various local and regional planning activities (Cheng & Ling,2007). It is a collaborative that allows using, creating, and sharing maps, apps, and data, including authoritative base maps. Al-Enazi et al. (2016) used to investigate school service area and define the inequalities services

distribution and noted that GIS based methodology could help planners in managing the distribution of the future services.Ogunyemi et al (2014) has demonstrated the dynamic capabilities of Geographic Information System application in analysis of spatial distribution and accessibility to secondary schools. Oloko-oba et al. (2016)has explored the use of GIS technology as a planning tool can be employed to enhance the location of educational infrastructure for equivalent distribution.

3. THE STUDY AREA

3.1. Location

Bishoftu is located at central parts of Ethiopia in Oromia Regional State, East Showa Zone; lay along the main road from Addis Ababa to Adama toward East at distance of 47 km from capital. Geographically it is located 8 degree 43' North – 8 degree 48' North latitude and 38 degree 00' East – 38 degree48' East longitude. It covers the total area of about 148.78 km2. Bishoftu has 9 urban kebeles and 6 sub-urban kebeles. With respect to natural heritages, Bishoftu is the home for 7 lakes which attract tourist and hotel, resort and recreational investment. This makes Bishoftu a so called ‘garden city’ due to abundance of garden flower and its greenness (OUPI, 2009).

The Town of Bishoftu owed its birth to the construction of the Addis Ababa – Djibouti railway line. Before the arrival of the railway line, the area of present day Bishoftu and its surroundings was known collectively as 'Ada’a'. The construction of the railway line reached the present Bishoftu between the years 1913 and mid 1914. The site where today's bus station situated was named "Bishoftu Station" which gradually became the name of the settlement around the station and of the Town later (NUPI, 1999 and OUPI, 2009).

Bishoftu town is also situated at the western tip of the Great African Rift Valley and at the transition zone of the western and eastern Ethiopian highland massifs. Bishoftu has common boundary with Dukem town in the Northwest direction and all other boundaries are with rural villages some of which are currently administered under Bishoftu Town Administration.

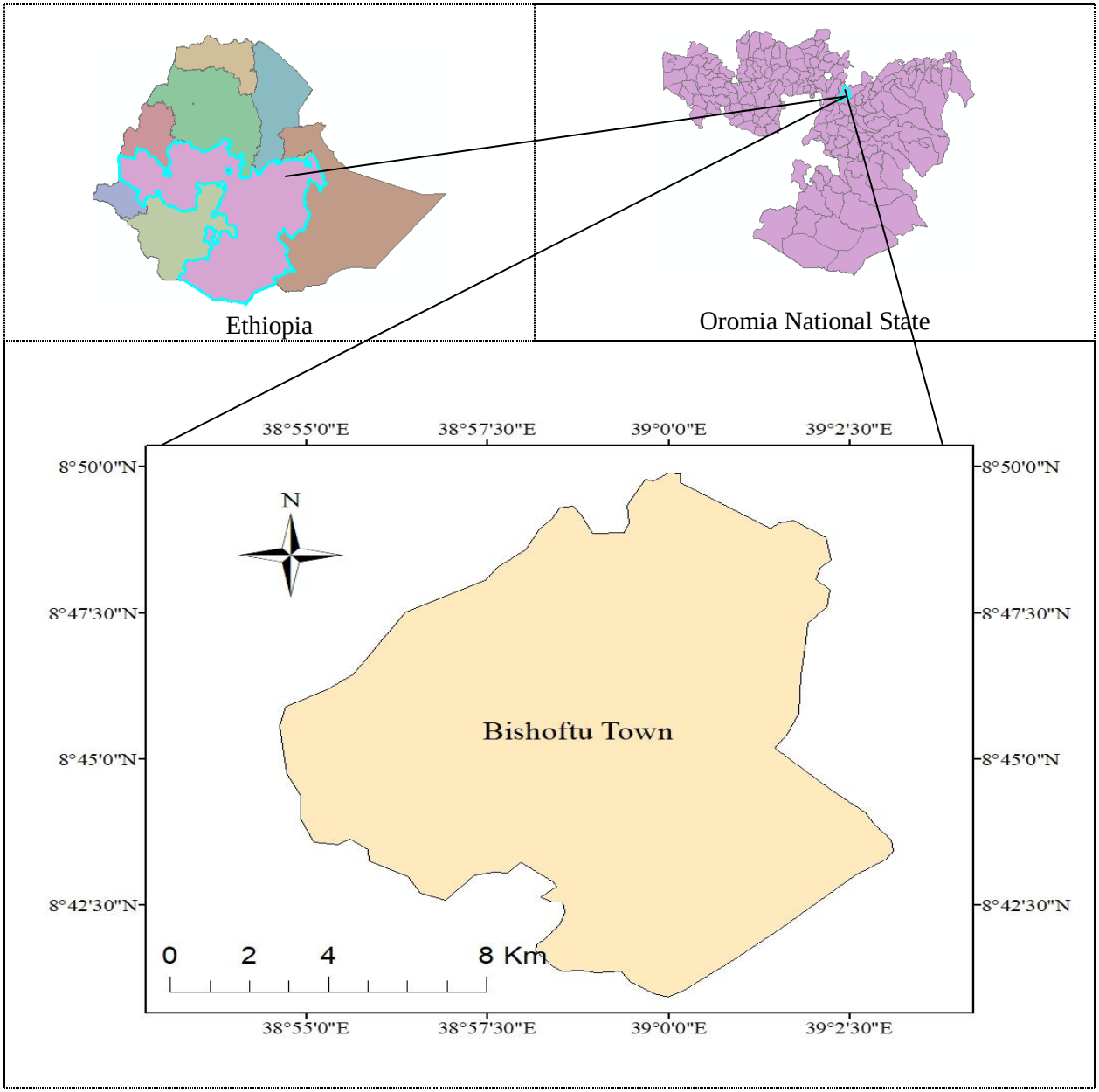


Figure 3-1 **location map of Bishoftu town**

3.2. Population

Although it is a Wereda administrative center, Bishoftu Town is the fourth largest urban center in Oromia Region in population size, next to Adama, Jimma and Shashemene and indeed it is one of few towns in the country with a threshold population of over 100,000.The 1994 census report shows that Bishoftu had a total population of 73,372 of whom 35,058 were men and 38,314 were women. According to the May CSA, (2007) data, the total enumerated population of the Town was 100,114 of whom 47,938 are men and 52,176 women And currently the total population of the town 213,689 of whom 99,201 are men and 114,488 women (BAO).Population size of Bishoftu town in 1994, 2007 and 2017 is shown in the following tables.

Table 3-1 **population number of Bishoftu town**

year	Male	Female	Total	Source
2017	99,201	114,488	213,689	Bishoftu administration office
2007	47,938	52,176	100,114	2007 statistical report of population and housing census report
1994	35,058	38,314	73,372	Census report

3.3. Topography

The topography of Bishoftu town and its environment comprises vast plain areas, swampy and water bodies, soft, rounded hips and hilly mountains, steep and rounded hills and associated undulating dissected areas. The town found at an average altitude of 1971m above sea level

According to the study made by (OUPI, 2009) Structure Plan of Bishoftu Town Demographic Profile, Utilities and Social Services Final Report, the city growth has been limited, because of many lakes, vast military camps, many research and educational institutions, industrial

establishments and developed urban agriculture within the town, its area is believed to be much larger than implied by its population size.

3.4. Climate

Climate is one of the prominent factors that affect the activities of people directly or indirectly. The elements of climate include temperature, humidity, rainfall and wind. All these elements affect the activity of every group of the society, including the urban community. It is mainly the altitude that makes the temperature and rain fall to vary from place to place and it controls other elements of climate.

The altitude of the town ranges from 1900-1995m above sea level. Thus, it belongs to Woina_dega (climate change), Its average temperature and rainfall are 18^0C and 816mm, respectively. May is the hottest month of the year, while November is the coldest month in the town. December and July are the driest and most rainy months of the year in the town with 2mm and 204mm of rainfall, respectively

3.5. Education coverage in the town

Education is a key for all activities involved in the development of a country. In order to support this key factor, the government plays great role in the development endeavors. There should be a due attention to the fair distribution of educational facilities in a sustainable manner.

There are a total of one hundred thirty nine (139), one hundred seven (107) of them are private and thirty-two (32) are government, this indicates us the involvement of private sectors in education in the area. According to the data, government owns thirty-two of the schools where the majorities are primary cycles.

In the school levels, there are fifty-three (53) **KG**s out of which forty four (44) of them are privates, five (5) are publics, three (3) are **FBO**s and the rest one is **NGO** owned. In the Primary education, there are sixty four (64) range from grades (1-8), twenty six (26) are owned by government, while the majority thirty eight (38) are private. In the secondary education, there are ten (10) schools ranging from grades (9-10), two (2) are owned by government while the majority eight are private and three (3) that ranges from grades 11 to 12

When we pass to higher institutions, there are three **TVET**s where two are privates and the rest governmental. There are six higher institutions where four of them are privates and two are governmental. These are Addis Ababa University of Veterinary Science, Defense Engineering and Health College, Rift Valley University College, and Admas University College. And the rest that does not constitute the number in the group of higher institution is Adama University where it delivers education on weekends on satellite links.

4. MATERIALS AND METHODS

This chapter mainly discusses about materials used and the techniques adopted to generate the end result. More specifically, it covers, the philosophical consideration, research design, steps to carry out the study, data requirement and availability, methods of data analysis. The choice of spatial distribution and accessibility measures used in the study are described as well.

4.1. Philosophical consideration

A research paradigm is a belief system that guides researchers. With the belief that Epistemology concerns the nature of knowledge, a combination of positivist and interpretivist epistemology was employed through the course of this research. Interpretivist and positivist analyses are compatible. They may each help achieve the goals of the other. Initially, the positivist position assumes that only "facts" derived from scientific methods can genuinely be viewed as knowledge. Thus, this epistemology is widely used in generating knowledge through the gathering of facts, which just fits the purpose of this research where the level of distribution and accessibility was examined through processing objective information. By contrast, interpretivism epistemology is built upon the view that knowledge is subjective and social phenomena together with their meanings rely on interpretation of individuals (Bryman, 2012). Thus, when analyzing the reasons that lead to existing spatial distribution and accessibility of the facilities, an interpretivism epistemological stance was taken.

4.2. Research design

This study evaluates the existing provision of primary and secondary schools in the town. The objective aspect of the facility evaluation takes into account of the relevant specifications of

urban planning and implementation manual published by the federal democratic republic of Ethiopia (MUDC, 2012). The standards show that the rationality of the planning of public facilities generally consists of two dimensions: the service radius (catchment area) and the population index. In this study, the spatial concentration directly reflects inequality of service provision between Kebeles. The spatial distribution of educational facilities directly reflects the pattern of service provision. The service area ensures that the people could find facilities in a certain traffic distance. The per capita amount is another way of reporting population index. From this, the spatial distribution of schools and the per capita level are important parameters to reflect the level of educational facilities provision in the town.

Provision of social infrastructures is related to how well they distributed and can serve the users. This also related to how many people can access these infrastructures. From the users' perspective, accessibility to social infrastructure is indicated by how well they can access the facility, in this case in terms of distance travelled by users. Therefore, the evaluation to the existing educational facilities was conducted by checking accessibility level of people to reach the existing facility, as well as checking the number of people which could be served by existing facilities.

Generally, the process of this study involves mapping of facilities, analysis of spatial concentration, measuring distance between facilities, determining the distribution pattern, road network dataset generation, service area computation, determination of accessibility of the schools to the residents, and analysis of major factors attributed to the existing distribution of the facilities. Figure 4-1 elaborates the research framework designed to carry out the study.

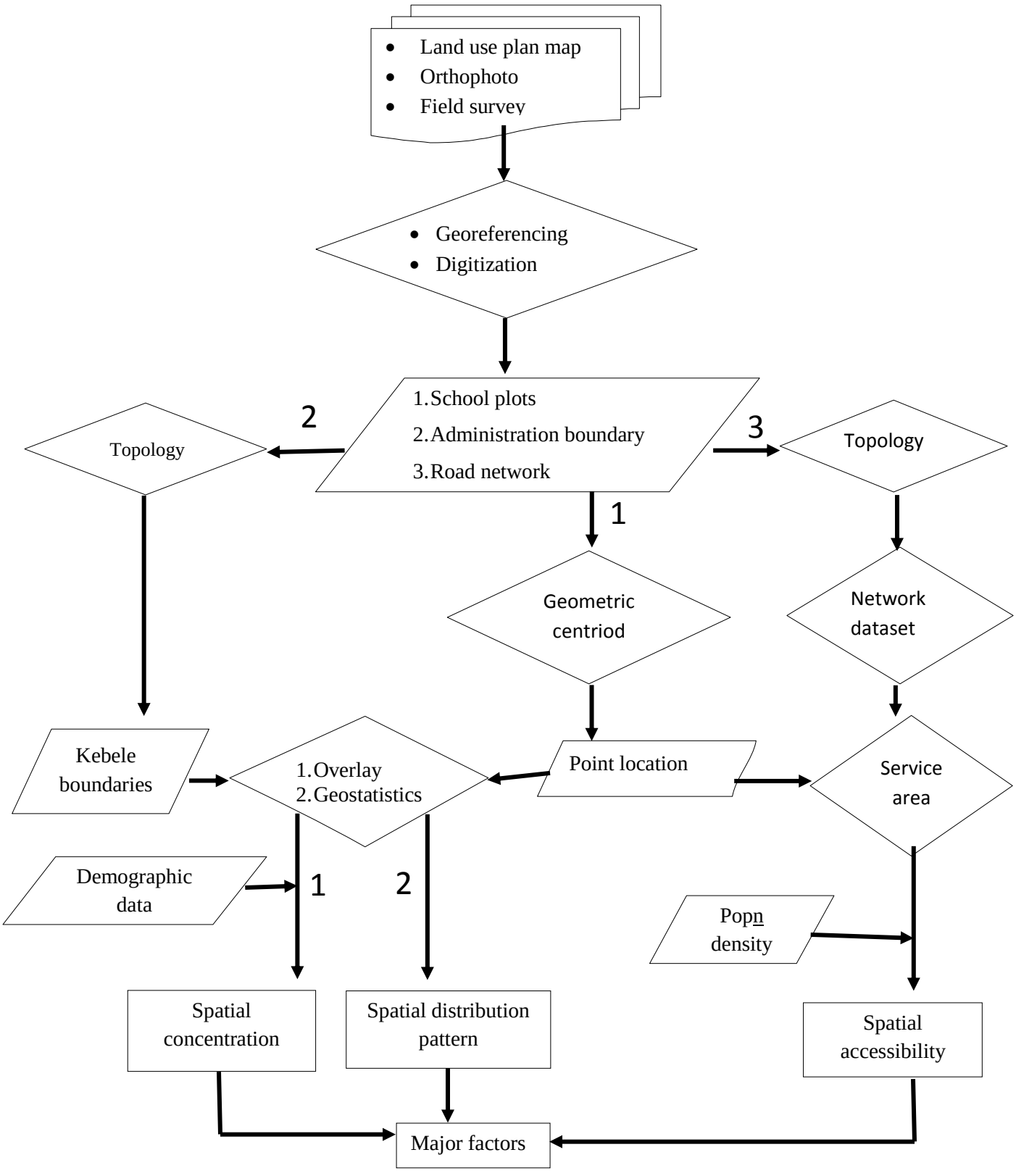


Figure 4-1 **flow chart of the methodology**

4.3. Data and data Sources

Results from Geographic Information System (GIS) spatial analysis will be unreliable in the presence of errors and inaccuracies in the input data. Underlined that "error and variation in geospatial data can contribute to unreliable results being produced by a geographical information system". This can be avoided by careful selection of tools for collection, sequencing of tools, selection of method for entering information into GIS and linking different data formats for analysis.

Primary and secondary data used in this study were collected from different sources and summarized in table 4-1.

Table 4-1 **data source and their purpose in the study**

Data source	Format	Date of production	Scale/spatial resolution	Purpose
Digital orthophoto	.jpg	2016	15cm	Extraction spatial data of plots of facilities
Land use plan map	.jpg	2004	1:5000	For extraction of road network, construction allowed area, administrative boundaries
Demographic data	.txt	2017		To compute population density

Digital orthophoto of the study area acquired in 2016 was obtained from town administration. It has spatial resolution of 15cm that enables extraction of plot of each facility. Land use plan map (.jpg document) prepared in 2004 was a base for extraction of spatial data used in this study including road data, Kebele administration boundary, restricted land use land cover. The map contains important cartographic information such as grid coordinates labeled in both Easting and Northing directions on the map. Intersections of these lines were useful for control points in geo-

referencing process as they can be easily and accurately identified on the map. Demographic data collected from respective Kebele administration offices were censes in 2017. It was in terms of age group which was useful for computation of population and can estimate the number of children for school. This number includes only registered population. However, it is believed by officers in kebele administration that unregistered population living in the town is estimated to be more than 10% of registered population.

4.4. Software and equipment

Garmin handheld GPS was utilized in this study for collection of spatial data and identification schools during field survey. ArcGIS 10.1 software package was used for spatial data processing, analysis, and output generation. Processing a large amount of information at the same time and present the information in a visualized way was one of the advantages of ArcGIS which made an evaluation of spatial distribution and accessibility of the facilities possible in this study. Microsoft office excel is used to correlation analysis.

4.5. Data preparation

Spatial location of Schools

As a result of field survey conducted using list of schools and handheld GPS, existing primary and secondary schools (governmental, public, non-governmental, and private schools) were identified on digital orthophoto. Next, each plot of the facilities was digitized in ArcGIS. Plots of facilities constructed between 2016 and 2017 were collected using handheld GPS and mapped to ensure the coverage of data collection. As a result, totally 64 primary schools among which 38 schools are owned by non-governmental organization. Regarding secondary schools in the town, among 10 secondary schools, 8 schools are owned by non-governmental organizations. This

indicates that the consideration of schools owned by non-governmental organizations in the analysis can increase the reliability of the end result.

Next, X and Y coordinates of geometric centroid of plot of each school was computed from the coordinates of vertices of respective plot in ArcGIS spatial analysis (figure4-2). This is to enhance the representation of each facility with most representative single point location. The coordinates of the centroid were converted to shape file for further analysis and descriptive information (School name, level, area, Kebele) were entered in attribute table.

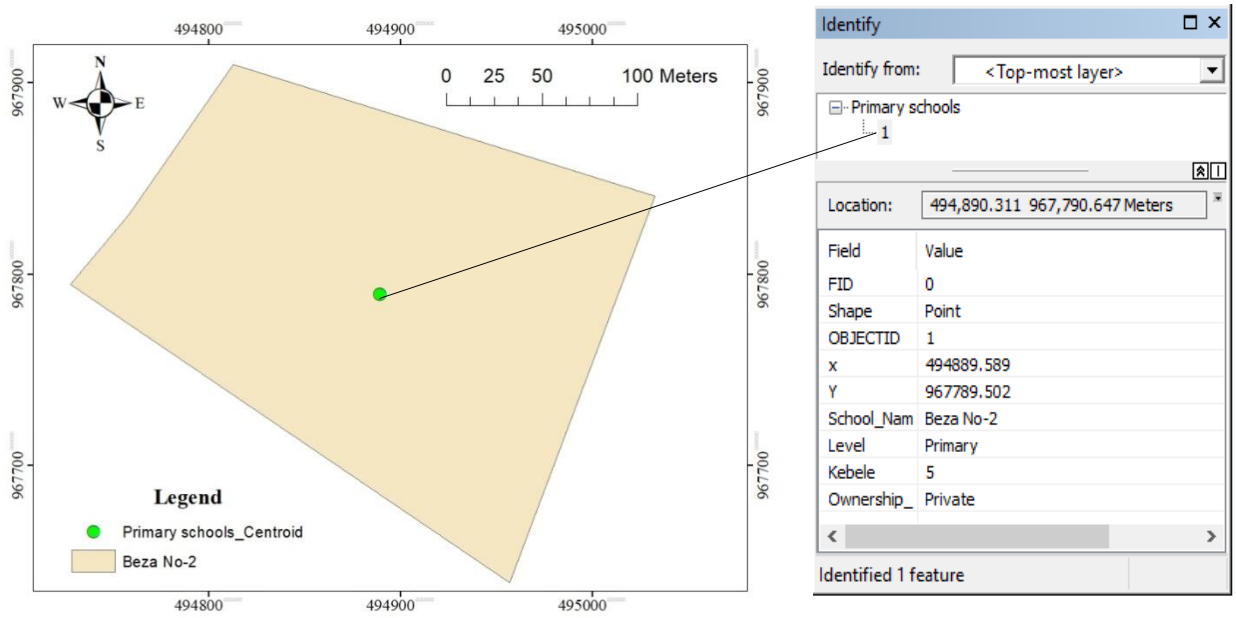


Figure 4-2 sample representation of spatial location of schools using computed geometric centroid

Geo-referencing of land-use plan map

First, eight grid line intersections as control points with uniform distribution were selected on the map and their ground coordinates (grid) are recorded. Next, in ArcGIS software, using geo-

referencing[1] function coordinates of all control points were registered to their respective grid intersection point.

Root Mean Square Error (RMSE) for all control points was computed using GIS geo-referencing function to estimate their positional accuracy. RMSE is the square root of the average of the set of squared differences between dataset coordinate values and known ground coordinate values entered manually. Accuracy was reported in ground distances at the 95% confidence level. This indicates the position in the dataset has an error with respect to true ground position that is equal to or smaller than the reported accuracy value (Wolf et al., 2006). Since positions will be determined with millimeter accuracy, the RMSEs standard was set to 0.5millimeters. Finally, the map was rectified with acceptable root mean square error (RMSE) of each point (table 4-2). The minimum and maximum RMSE were 0.002mm and 0.093mm respectively.

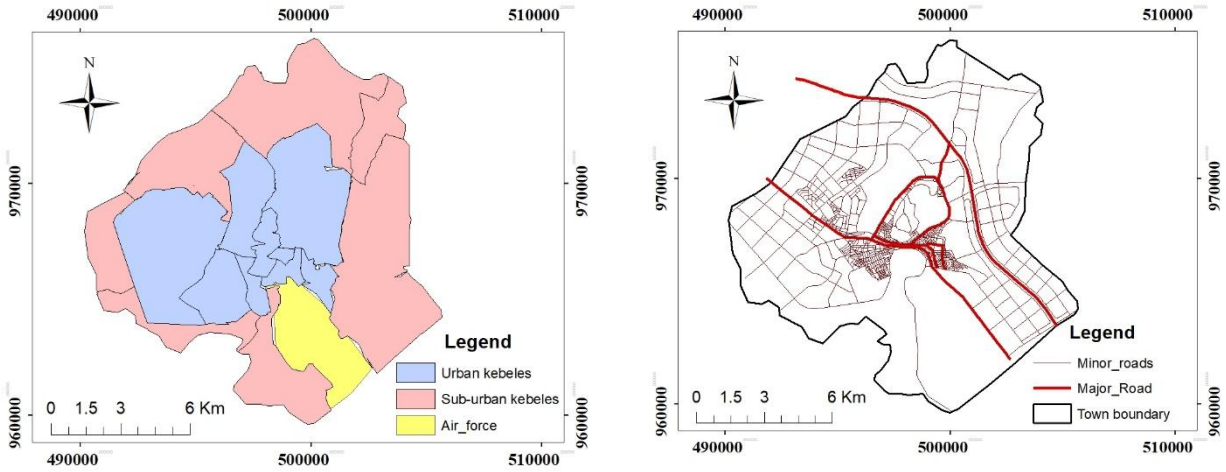
Table 4-2 accuracy of control points for geo-referencing land-use plan

Pt	δ_X **(mm)**	δ_Y **(mm)**	**RMSE (mm)**
1	-0.064	0.020	0.067
2	-0.082	-0.013	0.083
3	0.120	0.001	0.020
4	0.093	0.005	0.093
5	0.080	0.003	0.080
6	-0.053	0.063	0.083
7	-0.040	-0.029	0.049
8	-0.054	-0.050	0.073

[1] Georeferencing is a process of coordinate transformation from image dataset to ground coordinate system

Kebele Administration boundary, Road Network

Common Geodatabase was built using Universal Transverse Mercator projection system Adindan zone 37N. Feature datasets were created for the area and line feature geometry. Using ArcGIS functions, Kebele administration boundaries and road network were digitized from Georeferenced map and orthophoto into a common Geodatabase. Next, topology was created and applied for all datasets and digitization errors were corrected. Finally, road network dataset was developed for service area generation.



(a) (b)

Figure 4-3(a) kebele administration boundary (b) road network of the town as of 2017

Population Density

Population density in this study was indicated by the number of people living per hectare. First, built-up area was digitized from orthophoto for each Kebele. Restricted areas such as lakes, air force, and Defense University were left out in density computation. Spatial extent of net area used for population density was computed in hectare (ha). Demographic data was entered into

attribute table for net built-up area of each kebele (table 4-3). Population density was computed using the ratio of population number and spatial extent of net built-up area. Computed population density was adjusted to the next integer number.

Table 4-3 **population density of kebeles in Bishoftu as of 2017**

Kebele	Popn No	**Spatial extent (area)**		**Popn density(P.no/ha)**	
		Total (ha)	**Net (ha)**	**Computed**	**Adjusted**
1	43915	1984.902	1984.902	22.1	23
2	23338	610.641	610.641	38.2	38
3	8482	181.307	181.307	46.8	47
4	4192	214.764	110.048	38.1	39
5	19211	729.741	380.608	50.5	51
6	12118	52.214	52.214	232.1	233
7	19118	170.929	170.929	111.8	112
8	11879	155.052	155.052	76.6	77
9	22000	1180.702	962.414	22.9	23
Kajima	11099	536.130	536.130	20.7	21
Garbiicha	10050	1012.744	950.420	10.6	11
Qallittii	12543	2057.409	2057.409	6.1	7
Gorba	10961	1841.912	1841.912	6.0	6
Qurqura	2,609	438.190	438.190	6.0	6
Dambi	2,174	706.708	706.708	3.1	4

4.6. Methods

4.6.1. Spatial concentration

An idea about the extent of concentration of public facilities between neighbors; in this case Kebeles of the town was analyzed by taking distribution of population into consideration. In this context the use of location quotient method by Jahan & Oda (2005) was adopted. It was used to measure the extent of public facilities in different parts of the town. The location quotient (LQ) ratio was computed to quantify and benchmark the degree of relative concentration of an activity in the analysis of area localization. For calculating the location quotient for a particular facility 'i' in a particular Kebele, the following formula was used.

$$LQ = \frac{n_i/_p}{N_i/_P} \quad \text{.....Equation 4.1}$$

Where

$n_i = number\ of\ schools\ in\ particular\ Kebele$

$N_i = number\ of\ schools\ in\ the\ town$

$p = number\ of\ population\ in\ particular\ Kebele$

$P = number\ of\ population\ in\ the\ town$

- *LQ < 1*, suggests that the concentration of a particular facility in a particular Kebele is less than that of the Town as a whole
- *LQ = 1 or close to 1*, indicates self-sufficiency means a particular facility in a given Kebele is exactly sufficient to meet the local demand
- *LQ > 1*, concentration is indicated since the per capita availability of that facility in a particular Kebele exceeds that of the Town as a whole

4.6.2. Spatial distribution

The spatial distribution of schools was examined using standard distance measure in spatial statistic in GIS environment. It measures the degree to which features are clustered or dispersed around their geographic mean center. The spatial pattern was examined using Average Nearest Neighbor (ANN) analysis. ANN calculates a nearest neighbor index based on the average distance from each feature to its nearest neighboring feature. It was conducted using the distance between each feature geometric center and that of its nearest neighbor's location. Then, distances were averaged. The average nearest neighbor index (ANNI) was calculated as the ratio of observed average distance ($\overline{D}_0$)and the expected average distance ($\overline{D}_E$) (with expected average distance being based on a hypothetical random distribution with the same number of features covering the same total area).

$$ANNI = \frac{\overline{D}_0}{\overline{D}_E}$$

$$and \qquad \overline{D}_0 = \frac{\sum_{i=1}^{n} d_i}{n} \overline{D}_E = \frac{0.5}{\sqrt{n/A}}$$

Where

$\boldsymbol{d_i}$ equals the distance between feature $\boldsymbol{i}$ and its nearest neighboring feature.

$\boldsymbol{n}$ Corresponds to the total number of features

$\boldsymbol{A}$ the spatial extent of the expected area

In this regard, the distribution of the features being analyzed is considered as:

Clustered if ANNI < 1

Dispersed *if* *ANNI >1*

The z-score and p-value results will be used to measure statistical significance to determine whether or not to reject the null hypothesis. Because it indicates that rather than a random pattern, the features (or the values associated with the features) exhibit statistically significant clustering or dispersion. For the Average Nearest Neighbor statistic, the null hypothesis states that features are randomly distributed.

Z-score of indicates that maximum probability that the distribution likelihood could be the result of random chance. It was calculated as:

$$z = \frac{\overline{D}_0 - \overline{D}_E}{SE}$$

Where

$SE = \frac{0.26135}{\sqrt{n^2/A}}$S

The p-value is a probability that the observed spatial pattern is created by some random process. When the p-value is very small, it means it is very unlikely (small probability) that the observed spatial pattern is the result of random processes, so null hypothesis can be rejected. But how small enough? to answer this question, the table 4-4 below shows the critical p-values and z-scores for different confidence levels used in this study.

Table 4-4 **p-value and z-score for different confidence level**

z-score (Standard Deviations)	**p-value (Probability)**	**Confidence level**
< -1.65 or > +1.65	< 0.10	90%
< -1.96 or > +1.96	< 0.05	95%
< -2.58 or > +2.58	< 0.01	99%

4.6.3. Spatial accessibility

Actual accessibility is composed of three components: people, transport and activities. The size and composition of the population affect the accessibility, because it determines the scale of the demand for social infrastructures. The transport link reflects the travel time, costs and effort to travel between origin and destination. The activities reflect the spatial distribution of services at destinations and demand for those services. This concept fits the objective of this study and the components can be easily represented in GIS environment. Moreover, location-based accessibility measurement is best suited to this study as it deals with people's access to reach the social facilities from their origin and spatial distribution of the services.

Further, distance based measurement technique was used to analyze the spatial accessibility measure of residents. Because, distance measures are simple to calculate and interpret, requires small amount of data, used as average distance or weighted area distance or distance to the closest activity using road network distance measurement. In this case, the spatial accessibility was analyzed using road network based service area analysis which answers the question "what is the likely service area of a facilities based on actual travel distance?" In this regard an area was considered accessible if it is enclosed by a polygon generated by specified travel distance from a facility along a road network.

Then, number of served population was determined from the product of spatial extent inside service area and population density. Similarly, inaccessible population was computed from spatial extent outside the service area and population density of the area.

$$Serviced\ or\ unserviced\ population = \sum_{i=1}^{14} a_i * pd_i$$

Where

a_i is total serviced or unserved area in i^{th} Kebele

pd_i is population density of i^{th} Kebele

5. RESULTS AND DISCUSSIONS

5.1. Spatial concentration of schools

5.1.1. Primary schools

The number of primary schools, population number in each kebele as of 2017 along with computed value of spatial concentration measure (location quotient) is indicated in the table 5-1.

Overall, 64 primary schools are identified in the study area distributed in 9 urban and six sub-urban kebeles of Bishoftu town. Among urban kebeles, the maximum number of schools is found in kebele 01 as opposed to kebele 04 with no primary school. Concerning sub-urban kebeles, except Kality, no significant difference in number of schools is found. The information in the table reveals that the allocation of primary schools in Bishoftu town is very uneven indicating inadequacy and inequality in the allocation of primary schools among the various kebeles in the study area. Some areas are very well served while some are poorly served.

In terms of the allocation of schools with relatively more number of population such as kebele 01 are served with more than areas of low population density (kebele 02, 09). However, there is uneven allocation as some areas with denser population are not allocated with more for instance, kebele 07.

Further, the proportion of this particular facility to the number of population of the town is about 1 to 3340, which can be acceptable when compared to the standard set in terms of population index. However, the computed location quotient for each kebele in the study area demonstrates that the concentration of primary schools in each kebele is not uniform.

It is clear from the table 5-1 that two kebeles out of fifteen kebeles have absence of primary school, while five kebeles have deficiency in the establishment of primary schools, one kebele has self-sufficiency and the rest seven kebeles possess above normal concentration i,e. the per capita availability of the schools exceeds that of the town as a whole. Kebele wise, the value of location quotient shows that maximum concentration of primary schools (2.0) is associated with kebele 03 and kebele 08 as opposed to 0.3 in Garbicha and Kajima. Further analysis of location quotient reveals that the relative position of different kebeles with respect to a primary school has been identified. The analysis indicates that the level of concentration of schools varies quite significantly across kebeles in the Bishoftu town and this leads to believe that considerable disparity exists among the kebeles in terms of primary school facilities.

Table 5-1 number and spatial concentration of primary schools in Bishoftu town as of 2017. GOPS and POPS are Government owned and registered private owned primary schools respectively. LQ: Location quotient

Kebele Name	**Popn No**	**No of primary schools**			**LQ**	**Remark**
		GOPS	**POPS**	**Total**		
01	43,915	6	11	17	1.3	
02	23,338	1	8	9	1.3	
03	8,482	1	4	5	2.0	
04	4,192	-	-	-	-	
05	19,211	4	2	6	1.0	
06	12,118	1	2	3	0.8	Urban Kebeles
07	19,118	2	1	3	0.5	
08	11,879	2	5	7	2.0	
09	22,000	3	5	8	1.2	
Garbicha	10,050	1	-	1	0.3	
Gorba	10,961	2	-	2	0.6	Sub-urban Kebeles

Qurqura	2,609	1	-	1	1.3
Kajima_dibayu	11,099	1	-	1	0.3
Kality	12,543	-	-	-	-
Danbi	2,174	1	-	1	1.5
Total	**213,689**	**26**	**38**	**64**	

Further analyses of the data in the table 5-1 suggest that there are 26 GOPS and 38 POPS in Bishoftu. This shows that there may be less concerted effort on the part of the Government to establish primary schools. This can be seen as an evidence of Government less-response to address the increasing demand for primary education facilities by the increasing population of the area. This shortage encourages the proliferation of private developers. However, the concentration of POPS varies between urban kebeles while none of private developers are attracted to sub-urban kebeles. The result depicted in figure 5-1 demonstrates the number of primary schools owned by Government and Private Developers in all 9 urban Kebeles of Bishoftu town as of 2017.

Overall, the share of private developers is higher than government in urban kebeles. With exception of kebele 04 with no primary school, the number of schools owned by Government and Private Developers is higher in kebele 01. While the least investment by the Government is in kebele 06 as compared to kebele 07 by private developers.

In terms of kebele, significant differences in number of primary schools between government and private kebele 02 which is 7 followed by the difference in kebele 01 which is 5. Moreover, in the other four kebeles 03, 06, 08, and 09; the difference is reduced to 3, 1, 3, and 2 respectively. In contrary, the number of Government owned primary schools exceed the number of privately owned schools in kebele 05 by 2, and by 1 in that of kebele 07.

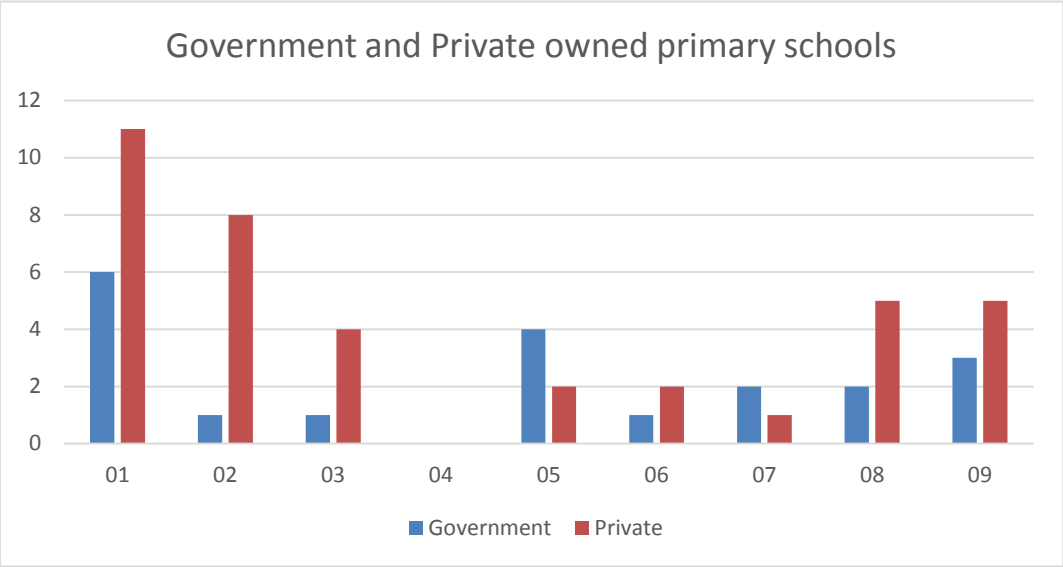


Figure 5-1 **number of GOPS and POPS in Bishoftu town as of 2017**

This disparity may be associated with not only increasing demand for educational services because of increase in urban population but also due to the inability of the few Government owned schools to provide sufficient and efficient education services. Areas that are poorly served with GOPS are, ideally supposed to be well served with POPS, but this is not the case due to the fact that owners of POPS consider profit maximization as their Primary objective of establishment, therefore prefer locating in areas with high population in order to attract high patronage. Consequently, areas like kebele 01, kebele 02 are served with POPS due to their high population. Kebeles like 06 and 07 are still poorly served while kebele 04 is not served at all.

5.1.2. Secondary schools

In Bishoftu, 10 secondary schools are identified. The proportion of this particular facility to the population in the town is about 1 to 21,370 which is below the regional standard ratio for

provision of secondary school education. This underscores inadequate provision of Secondary school services.

Moreover, the secondary schools are distributed in four urban kebeles (table 5-2), and while no secondary school in sub-urban kebeles at all. These kebeles are relatively with high population compared to the remaining kebeles. Further, the maximum number of secondary schools is associated with kebele 01 while the least is in that of kebele 05.

Table 5-2 number of secondary schools in Bishoftu town as of 2017. GOSS and POSS are Government owned and registered private owned secondary schools respectively

Kebele	No of secondary schools		
	GOSS	POSS	Total
01	-	4	4
02	-	2	2
05	1	-	1
09	1	2	3
Total	**2**	**8**	**10**

The numbers of private owned secondary schools are four times that of government owned secondary schools indicating the large share of private sectors in contributing to middle level education in the town as compared to government.

The shortage of infrastructures and availability of land for development might have contributed to less attraction of the private sectors. Because, secondary school by its nature requires better facilities and large spatial extent than primary level. This can be evident that almost all of privately owned secondary schools in the town are within the same compound with primary

schools. On the other hand, purchasing power of the community for secondary schools might be another potential factor affecting provision of private secondary schools. In such circumstances the focuses of government towards establishment of secondary schools in the town become the primary important. However, less attention is paid to the sector by Government.

5.2. Spatial distribution

5.2.1. Primary schools

The result of spatial mapping in this study depicted in figure 5- 2 shows spatial distribution of primary schools in Bishoftu town as of 2017. It demonstrates that most of the primary schools are located in the central part of the town, which is urban biased as a result of high population density except there primary schools located in sub-urban kebeles. It can also be said that most primary schools in the town are POPS, more profit oriented instead of the public benefit because most of the school are private owned who tend to target the populated (urban) areas for sighting the school for financial benefit. On top of this, better infrastructures can be found at the central part of the town.

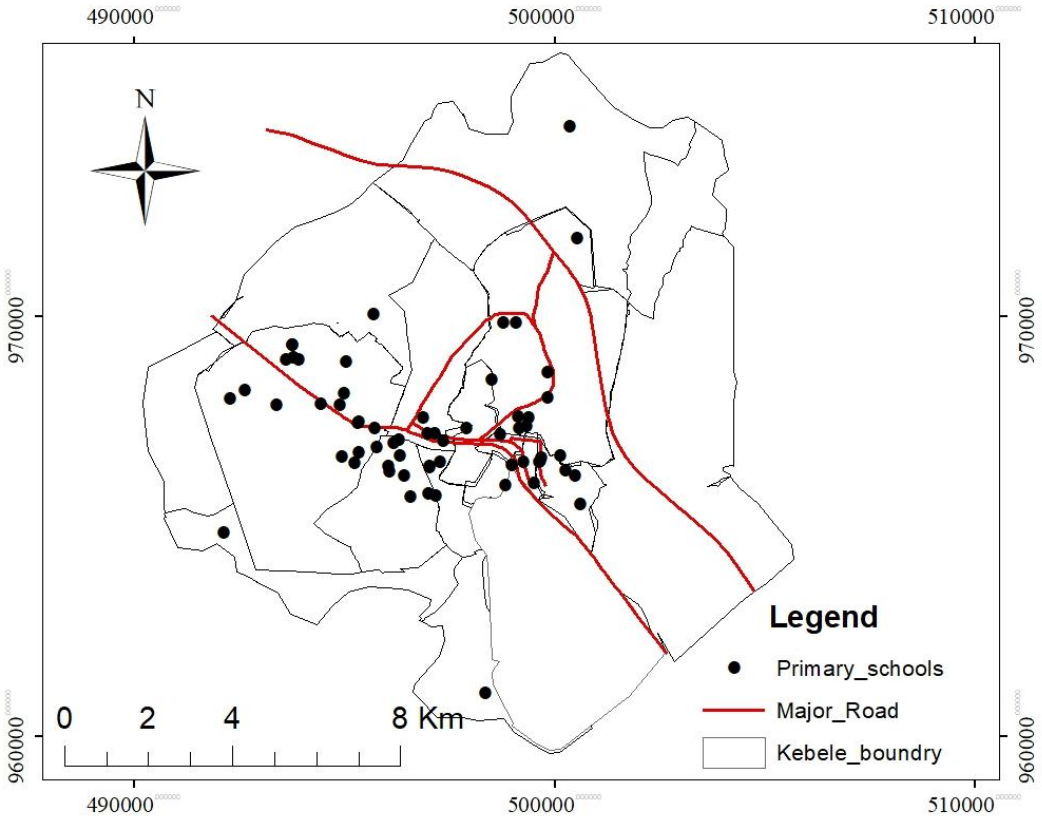


Figure 5-2 spatial location of primary schools in Bishoftu town as of 2017

Further, the Nearest Neighbor Analysis which examine the distance between each point and the closest point to it and measures the extent to which a particular pattern is clustered (nucleated), Random and dispersed was conducted in GIS environment. The nearest neighbor analysis for the spatial distribution of primary schools in Bishoftu town revealed two major spatial patterns, that is the overall general pattern and specific pattern within kebeles.

Figure 5-3 shows the result of average nearest neighbor analysis conducted using spatial statistics tool in in ArcGIS. The value of Nearest Neighbor Ratio NNR (0.771) less than 1. This reveals that the overall distribution of primary schools in the town shows clustered pattern. With

this z-score value, there is less than 1% likelihood that the clustered pattern could be the result of random chance. The clustered pattern of distribution observed in the study area shows that there is uneven distribution of primary schools in Bishoftu town as a whole.

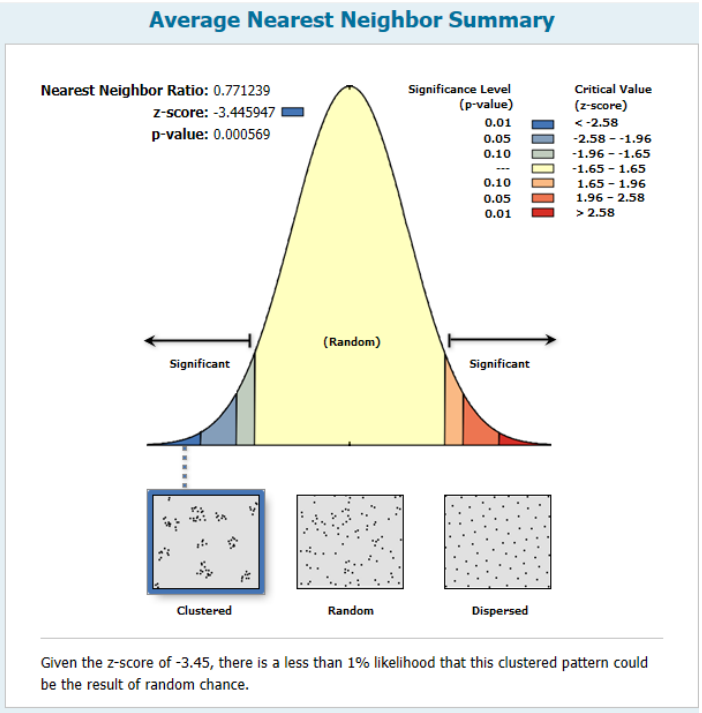


Figure 5-3 Nearest Neighborhood Analysis of primary schools in Bishoftu town as of 2017

The result of investigation of patterns of primary schools at lower spatial scale, kebele, is shown in figure 5-4 and the value of analysis is summarized in table 5-3. The result indicates different spatial patterns are perceived in the town. The Nearest Neighbor Ratio NNR in most of the kebeles is greater than 1 implies the patterns are more dispersed than clustered. However, in order to reject the null hypothesis, further analysis of z-scores and p-values is important.

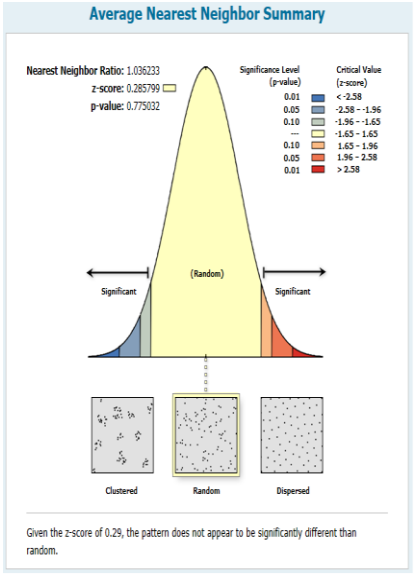
The p-value is a numerical approximation of the area under the curve for a known distribution, limited by the test statistics. It is a probability. For the pattern analysis tools used in this study, it

is the probability that the observed spatial pattern of schools was created by some random process. When the p-value is very small, it means it is very unlikely (small probability) that the observed spatial pattern is the result of random processes thus, the null hypothesis can be rejected. On top of this, to investigate the question "how small is small enough?" the critical P-value and Z-score at 90%, 95%, and 99% were utilized.

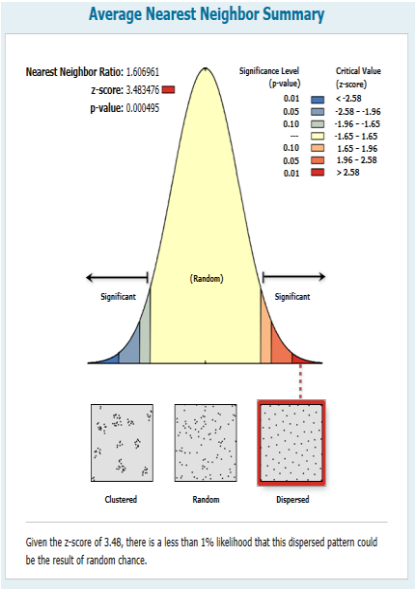
Accordingly, p-values of kebeles 02, 03, 06, 07, 08, 09 are small and their patterns as a result of neighbor analysis are classified as dispersed. Moreover, z-score values of these kebeles are greater than the critical values of z-score which is +2.58 and at the same time, their p-values are less than critical value (0.01). Hence, it can be concluded that the spatial distribution pattern of primary schools in kebeles 02, 03, 06, 07, 08, and 09 of town shows dispersed pattern at 99% significant level. Moreover, p-values of kebele 03 and 09 are between 0.05 and 0.01 indicating that the distribution pattern in these kebeles shows dispersed at 90% confidence level. In contrary, in the case of the remaining urban kebeles, kebele 01 and 05, p-value are larger than 0.01, suggesting to accept null hypothesis i.e. the pattern exhibited could very likely be the result of random spatial processes.

Table 5-3 statistics of distribution pattern of primary schools in kebeles of Bishoftu town as of 2017. NNR: Nearest Neighborhood Ratio

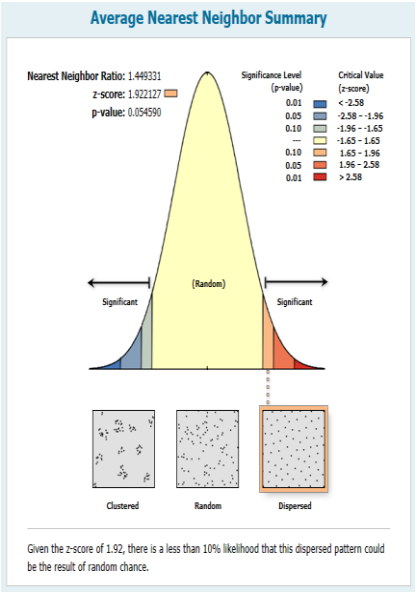
Kebele	NNR	Z-score	P-values
01	1.036	0.286	0.775
02	1.607	3.483	0.0005
03	1.449	1.922	0.0546
05	1.351	1.646	0.998
06	3.284	7.567	0.000
07	3.483	8.229	0.000
08	1.574	2.907	0.0036
09	1.295	1.691	0.0907


Average Nearest Neighbor Summary
Nearest Neighbor Ratio: 1.036233
z-score: 0.285799
p-value: 0.775032
Significance Level (p-value)
Critical Value (z-score)
0.01 < -2.58
0.05 -2.58 - -1.96
0.10 -1.96 - -1.65
--- -1.65 - 1.65
0.10 1.65 - 1.96
0.05 1.96 - 2.58
0.01 > 2.58
(Random)
Significant
Significant
Clustered
Random
Dispersed
Given the z-score of 0.29, the pattern does not appear to be significantly different than random.

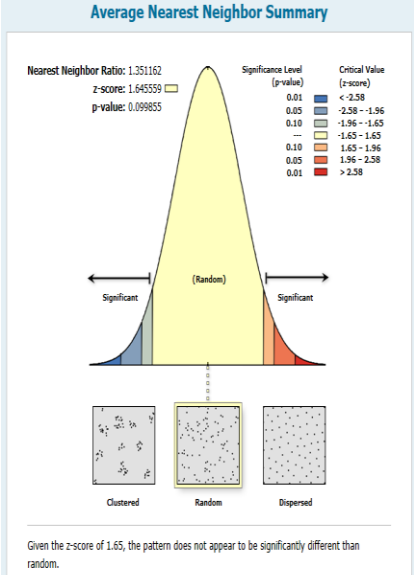
(a)


Average Nearest Neighbor Summary
Nearest Neighbor Ratio: 1.606961
z-score: 3.483476
p-value: 0.000495
Significance Level (p-value)
Critical Value (z-score)
0.01 < -2.58
0.05 -2.58 - -1.96
0.10 -1.96 - -1.65
--- -1.65 - 1.65
0.10 1.65 - 1.96
0.05 1.96 - 2.58
0.01 > 2.58
(Random)
Significant
Significant
Clustered
Random
Dispersed
Given the z-score of 3.48, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance.

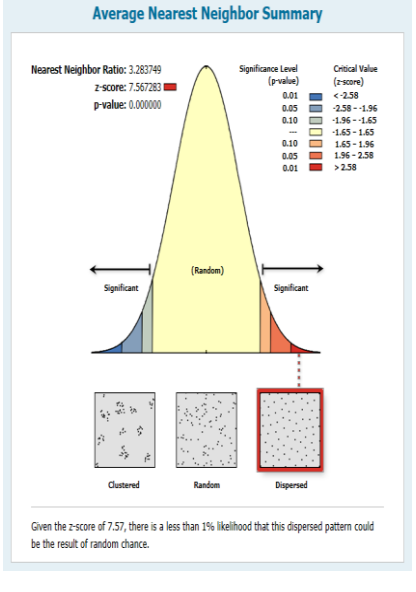
(b)


Average Nearest Neighbor Summary
Nearest Neighbor Ratio: 1.449331
z-score: 1.922127
p-value: 0.054590
Significance Level (p-value)
Critical Value (z-score)
0.01 < -2.58
0.05 -2.58 - -1.96
0.10 -1.96 - -1.65
--- -1.65 - 1.65
0.10 1.65 - 1.96
0.05 1.96 - 2.58
0.01 > 2.58
(Random)
Significant
Significant
Clustered
Random
Dispersed
Given the z-score of 1.92, there is a less than 10% likelihood that this dispersed pattern could be the result of random chance.

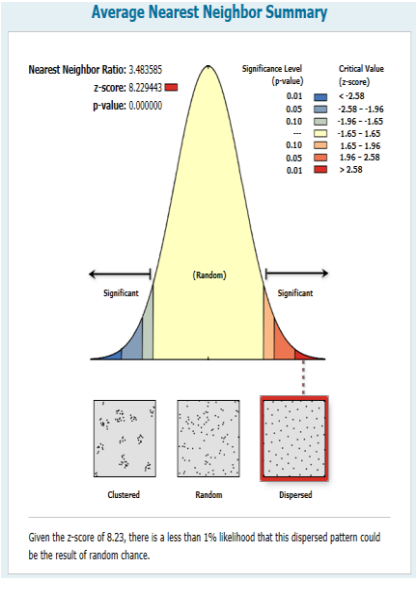
(c)


Average Nearest Neighbor Summary
Nearest Neighbor Ratio: 1.351162
z-score: 1.645559
p-value: 0.099855
Significance Level (p-value)
Critical Value (z-score)
0.01 < -2.58
0.05 -2.58 - -1.96
0.10 -1.96 - -1.65
--- -1.65 - 1.65
0.10 1.65 - 1.96
0.05 1.96 - 2.58
0.01 > 2.58
(Random)
Significant
Significant
Clustered
Random
Dispersed
Given the z-score of 1.65, the pattern does not appear to be significantly different than random.

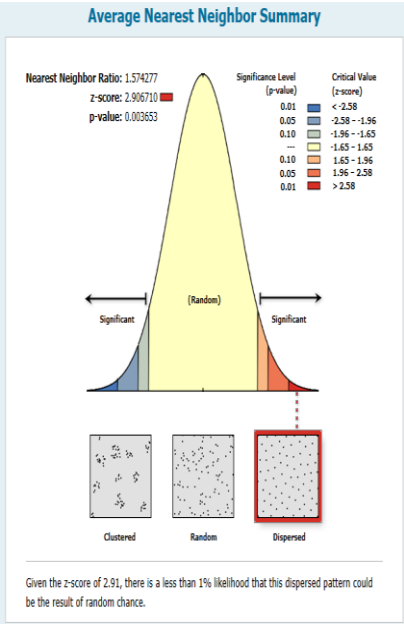
(d)


Average Nearest Neighbor Summary
Nearest Neighbor Ratio: 3.283749
z-score: 7.567283
p-value: 0.000000
Significance Level (p-value)
Critical Value (z-score)
0.01 < -2.58
0.05 -2.58 - -1.96
0.10 -1.96 - -1.65
--- -1.65 - 1.65
0.10 1.65 - 1.96
0.05 1.96 - 2.58
0.01 > 2.58
(Random)
Significant
Significant
Clustered
Random
Dispersed
Given the z-score of 7.57, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance.

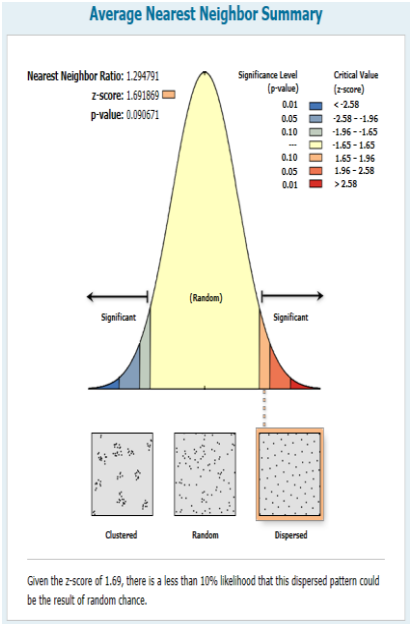
(e)


Average Nearest Neighbor Summary
Nearest Neighbor Ratio: 3.483585
z-score: 8.229443
p-value: 0.000000
Significance Level (p-value)
Critical Value (z-score)
0.01 < -2.58
0.05 -2.58 - -1.96
0.10 -1.96 - -1.65
--- -1.65 - 1.65
0.10 1.65 - 1.96
0.05 1.96 - 2.58
0.01 > 2.58
(Random)
Significant
Significant
Clustered
Random
Dispersed
Given the z-score of 8.23, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance.

(f)



(g)



(h)

Figure 5-4 Nearest Neighborhood Analysis of urban kebeles in Bishoftu town as of 2017. (a) kebele 01, (b) kebele 02, (c) kebele 03, (d) kebele 05, (e) kebele 06, (f) kebele 07, (g) kebele 08, and (h) kebele 09.

5.2.2. Spatial distribution of secondary schools

Spatial distribution of secondary schools in Bishoftu town is depicted in figure 5-5. Alongside to inadequate number of provision, the secondary schools in Bishoftu are located in the central urban area. This indicates that there is uneven spatial distribution of middle level educational facilities. Most of the facilities are located close to main Arterial Street passing through the town. Relatively other services such as water, electricity are better provided in this area. This underpins the level of infrastructure in urban areas can influence the establishment of secondary schools. Moreover, existence of such infrastructures can highly attract private developers.

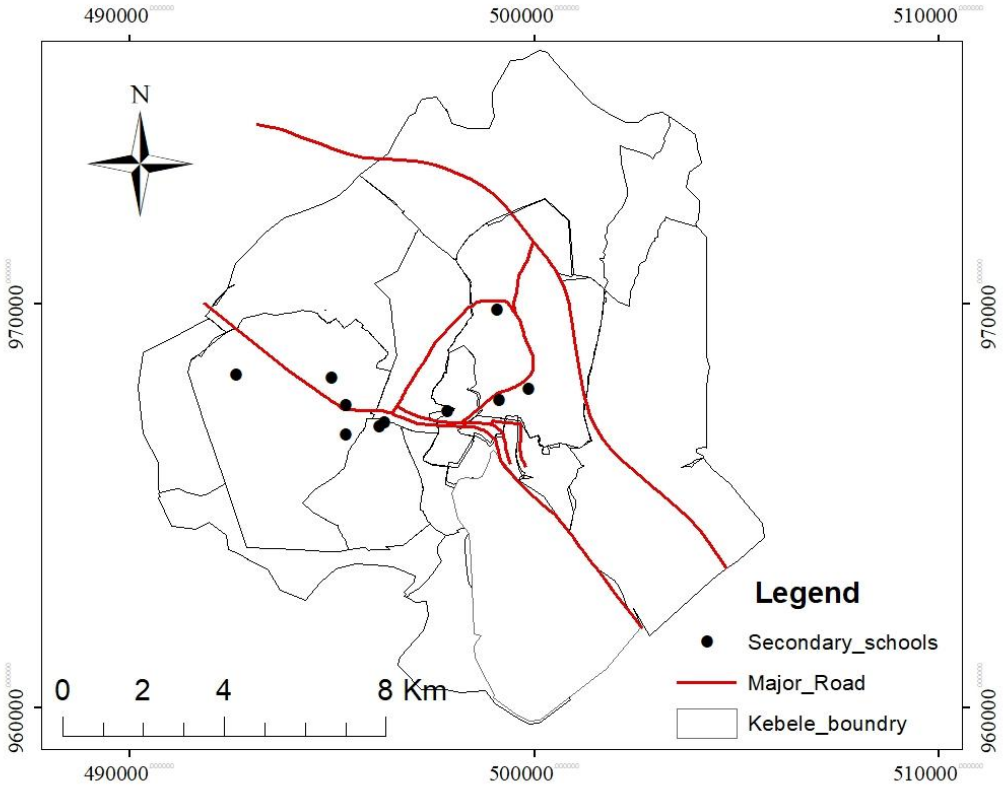


Figure 5-5 spatial location of secondary schools in Bishoftu town as of 2017

However, the values of the result of nearest neighbor analysis of spatial distribution of secondary schools in the town (figure 5-6) shows NNR (1.607) which is greater than 1 indicating dispersing pattern. Further, values of Z-score (3.672) is greater than the critical value, +2.58, and P-value (0.0024) which is less than 0.01, reveal that the observed distribution pattern is dispersed at 99% confidence level.

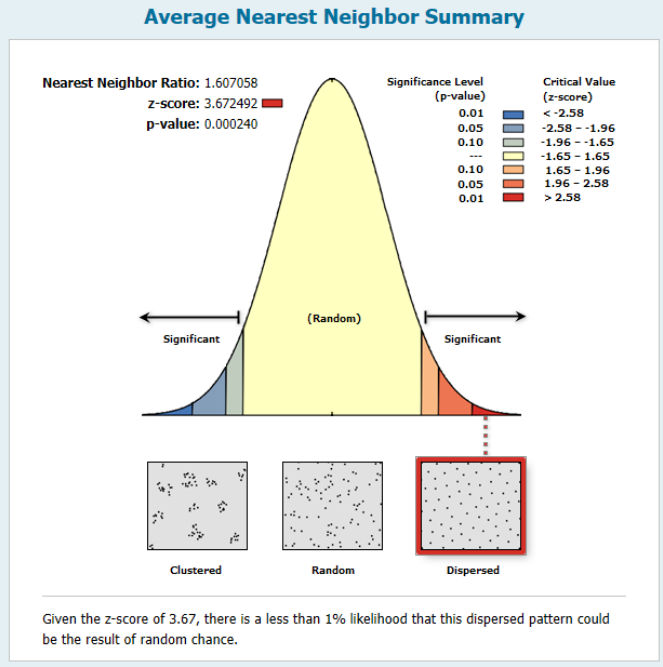


Figure 5-6 distribution pattern of secondary schools in Bishoftu town as of 2017

5.3. Spatial Accessibility

5.3.1. Spatial accessibility of primary schools

The result of spatial accessibility of primary schools is depicted in figure 5-7 and table 5-5. The results reveal that spatial variation in accessibility of primary schools in Bishoftu. Accessibility was examined at 2km, 3km, 5km, and greater than 5km. At larger spatial scale (i.e. town level),

98,808 (46.24%) residents are accessible to primary schools at a maximum of 2km distance which is maximum acceptable distance as per recommendation of the standard. Moreover, while **31,648 (14.81%)** populations in the town are accessing the schools with a maximum of 3km, **32, 233 (15.08%)** of residents are expected to travel up to 5km. In the contrary, **51, 000 (23.87%)** of the town residents are more disadvantaged as they should travel more to access the facility.

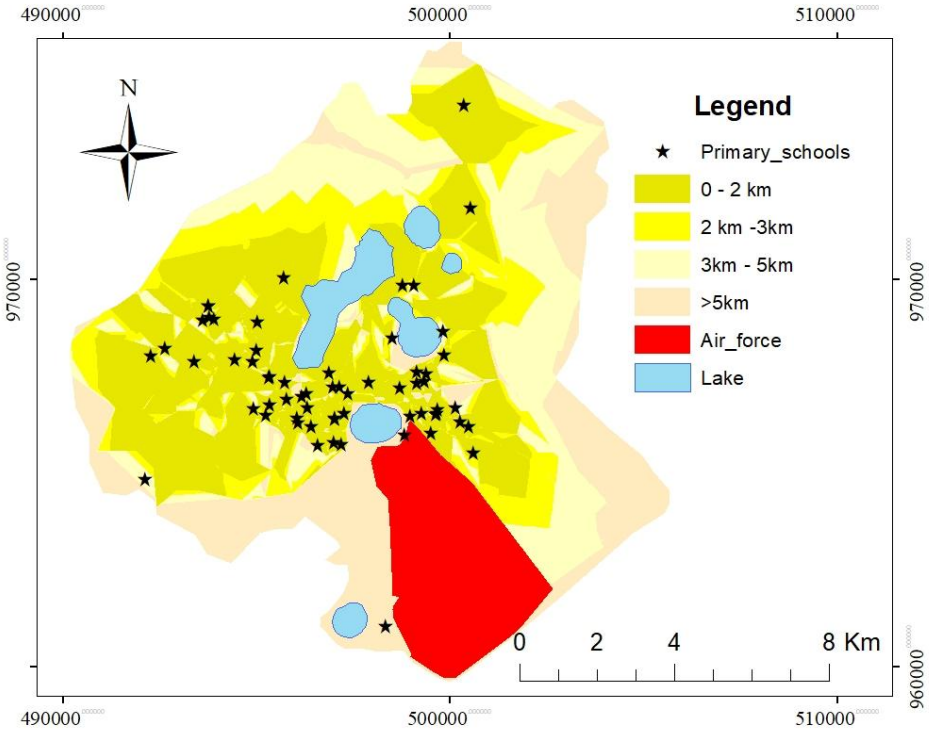


Figure 5-7 spatial accessibility level of primary schools in Bishoftu town as of 2017

In terms of kebele, large number of population (33,360) in kebele 01 are served within the first range of travel distance as opposed to 2,073 in kebele 04. In addition,In the second range of travel distance, Garbicha is identified with more served population as compared to kebele kajima in which least number of served population.

In contrary kebele 06 and kebele 05 are relatively better served in the travel distance of 3-5 km. Even though, unserved populations (> 5km) are identified in each kebele. However, the number is maximum in kebele 07.

Table 5-4 population of Bishoftu town at different level of spatial accessibility to primary schools as of 2017

Kebele	No of population served at different distances(km)				Total
	0-2	2-3	3-5	>5	
01	33360	3814	3895	2601	**43670**
02	9036	3012	3921	7237	**23206**
03	2096	127	65	6055	**8343**
04	2073	371	198	1441	**4083**
05	9108	4462	5032	373	**18975**
06	4917	659	6368	172	**12116**
07	6794	532	649	11000	**18975**
08	10135	1087	465	100	**11787**
09	12271	3573	3312	2098	**21254**
Kajima	35	74	93	9848	**10050**
Garbiichaa	4496	4859	53	1553	**10961**
Qaallittii	158	360	1922	169	**2609**
Gorbbaa	2419	3721	2318	2641	**11099**
Qurquraa	1501	4628	3927	2487	**12543**
Dambi	409	369	15	1381	**2174**
Total	**98808**	**31648**	**32233**	**51000**	**213689**

5.3.2. Spatial accessibility of secondary schools

Figure 5-8 and tables 5-5 demonstrate the result of spatial accessibility analysis of secondary schools in Bishoftu as of 2017.Overall, residents in kebele 01 followed by kebeles 09 and 02 are well served within the maximum travel distance set by standard (5km) while Garba kebele is not accessible at all to secondary schools when compared in terms of standard. In addition, almost all residents in Gorba kebele are expected to travel more than 10km to access the secondary schools. Relatively, Kebele 08 and 04 are well access the secondary schools within the standard. The findings indicate that secondary schools in Bishoftu town are accessible unevenly by residents. This might be due to lack of timely evaluation and monitoring. In addition, lack of road network development and disparity in population density might have influenced the resulted distribution.

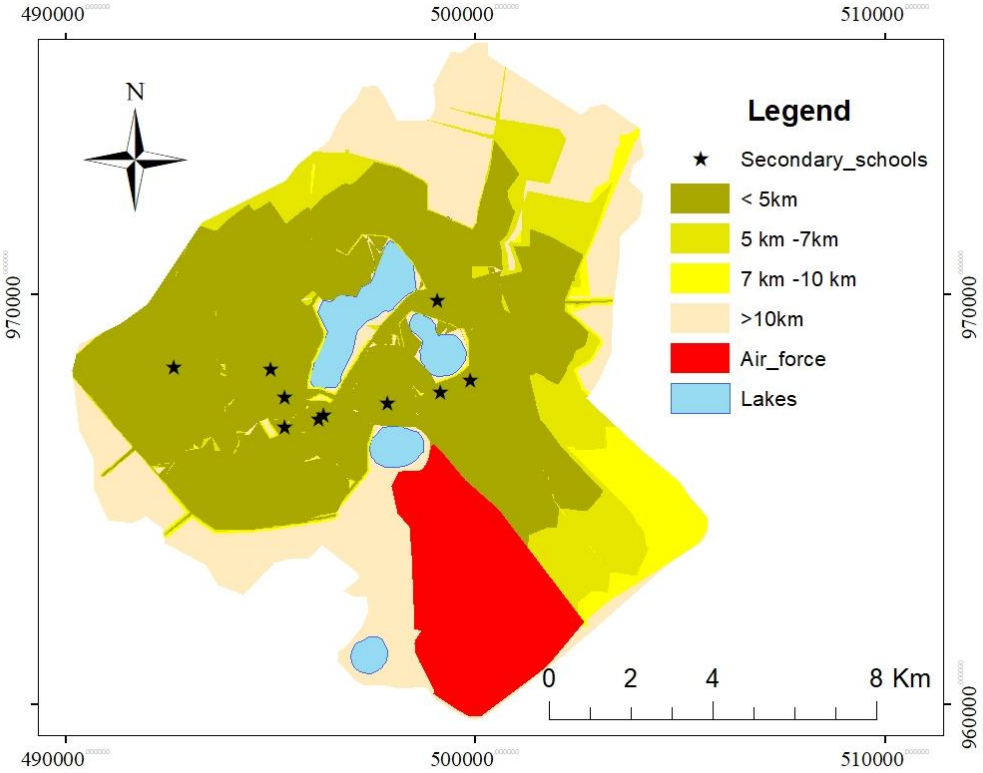


Figure 5-8 spatial accessibility level of secondary schools in Bishoftu town as of 2017

Table 5-5 spatial accessibility of secondary schools in Bishoftu as of 2017

Kebele	No of population served at different distances (km)				Total
	< 5	5-7	7-10	>10	
01	40278	1319	1062	1255	**43914**
02	13484	786	1041	8027	**23338**
03	2459	117	162	5744	**8482**
04	3904	49	89	149	**4191**
05	13669	971	764	3807	**19211**
06	11914	3	1	201	**12119**
07	8861	205	287	9765	**19118**
08	10399	1	1	1478	**11879**
09	19532	1011	169	1288	**22000**
Qaajima	35	74	93	9848	**10050**
Garbicha	4496	4859	53	1553	**10961**
Qalittii	158	360	1922	169	**2609**
Gorbaa	0	0	8	11090	**11098**
Qurqura	1501	524	42	10476	**12543**
Dambi	409	369	15	1381	**2174**
Total	**131100**	**10649**	**5702**	**66236**	**213687**

5.4. Factors affecting spatial distribution of schools

In this study, spatial distribution and accessibility of primary and secondary schools in Bishoftu were examined in GIS environment. By spatial mapping of educational facilities, the level of concentration of schools is evaluated at kebele and town levels. Moreover, spatial accessibility of each school was measured using road network distance.

The findings reveal that the level of spatial distribution of schools is uneven and inequality of primary school between kebeles in Bishoftu is observed. In terms of quantity, the number of primary schools is acceptable in contrast to secondary schools identified below the recommended standard. In contrary, level of spatial disparity is observed between kebeles of the town. Further, spatial distribution of primary schools shows clustering pattern when viewed with respect to the town as the whole. Moreover, spatial accessibility of the facilities forced a significant number of residents to travel more distances to access the facilities.

Based on these evidences, it is enough to conclude that spatial distribution and accessibility of primary and secondary schools in Bishoftu town has limitation in provision of sustainable services. The unbalanced developments observed might result from the following four potential factors.

- ***Population distribution***

Disparity in population distribution in different kebeles of Bishoftu town might be important reason for resulted distribution of the schools. To investigate the relationship between population and number of primary schools, Pearson Product Moment Correlation Coefficient technique was applied to the data in table 5-1. The result depicted in figure 5-9 shows that there is a positive relationship between the number of primary schools and population of kebeles in Bishoftu town. The line of best fit is linear, while the coefficient of correlation (r) in this case 0.89 is highly significant at 0.05 (95%) confidence level. The coefficient of determination (R- square) value of 0.7967 indicates that about 79.67% of variance in primary schools is due to population of the study area. This is a moderate influence and thus implies that the larger the population of Bishoftu, the greater the number of primary schools provided. What this result portends is that,

the distribution of primary schools is not entirely based on population. This situation therefore negates the principle of equity and social justice. Obviously other factors outside population could have influenced the spatial distribution of primary school in Bishoftu.

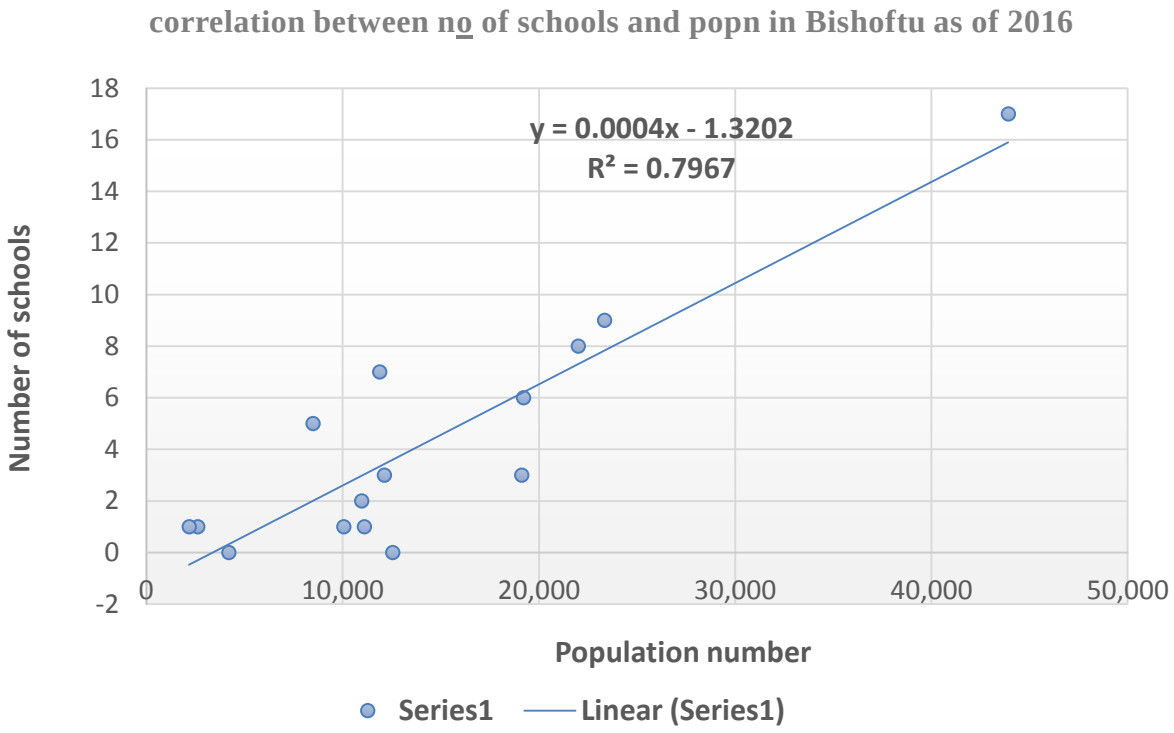


Figure 5-9 correlation between number of population and primary schools in each kebele in Bishoftu town as of 2017

- ***Socio-economic***

Apart from other factors, the private sector may be influenced by the purchasing power of the population as well. Because for investors were completely market-oriented, the decisions they made for the locations were mostly based on cost-benefit analysis. Thus, they seldom took the distribution of schools into account. If the sites were economic and appropriate in their opinions, they would definitely apply for that land than other places. This explains why privately owned

schools are more in kebele 01.Majority of residents in this kebele are relatively middle incomes earning groups.

- ***Monitoring and evaluation***

Lack of monitoring and evaluation might be another important reason for the uneven distribution of primary schools in Bishoftu. Because technically, through regular monitoring and evaluation, using geospatial technologies i.e. geographic information system and remote-sensing, it would be possible to identify unserved area and take measures to ensure adequate provision of the facilities in a timely manner.

Further analysis of data in the table 5-1 suggest that there are 26 GOPS and 38 POPS in Bishoftu. This shows that there may be no concerted effort on the part of the Government to establish primary schools. This can be seen as an evidence of Government less-response to address the increasing demand for primary education facilities by the increasing population of the area.

- ***Spatial variables***

Proximity to likely public infrastructures and major transportation corridors and urban bias have significantly affected the spatial distribution of educational facilities in Bishoftu. As noted in different study, transportation routes are responsible for unbalanced public amenities provision (Al-Enazi, 2016; Han & Lu, 2012), the spatial variables support the visual results of the study and indicate that most of secondary schools in the town are suited along major road passing in the town due to better transportation access. It is also perceived that other infrastructure developments in these areas are relatively good.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

By mapping spatial location of schools and road network in Bishoftu town as of 2017, the present study examines spatial distribution and accessibilities of the facilities to the residents. The findings can be explained in different ways.

First, the analysis of the spatial concentration of primary and secondary schools of the town presented in this study indicates that there is a lead-lag relationship among different kebeles in terms of the facilities. Some kebeles are more developed in terms of a primary school while others lag far behind the mean level of development of the city in terms of these facilities. The varying degrees of concentration of educational facilities can help to improve the existing planning efforts to produce satisfactory results to ensure balanced facilities' provision in different parts of the town.

Second, spatial distribution of primary schools shows clustered pattern where as that of secondary schools exhibits dispersed pattern. This uneven spatial distribution can help the planners and the Government to identify directions of future spatial development of the services to ensure sustainable development.

Third, the result of spatial accessibility of schools reveals that significant number of residents have little access to both primary and secondary schools. In other words, they are expected to travel more than twice of the maximum distance set by planning guide. This provides important information to the Government to focus in proper planning as it is now expected that the population of the town will increase quite significantly during the next decade thereby

multiplying the need for more educational facilities. Absence of proper planning of this facility might lead to a clustered pattern of development which in turn leads to further deterioration in the living environment of the town.

Fourth, the limitation of the spatial distribution and accessibility of schools in the town may be related to, variation in population distribution, spatial variables, socio-economic status, and evaluation and monitoring. Identification of why uneven distribution of facilities occurred can help planners to reduce such an occurrence in the future. Moreover, it helps the government to design spatial policies to the context to improve provision of public facilities, and to mitigate unbalanced development pattern.

6.2. Recommendations

Although this study provides important information on the spatial distribution of educational facilities in Bishoftu and major influencing factors, the results should be considered only an initial step towards understanding the provision of facilities. Hence, further researches are needed on several fronts.

In this study, only one urban center is considered which by itself is not sufficient. It is recommended that in more urban centers in the country should be examined, as comparative analysis would provide an increased understanding of the effectiveness of facility planning. More importantly, the study shades light on potential underlying factors for observed limitations. But further studies are required to examine the trend of these factors in spatio-temporal scales to develop sustainable spatial policy. Finally, the correlation between actual services and performance of schools and distribution of the facilities should be examined.

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APPENDIX

Name of Primary Schools in Bishoftu town 2016/17 Registered of POPS

No	Name	Level	Owners
1	Riqicha	Primary	Private
2	Zukala Abo	>>	>>
3	Tokumma	>>	>>
4	Zawude Zeleke	>>	>>
5	Family Youth	>>	>>
6	Best youth acadamy	>>	>>
7	Beza No1	>>	>>
8	Foqa	>>	>>
9	Ethio Evangelic church	>>	>>
10	Metropolitan Tabernacle church	>>	>>
11	Ripsin International	>>	>>
12	Akkas academy	>>	>>
13	Nafyad	>>	>>
14	Bethlehem	>>	>>
15	Time choice	>>	>>
16	Great Ethiopian Transformer	Primary	Private
17	Lemlem Tesfa	>>	>>
18	T.Beza	>>	>>
19	Diziniland	>>	>>
20	Hindake	>>	>>
21	Modern Youth	>>	>>
22	S.Gorg	>>	>>
23	Yerosan	>>	>>
24	Beza No.2	>>	>>
25	Beza No.3	>>	>>
26	Bulcha wali	>>	>>
27	Malalikt	>>	>>
28	Makane Yesus	>>	>>
29	Tekzore	>>	>>
30	ASA Bethel	>>	>>
31	Bright Hope	>>	>>
32	Adventist	>>	>>
33	Tenaria	>>	>>
34	Lama Guya	>>	>>
35	Salam Acadamy	>>	>>
36	Mekdalawit	>>	>>
37	Marsha	>>	>>
38	Abenezer	Primary	Private

Name of Primary schools in Bishoftu town 2016/17 Registered of GOPS

No	Name of schools	Level	Owners
1	Biftu	Primary	Government
2	Garbicha	Primary	Government
3	Katta	Primary	Government
4	Karra Hora	Primary	Government
5	Kananisa	>>	>>
6	Babogaya No.1	>>	>>
7	Gorba	>>	>>
8	Calalaqa	>>	>>
9	Barkume/miliniyem	>>	>>
10	Istil.R.M.I	>>	>>
11	Bole	>>	>>
12	Maranatha	>>	>>
13	Jorgo	>>	>>
14	Interlakes International	>>	>>
15	Qurqura No 1	>>	>>
16	Dambi	>>	>>
17	Babogaya No.2	>>	>>
18	Fedhi Adda	>>	>>
19	Dhibayu	>>	>>
20	Yahiwenes	>>	>>
21	Dombosko	>>	>>
22	Darara	>>	>>
23	Nuur	>>	>>
24	Hora Arsadi	>>	>>
25	Bakalcha	>>	>>
26	Ganda Gorbabe	Primary	Government

Name of Secondary Schools in Bishoftu Town 2016/17 Registered Both GOSS and POSS

No	Name	Level	Owners
1	Ada'a Model	Secondary school	Government
2	Bishoftu	Secondary school	Government
3	Beza No 1	Secondary school	Private
4	Ethio Evangelic church	Secondary school	private
5	Nafyad	Secondary school	private
6	Bethlehem	Secondary school	private
7	Time choice	Secondary school	private
8	Lemlem Tesfa	Secondary school	private
9	T.Beza	Secondary school	private
10	Abenezer	Secondary school	private