University of Nairobi

School of Engineering

A GIS-BASED INVESTIGATION OF THE EFFECTS OF PHYSICAL ACCESS ON PRIMARY SCHOOL ENROLMENT:

Case study of Loitokitok Sub County.

BY

John Mwangi Maina

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Department of Geospatial and Space Technology

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Declaration

I, John Mwangi Maina, hereby declare that this project is my original work. To the best of my knowledge, the work presented here has not been presented for a degree in any other university.

John Mwangi Maina	……	…….
Name of student	**Signature**	**Date**

This project report has been submitted for examination with my approval as university supervisor.

Professor G.C.Mulaku	……	……
Name of supervisor	**Signature**	**Date**

Dedication

This project is dedicated to my mother Kellen and my Spouse Ann.

Acknowledgements

I would like to acknowledge the advice accorded by my supervisor Professor G. C. Mulaku of the Department of Geospatial and Space Technology, University of Nairobi, which enabled me to successfully complete the project.

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Abstract

Education is considered as one of the most effective ways to reduce poverty, give people opportunities to improve their lives and raise their voice, improve their health, productivity and foster participation in civil society activities. It has been noted that increasing the number of pupils who finish school leads to economic growth, social and political stability, decline in the crime rate, and improved social services. School enrolment is the entry point to the education system and the study of the same and its access greatly impacts on education management.
Several factors e.g. household conditions, educational facilities, social cultural practices, environmental conditions, institutional barriers and physical access affect enrolment levels.

The main objective of this study was to demonstrate the use of a Geographic Information System (GIS) in determining the relationship between physical access and school enrolment. The methodology for the study involved collection of various datasets for schools and roads in Loitokitok Sub County which is part of the larger Kajiado County in Kenya. This was done by collecting the school spatial and enrolment data, spatial data on roads and road surface condition. From the data collected and using GIS analysis techniques, proximity distances of schools to roads were estimated. Using the population census data of 2009, projections were made for the population of school going children in the area of study and in the catchment area of each school. The catchment area was determined by creation of thiessen polygons using the schools as the sample data points. The spatial and attribute data collected were processed and analysed to determine the differences between expected enrolments and actual enrolments. This was further analysed in relation to the proximity distances of schools to roads and road surface conditions.

Key results were maps for the schools and road locations and scatter plots for the enrolments versus proximity distances of schools to roads .The results revealed that there exists a weak relationship between road proximity and road surface condition to the school enrolments. Differences between actual and projected enrolments increased with increased distances of schools from roads .The actual enrolment decreased with increased distances of schools from nearest roads. Thus as per the objective of the study, the relationship between physical access and school enrolment was determined.

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Abbreviations and Acronyms

AIDS	Acquired Immune Deficiency Syndrome
ASAL	Arid and Semi-Arid Lands
EFA	Education For All
ESRI	Environmental Systems Research Institute
FPE	Free Primary Education
GIS	Geographic Information System
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
KNBS	Kenya National Bureau of Statistics
MDGs	Millennium Development Goals
NER	Net Enrolment Rate
PPP	Public Private Partnerships
UNESCO	United Nations Educational Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund

CHAPTER 1
INTRODUCTION

1.1 Background

Kajiado County is predominantly a sparsely-populated, semi-arid county, with pastoralism as the main source of livelihood. However Kajiado's northern boundary abuts the rapidly-expanding residential belt surrounding Nairobi City, so this locality houses growing numbers of commuters, of mixed socioeconomic status. Loitokitok is a Sub County of the larger Kajiado County and borders the Republic of Tanzania to the southwest, Taita Taveta County to the Southeast and Makueni County to the Northeast. It covers an area approximately 6411 square kilometres and is divided into six administrative divisions. The general topography of the county is characterized by plains and occasional volcanic hills.

Despite the introduction of universal free primary education in Kenya in 2003, the enrolment rates among the pastoralists in Kajiado County as a whole still remain low. Lack of access to quality education has denied many pastoralists the chance to exploit the available opportunities to improve their welfare.

Lack of education and appropriate skills implies that many of the people in the County cannot compete in the modern economy or effectively participate in decision making, locally and internationally. Consequently, many uneducated youths from Kajiado County end up taking unskilled, low end jobs as guards for commercial properties and private homes in the rapidly expanding peri-urban centres of Ongata Rongai, Kiserian and Ngong around Nairobi. These jobs do not only entail considerable risks, but the low wages provide limited prospects for worthwhile investment or chance for self-development.

The study seeks to spatially analyze the impact of physical access on school enrolment in relation to the population distribution data in the area of study. The physical access elements include road surface condition and the minimum distance between the schools and the road, which determine the travel time to and from school.

In Loitokitok Sub County there exists statistical data on education enrolment and the status of various schools in the area with their corresponding GPS spatial locations. There also exists road

network data and road surface condition data for the roads in the area. The available datasets (Road network, road surface condition and school spatial and statistical datasets) have not been correlated in a GIS environment for analysis and visualization.

According to Bell (2010) the benefits of better roads in villages and towns is manyfold. First, the residents as consumers enjoy reduced prices and as producers they can negotiate for higher prices for their marketable surplus. Second, students can access schools located outside village. Finally, with better access to medical amenities and crucial drugs not only can their health condition improve but it actually can make a divergence between life and death in several situations.

Education is critical to economic development and social welfare in developing nations. For example, the second Millennium Development Goal adopted by world leaders in 2000 is universal primary education for all boys and girls, while the third called for the elimination of gender disparities in education. Prioritizing education in such a way has several rationales. For one, investments in education are believed to yield returns in poverty reduction, improved health outcomes, and economic growth.

The Education for All goals (EFA, 2007) state that by 2015 all children particularly girls, children in difficult circumstances and those belonging to ethnic minorities, should have access to and completely free and compulsory primary education of good quality (World Bank and UNICEF, 2009).

1.2 Problem Statement

Physical inaccessibility has often been cited as a major hurdle for the rural poor in developing countries to embark on a path to better lives. Inaccessibility prevents them from reaching facilities for getting basic services, such as education and medical care. The main actors in education management and planning in Kenya often do not integrate spatial analysis in their planning phases to analyze physical inaccessibility to the various education institutions in their areas with respect to road surface conditions.

Various studies have been undertaken on the various barriers to education access internationally and locally in Kenya. However the vast majority of these studies have concentrated on the statistical data collection and hypothetical analysis on the social and economic barriers.

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Previous school mapping projects have concentrated on data collection, the creation of Geodatabases and visualization of the same. The problem is that the studies have not revealed the spatial relationships between the various access barriers, including the physical access, and the school enrolment in a GIS environment. This study seeks to address this gap.

A considerable amount of travel time is involved in accessing these schools in rural areas. The time lost in travelling by the students cannot be used either for productive activities, it is just an additional cost that has to be borne to acquire education and is not used in actual learning. In many instances, the long distances have to be covered on foot by the students which leads to physical discomfort especially in hot areas. The time lost is a major implicit cost in schooling decision.

The effects of physical access on school enrolments are not known. The research problem is thus to determine the relationship between physical access and school enrolment.

1.3 Objectives

General Objective

The main objective of this project is to demonstrate the use of GIS in determining the relationship between physical access and primary school enrolment.

Specific Objectives

- To collect spatially referenced information on the status of primary schools and roads in the area.
- To determine the level of access to education based on:
    a) Proximity of the primary schools to the roads network in the area.
    b) Net Enrolment Rate (NER) with respect to roads
    c) The Number of day primary schools and population of school going children in the area.

1.4 Justification for the Study

Universal primary education involves entering school at an appropriate age and progressing through the system and completing a full cycle .Only about three quarters of primary school age children have access to education at this level and of these less than 50% complete the cycle (World Bank and UNICEF, 2009). In spite of governmental and parental commitment to keeping the children in school a large number are still out of school in most countries.

More than 100 million primary school-aged children are not in school and, of those that are; as many as 49 percent in Africa, for example—do not complete primary school (Birdsall *et al*, 2005).

Integration of GIS capabilities in investigation of the physical accessibility to schools can enable education managers, national and county development authorities to make quick and accurate decisions in project design, planning, implementation and monitoring to achieve desired goals, one of which is universal primary education for all.

1.5 Scope and limitation of the study

The study covers only the spatial aspects of geographical accessibility and does not analyze the social-cultural aspects that also prevent accessibility to education in the area of study. There are other factors that could affect school access for example topography, religion,gender, culture, settlement patterns and political factors. However due to financial and time constraints, the study is limited to the physical access factors as determined by road proximity and surface conditions.

The dependent variable of the study is access to primary education as indicated by school enrolment while the independent variables are roads conditions, proximity of schools to roads and the population distribution of school going children.

The study is also limited by various factors including financial and logistical constraints and the vastness of the study area. The study is therefore confined to public primary schools in Loitokitok Sub County. This is because the public primary schools enjoy direct government support in the provision of government educational services and students have to walk to and from schools on daily basis.

1.6 Organization of the report

This report is organised into five chapters. Chapter 1 of the report provides an introduction to the subject states the problem, outlines the objectives, justification and the scope of the study. Chapter 2 provides a literature review on access to education. Chapter 3 sets out the methodology followed during research while chapter 4 sets out the results obtained and their analysis. Chapter 5 gives conclusions and some recommendations for future work, followed by references and appendices.

CHAPTER 2
LITERATURE REVIEW

2.1 Education for all

In many developing countries, schools are not easily accessible and thus social scientists and policy makers are considerably interested in whether better access to schools increases students' enrolment. Since the adoption of the universal declaration of human rights in 1984, education has been formally recognized as a human right. The right to education has long been recognized as encompassing not only access to educational provision but also the obligation to eliminate discrimination at all levels of the educational system (World Bank and UNICEF, 2009).As stated by Dalte (1984), in industrial and industrializing societies, education is seen more and more as the most important channel of social mobility.

The Education for All (EFA, 2007) goal states that by 2015 all children particularly girls, children in difficult circumstances and those belonging to ethnic minorities should have access to and complete free and compulsory primary education of good quality (World Bank and UNICEF, 2009).The international community, through EFA, at various conventions advocated strongly for access to education and particularly at primary level. Access to education is therefore no doubt an international agenda. This is attested to by the United Nations Convention on the rights of the child of 1989 which further strengthens and broadens the concept of the right to education in particular through the obligation to consider its implementation.

In Kenya, on attainment of political independence in 1963, the government of the Republic of Kenya, households and private sector collectively endeavored to enhance the development of education in the country. This aspiration has consistently been reflected in various government documents such as National development plans, sessional papers and education commission reports. The most important is the sessional paper No. 10(1965) on African Socialism and its application to planning. The major objective highlighted in this paper was that every Kenyan child irrespective of gender, religion, and ethnicity has the inalienable right to access basic welfare provisions including education (Orodho, 2002). Since then, the Kenyan government has placed education at the center of national development.

2.2 The accessibility concept

Although the focus of this study is on the geographical dimension of accessibility, the term as employed in diverse development literature has a much broader meaning. The term is often employed in relation to access to services, opportunities, goods and resources which have the potential to improve people's basic living conditions which are generated through provisions of transport, health, education, commercial establishments, banks, markets and communication infrastructures. It is also argued that absence of adequate accessibility undermines the process of empowering the citizens economically, politically and socially. The concept of accessibility is broadening to include not only geographical accessibility but also factors such as social inclusion and social exclusion (Donnges *et al*, 2005).

Shyam, (2007) in his study identifies the issues relating to accessibility to be: dimensions of accessibility, access to whom (or, who benefits?), measurement issues, factors that prohibit or encourage people's access to various socio-economic arrangements and the social structure of accessibility. Dimensions according to his study refer to the distance one has to travel to acquire basic services, the quality of available service, affordability, reliability, and the ease with which services can be acquired. In this context he notes that it is important to look at who is benefiting from services by segregating different socio-economic groups under access to whom. On Measurement issues Shyam (2007) in his study further recognizes the various categories of access for the rural setting in four levels, mainly: no motorized access, partial access, basic access and full access. Full access refers to the uninterrupted all-year, high quality access, while basic access refers to the reliable all-season access for the prevailing means of transport, with limited periods of inaccessibility.

There are three broad kinds of factors that prohibit accessibility to the available development benefits which include geographical, institutional and social. Geographical barriers imply long distances to travel to reach the institutions that provide the facilities. Social barriers imply barriers that emanate from local cultural, social and political systems. In this category of barriers, household characteristics such as caste, ethnicity, and religion, education level of household members, location (urban, rural, ecological belt, region) and household welfare level can be listed. Institutional barriers imply the lack of or low quality institutions (schools, health posts,

security posts etc.) within the reach of rural residents that can provide the much needed facilities to the villagers.

2.3 Factors influencing access to primary education.

There are various reasons why potential school going children either do not enrol or are forced out of school at early stage. These include high poverty levels among the rural and urban slum dwellers, geographical barriers, regional disparities providing a lag between population growth and expansion of education facilities and increase in HIV/AIDS orphans. These reasons provide a disadvantage which implies the denial of equal access to educational opportunities where there is the tendency to have education at the first opportunity and the hindrance of achievement by social and environmental factors. This disadvantage both limits access to educational opportunities and reduces the ability of children to benefit from the schooling that they do get.

It is however true to note that provision of and access to education are the vehicles through which people acquire knowledge, skills, values and attitudes. By these, they develop and appreciate their cultural values, make necessary rules, laws and obligations that ensure the survival of society. It is clear that access to education is the bedrock of society, culture civilization and a powerful tool for perpetuating socio-economic and political development (EFA, 2007).

2.4 Kajiado County and Free Primary Education

In January 2003, Free Primary Education (FPE) programme was launched in Kenya and the initiative had a straightforward, but ambitious purpose to make primary schooling accessible to all young Kenyans of appropriate age, wherever they lived and irrespective of their family's social and economic status. The 2003 programme of free primary education was not the first initiative directed at the achievement of free, universal primary education in Kenya. There had been two predecessors: the first in 1974, launched by President Kenyatta; the second in 1979, launched by President Moi shortly after he assumed office following Kenyatta's death. Both programmes brought about substantial enrolment increases in the class one intakes, but by the time the students reached the higher grades their impact had virtually disappeared. Neither programme came near to achieving universal participation over the full primary cycle.

Table 2.1 shows that enrolment in public primary schools in Kenya grew from 6.9 Million pupils in the year 2003 to 7.4 Million in the year 2007; translating to an increase of 7.2%. The drastic increase in enrolment was as a result of the implementation of the free primary education program. Table 2.2 indicates that the enrolment in public primary schools in Kajiado County grew significantly from 66,295 pupils in the year 2003 to 82,088 pupils in year 2007. This translates to a remarkable increase of 23.8% over a span of 5 years (Saitakwet, 2012).

Table 2.1: National public primary school enrolment (2003-2007)

2003			2004			2005			2006		
Boys	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**
3543807	3362548	6906355	3678182	3447225	7122407	3739802	3494397	7234199	3722255	3537863	7260118
2007											
Boys	**Girls**	**Total**									
3804111	3636845	7440956									

Source: EMIS, Ministry of Education

Table 2.2: Kajiado County primary school enrolment (2003-2007)

2003			2004			2005			2006		
Boys	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**
36110	30185	66295	39735	34246	73981	42390	35438	77828	42109	36904	79013
2007											
Boys	**Girls**	**Total**									
44133	37955	82088									

Source: EMIS, Ministry of Education

Saitakwet, (2012) in his study noted that there was an increase on the national average by 16.6% which stands at 7.2% over the same period of time and it is therefore evident that the free primary education programme was highly effective in Kajiado County. However, Saitakwet, (2012) acknowledged that the gross enrolment which is the relationship between the number of pupils enrolled at an academic level (primary) and the school eligible population for this level for a given academic year, stands at 82.3% for a period of five years translating to 75, 841 pupils in Kajiado County. This meant that 17.7% of the school eligible population was out of school, which translates to 16, 311 pupils over a period of five years in the same County. The FPE strategy of capitation grants enabled schools to procure teaching and learning materials, which they did not have access to due to previous inequalities in the public primary education, resulting in improved access to primary education. Physical networks in the form of roads have the potential to enhance social networks and the political voice of isolated households, which in turn

enables them to value and demand education for their children (Saitakwet, 2012). In his study Saitakwet, (2012) noted that sociology of roads is a field that needs to be expanded to get a better insight on the social changes that are associated with the building of roads.

2.5 Geographic Information System (G.I.S.)

2.5.1 GIS definition and relevance

Until now, GIS has been defined in a number of ways but there are two scenarios when defining it; through formal definitions or through technology's ability to carry out spatial operations and linking data sets together. It collectively refers to a system consisting of hardware, software, organizing procedures and personnel capable of acquisition, management, analysis, and dissemination of geographically referenced data. Geographic Information System (GIS) may be defined as a computer based information system, which attempts to capture, store, manipulate, analyze and display spatially referenced and associated tabular attribute data, for solving complex research, planning and management problems (Fischer and Nijkamp, 1992).

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analytical benefits offered by maps. These abilities distinguish GIS from other information systems making it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. For a long time, GIS applications focused heavily on the traditional areas of its applications such as land use and land cover mapping, census mapping, urban mapping, environmental planning and management, disaster and hazard risk management, among numerous others. Even within these traditional areas of GIS application, emphasis remained on macro level mapping where interest was on mapping expansive entities such as natural resources, urban areas and population.

With the rapid evolution of digital technology, and more specifically GIS, the horizon of GIS applications has tremendously broadened. GIS now utilizes database systems, allows easy overlay of data in different projection systems, fully integrates raster data and allows Internet mapping. GIS is therefore not only becoming more powerful but more relevant. In addition to permitting linkage between various types of data and maps, GIS is able to manipulate and

visually display numerous types of data for easy comprehension. Recently, systems using GIS have been developed for use in various disciplines which highly supports decision making.

2.5.2 GIS Analysis Methods (proximity analysis)

The Analyses applicable in this study are based on the measurement of the accessibility of pupils residing within the boundaries of the sub county to the institutions. The Proximity toolset contains tools that are used to determine the proximity of features within one or more feature classes or between two feature classes. These tools can identify features that are closest to one another or calculate the distances between or around them. The proximity analysis is performed by creating thiessen polygons and finding the near feature. Proximity analysis tools in Arc GIS include:

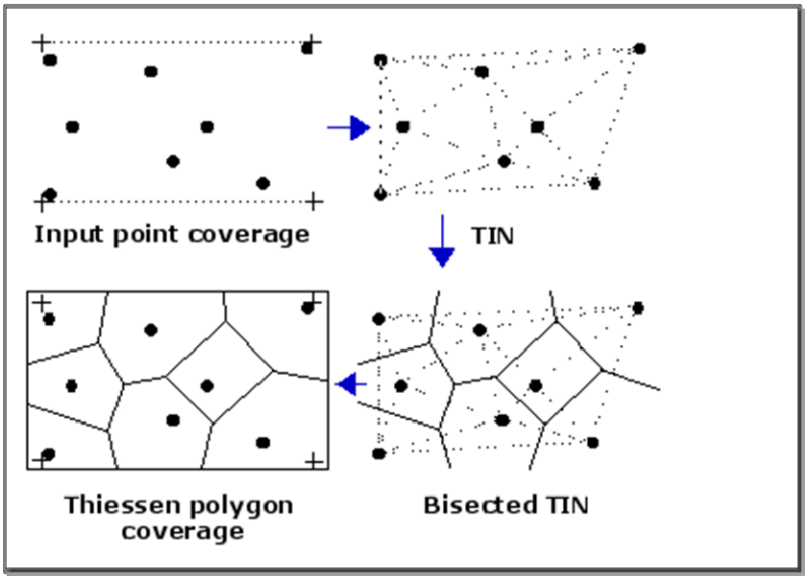
- Buffer
- Create Thiessen Polygons
- Multiple Ring Buffer
- Generate Near Table
- Near
- Point Distance

a) Thiessen polygon creation

Each Thiessen polygon contains only a single point input feature. Any location within a Thiessen polygon is closer to its associated point than to any other point input feature. Creating thiessen polygons to determine schools accessibility is done in such a way that each thiessen polygon contains only a single point input feature (school). This is then interpreted as all locations within the thiessen polygon being closer to the school in that polygon than any other school in the area and hence the centres of settlement and roads.

The thiessen polygon is considered as a proximal zone of that school and from these zones a critical analysis of the road surface condition surrounding the school can be carried out and related to the population in the area and the school enrolment.

Figure 2.1 represents the procedure followed when creating thiessen polygon coverage from point features.



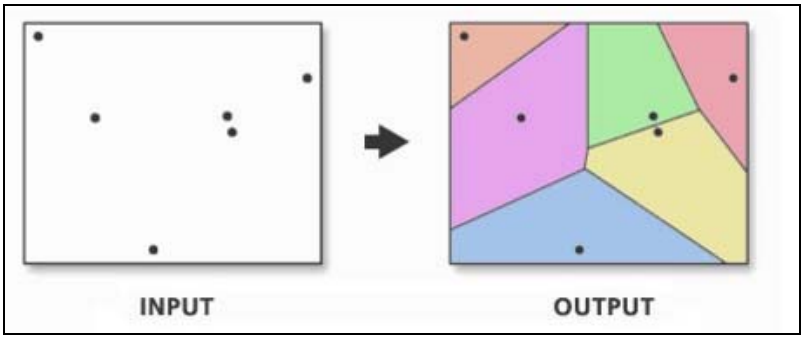


Figure 2.1: Creating Thiessen polygons from point features (source: Resources.esri.com)

b) Near Features

Determines the distance from each feature in the input features to the nearest feature in the near features, within the search radius. The near features are used to find the nearest features from input features. There can be one or more entries of near features; each entry can be of point, polyline, polygon or multipoint type. When multiple entries of near features are specified, a new field NEAR_FC is added to the input table to store the paths of the source feature class that contains the nearest features. The NEAR tool in proximity toolset in Arc GIS adds attribute fields to a point feature class containing distance, feature identifier, angle and coordinates of the nearest point or line feature. Figure 2.2 illustrates the determination of near features from input features of points, lines, polygons and mixed feature types of points, lines and polygons.

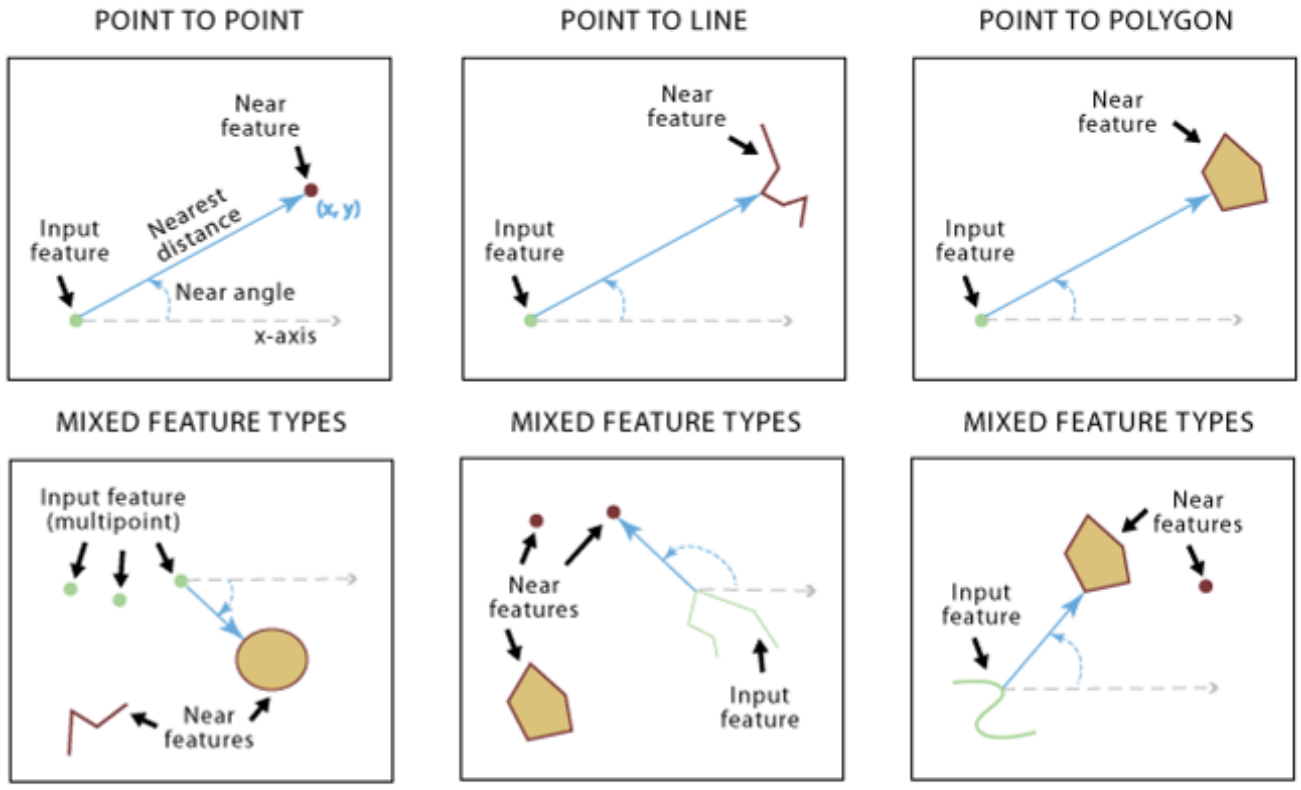


Figure 2.2: Illustration of Near Feature tool (source: Help.arcgis.com)

2.6 Review of previous studies

Various studies indicate that there are economic and other structural forces that present barriers of access to education. For example, in some countries, such as India, Mali, and Burkina Faso, school enrolment is very low due to the cost of schooling (both direct and opportunity costs), poor school infrastructure, teacher shortages, and safety and sanitation problems (Birdsall *et al*, 2005). Studies done in other areas, such as several Latin American countries reveal that enrolment may be nearly universal, but retention and completion may be quite low for a myriad of reasons, including poor health of students or members of their households, teacher absenteeism and curricula that do not match students' needs(UNESCO, 2005).

Many studies have examined the relationship between geographical accessibility and development. However, most of the research focuses around improved accessibility through roads as a factor of economic growth. Although measuring social outcomes of investments on roads such as increase in school participation has generally remained peripheral in roads evaluation, recently a renewed emphasis in the development community has been put on examining how and whether roads can help achieve social development.

Shyam(2007) carried out a study on geographical accessibility and its effects on school enrolment in Nepal where the study specifically, examined how improving accessibility levels of households through building roads can affect school enrolment of children, and how such provisions may differentially affect various groups in society such as boys and girls, younger children and older children, and poor and non-poor households. To surmise, it probes if the impact of improved accessibility is beneficial to human development and more beneficial to the disadvantaged. The study however did not reveal the spatial relation of the effects in a GIS environment.

Shyam (2007) argues that achieving geographical accessibility may be beneficial for breaking other forms of accessibility barriers— the barriers originating from socio-economic stratification in the society, and the lack of or low quality institutions. In his study he discusses the social barriers of accessibility to Education. Saitakwet (2012) carried out a study on access to primary education for the pastoralists in Namanga division of Kajiado County in the then Rift Valley

province of Kenya. The objectives of the study were to find out how household conditions, educational facilities, socio-cultural practices and environmental factors affect access to primary education for the pastoralist of Namanga division.

Saitakwet(2012) in his study concluded that household conditions, educational facilities, socio-cultural practices and environmental factors influence the access to primary education for the pastoralists in Namanga division. He recommended that there is need of integrating all stakeholders' involvement in the education sector in order to address the above mentioned factors, diversify on economic activities and create awareness on the importance of education for all in the study area. He also suggested the need for the government to build more boarding schools in the study area, have consistent provision of lunch to schools, provide adequate learning materials, abolish retrogressive socio-cultural practices, drill more boreholes and promote equitable distribution of resources across the pastoral areas in the Republic of Kenya to ensure that all learners across the County have access to primary education, thus improving livelihoods and striving to achieve Vision 2030. The study recommended the need for further studies in other ASAL areas to ascertain the factors affecting access to primary education.

In the vast majority of the studies done on education accessibility, the spatial relationship between geographical accessibility to primary schools and school enrolment has not been revealed in a GIS environment to support decision making. This study seeks to address this gap and contribute to the scanty body of literature on the measurement of social-economic benefits that comes with better connectivity and physical access. It seeks to reveal the relationship between physical access to school and school enrolment. The outcome may support decision making especially in prioritizing development of physical infrastructure in view of achieving the desired Millennium Development Goal of Free Primary Education for All.

CHAPTER 3

MATERIALS AND METHODS

3.1 Area of Study.

The study was carried out in Loitokitok Sub County in Kajiado County; one of the 47 Counties in Kenya. Kajiado County borders Narok and Kiambu Counties to the West, Nairobi and Machakos Counties to the North, Makueni and Taita-Taveta Counties to the East and Tanzania to the South. It has an approximate population of 687,000 and occupies an area of 21,902 square kilometers. Kajiado County is divided into five administrative sub-counties namely: Kajiado Central, Kajiado North, Loitokitok, Isinya and Mashuuru, with a total of 17 administrative divisions. Table 3.1 shows the county's area and administrative units by sub-county while figure 3.1 shows a map of the study area.

Table 3.1 : Administrative units of Kajiado, year 2013.

Sub-county	Area (sq km)	No. of Divisions	No. of Locations
Kajiado North	6,344.9	4	30
Kajiado Central	5,186.0	3	32
Isinya	1,056.0	2	16
Mashuru	2,903.0	2	11
Loitokitok	6,411	6	16
Total	**21, 900.9**	**17**	**105**

Source: County Commissioner, Kajiado, 2013

Loitokitok sub county lies approximately between latitudes 36°45' east to 37°45'east and 2°00 south to 3°15' South. The Sub County is predominantly occupied by the Maasai community. Loitokitok name is derived from a spring with Maasai name 'enkoitokitok' that means a bubbling spring. The Sub County has a bimodal rainfall pattern. The short rains fall between October and December while the long rains fall between March and May. The Economic activities practiced within the Sub County are nomadic pastoralism and small scale farming.

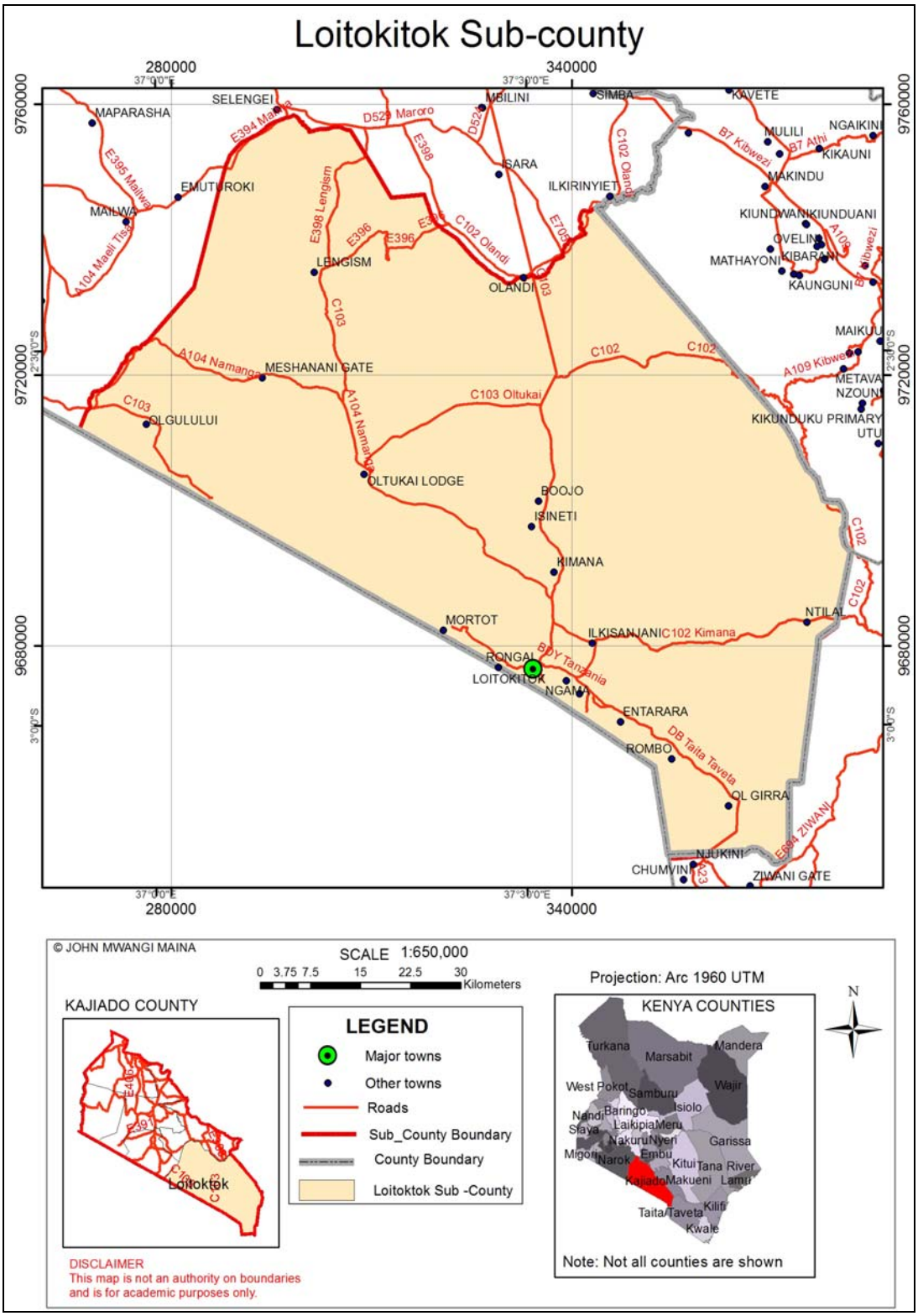


Figure 3.1: Area of Study

3.2 Overview of the Methodology

Figure 3.2 shows the overview of methodology used in the study.

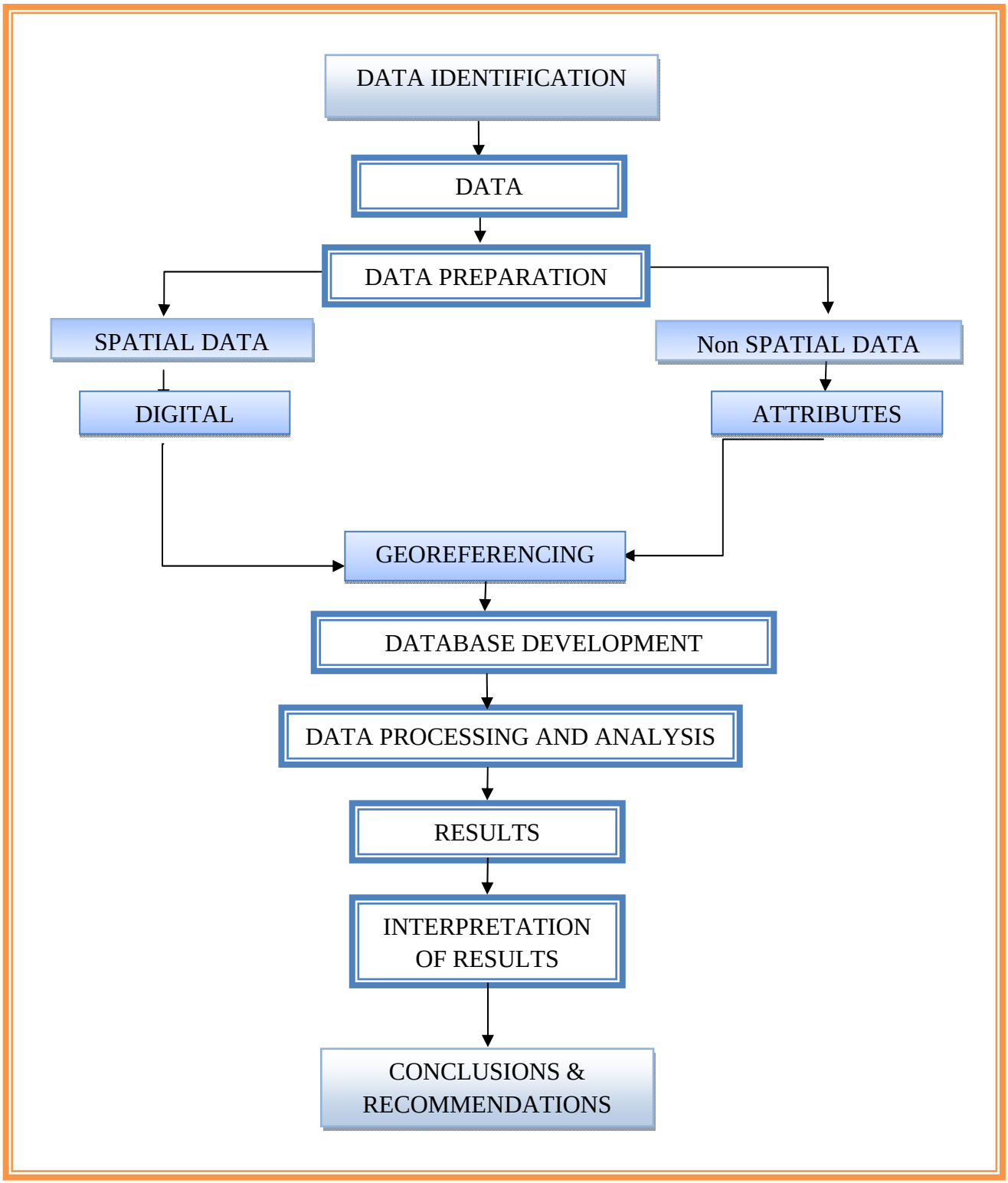


Figure 3.2: Overview of Methodology

3.3 Data Sets and Tools

Table 3.2 : Dataset types and sources

DATA TYPE	CHARACTERISTICS	SOURCE
Kajiado centres and villages , Roads data	Shape files	World Resource Institute-Kenya GIS Data and Ministry of Roads
Primary School Enrolment Data	Hard / Soft copy (Excel sheets and pdf files)	Ministry of Education.
Topographic Map	Scale 1:50,000	Survey of Kenya
Administrative Boundaries	Shape files	Survey of Kenya
Population data and projections	Excel format	KNBS

3.3.1 Hardware:

- A computer with 2 GB of RAM, 5.2 GHz speed and 320 Gb Hard disk.
- A flash disk of capacity 4 GB
- HP Printer

3.3.2 Software:

- ArcGIS 10.1
- Global Mapper 12.0
- Ms Office (2010) suite
- Adobe Photoshop
- Mozilla Firefox

3.4 Data collection and Preparation

3.4.1 Scanning of Topographical Map and Road maps

A large format scanner was used to create a raster digital file from an existing hardcopy topographical map and Road maps which was saved as a JPEG file interchange format. Adobe Photoshop software was used to clean the resulting raster images and to enhance the colour, contrast and brightness for easier interpretation of details in the resulting image.

3.4.2 Georeferencing of Topographical Map and Road maps

The Scanned raster image of the maps was geo-referenced using ArcGIS software. The Arc 1960 datum and Universal Transverse Mercator (UTM) Zone 37 South projected coordinate system was used and the measurement unit was in metres. Four tic marks with coordinates in easting and northing at the four corners of the image were used as the control points. Registration of geo-referenced image points was applied and the root means square (RMS) error automatically generated by the software for evaluation of georeferencing precision. A root mean square error of 5.4086 was realized as a result of georeferencing which was found acceptable. The georeferenced image was then rectified and exported in the Tagged Interface File format (TIFF). Figure 3.3 shows a screenshot of the process of georefencing the topographic map in Arc GIS.

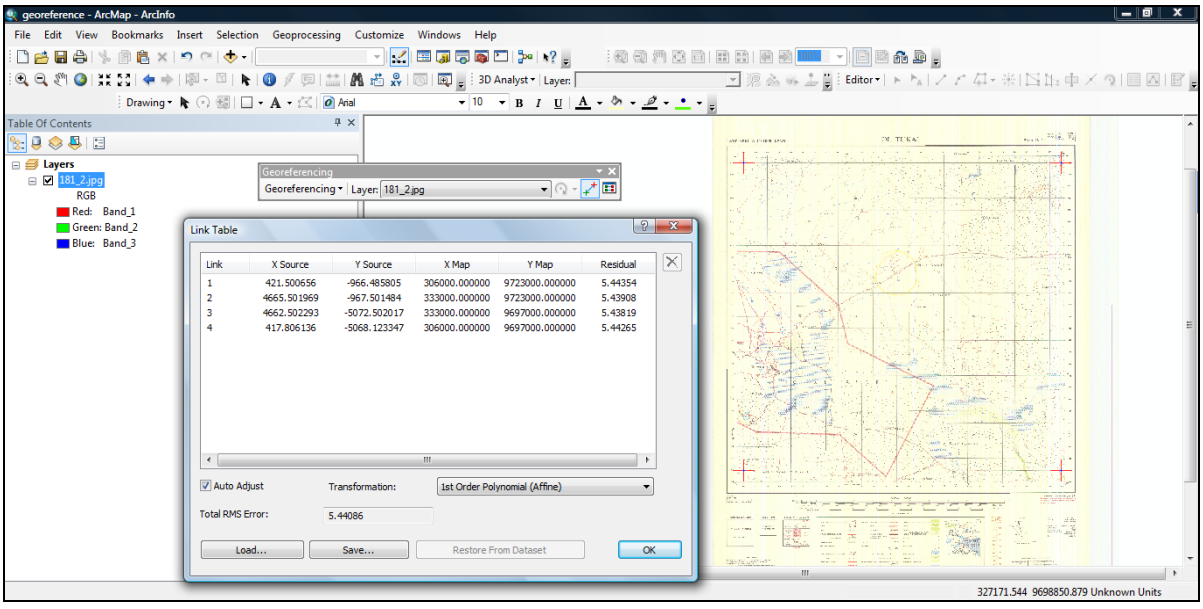


Figure 3.3: Screenshot of Geo-referencing Topographical Map using ArcGIS.

3.4.3 Clipping of Topographical Map and Road maps

This was carried out to precisely extract the relevant data covering the study area and to extract the specific area of interest which is Loitokitok Sub County from the larger area covered by the topographical map. The rectified topographical maps were added to the map layers containing the area of study. The polygon defining Loitokitok Sub County was then used as the overlay polygon for clipping.

3.4.4 Primary school enrolment 2013 data

Primary school children enrolment and spatial data were collected in both pdf format and excel sheets from the Ministry of education. The required data was extracted from the pdf file and entered into an excel file for the respective schools alongside their coordinates. Table 3.3 shows a sample extract of the schools' spatial location data while Table 3.4 shows sample school enrolment data for the year 2013.

Table 3.3: Sample school spatial location data

Name of School	Sponsor of School	Division	Location	Latitude	longitude
AIC LOITOKITOK	CENTRAL GOVERNMENT/DEB	LOITOKITOK	KAJIADO SOUTH	-2.92959	37.50385
AMBOSELI	CENTRAL GOVERNMENT/DEB	LOITOKITOK	KAJIADO SOUTH	-2.74112	37.36542
CHIEF OLE MUTURY	CENTRAL GOVERNMENT/DEB	LOITOKITOK	KAJIADO SOUTH	-2.90707	37.52267
DEB LOITOKITOK	CENTRAL GOVERNMENT/DEB	LOITOKITOK	KAJIADO SOUTH	-2.92889	37.50289
ELANGATA ENKIMA	CENTRAL GOVERNMENT/DEB	LOITOKITOK	KAJIADO SOUTH	-2.80615	37.67245
ELERAI	CENTRAL GOVERNMENT/DEB	LOITOKITOK	KAJIADO SOUTH	-3.17259	37.73584
ENCHURRAI	CENTRAL GOVERNMENT/DEB	LOITOKITOK	KAJIADO SOUTH	-3.04287	37.67236

Table 3.4 : Sample school enrolment data

Name of School	Actual Enrolment
AIC LOITOKITOK PRI SCH	872
AMBOSELI PRI SCH	325
CHIEF OLE MUTURY PRI SCH	551
DEB LOITOKITOK PRI SCH	850
ELANGATA ENKIMA PRI SCH	854
ELERAI PRI SCH	385
ENCHURRAI PRI	450
ENKAJI NAIBOR PRI SCH	360
ENKII PRI SCH	435
ENKIJAPE PRI SCH	580
ENKONGU NAROK PRI SCH	428
ENTARARA PRI SCH	1509
ENTONET PRI SCH	1176
ESITETI PRI SCH	348
ESOSIAN PRI SCH	438
ILCHALAI PRI SCH	330
ILLASIT PRI SCH	1590
ILOIRERO PRI SCH	282
ILTILAL PRI SCH	643

3.4.5 Population data and projections

Population projections for 2013 for school going children in the area were obtained in excel format. This projected data was obtained from Kenya National Bureau of Statistics (KNBS) and was based on the 2009 Kenya population census data. The projections were tabulated for the various locations in Loitokitok Sub County. The projected population densities for school going children were computed based on the areas for the sub locations and the projected population of school going children in that location. This density was estimated from dividing the number of projected school going children by the area of the location as obtained from KNBS. The densities in number of children per square kilometre then formed part of the data sets.

An assumption of uniform population density of school going children within each location of the study area was made. This assumption was made to enable the estimation of population of school going children in a school's catchment area.

3.4.6 Roads data

Roads data was obtained from Kenya Rural Roads Authority (KERRA) and the Kenya Roads Board (KRB). The data from KERRA was both in excel format and shape files. The KRB data was in form of a map. Table 3.5 shows an extract of the roads data collected.

Table 3.5: Sample extract of road data

ROAD ID	SURFACE TYPE	SURFACE CONDITION	NUMBER OF LANES	DISTRICT	LENGTH (KM)
C103	Gravel	Fair	2	Kajiado	37.942
D536	Gravel	Poor	2	Kajiado	35.039
C102	Surface Dressing	Good	2	Kajiado	11.895
C103	Gravel	Good	2	Kajiado	48.311
C103	Gravel	Good	2	Kajiado	10.431
D536	Gravel	Fair	2	Kajiado	4.149
E400	Earth	Poor	1	Kajiado	15.780
E399	Gravel	Fair	1	Kajiado	16.407
E399	Earth	Poor	1	Kajiado	16.187

3.5 Data processing and analysis

The data processing and analysis involved the projection of the population of school going children in the catchment area, determination of the distance from school to nearest road, determination of differences between projected and actual enrolments and establishment of any relationship between enrolment and school proximity. The roads were classified according to the surface condition ranging from poor to excellent conditions with some being classified as under construction. Scatter plots of enrolment and enrolment differences versus proximity distances of

schools to roads were made for all the schools and various classes of roads to determine the relationships between enrolment and school proximity.

3.5.1 Creation of Personal Geodatabase

A personal geodatabase was created containing all the layers of the datasets collected to aid in manipulation and processing. In Arc catalog, a new folder was opened in which a personal geo-database was created containing feature classes, raster datasets and tables and renamed education and access. Figure 3.4 shows a screenshot of the Arc catalog view of the personal geodatabase created.

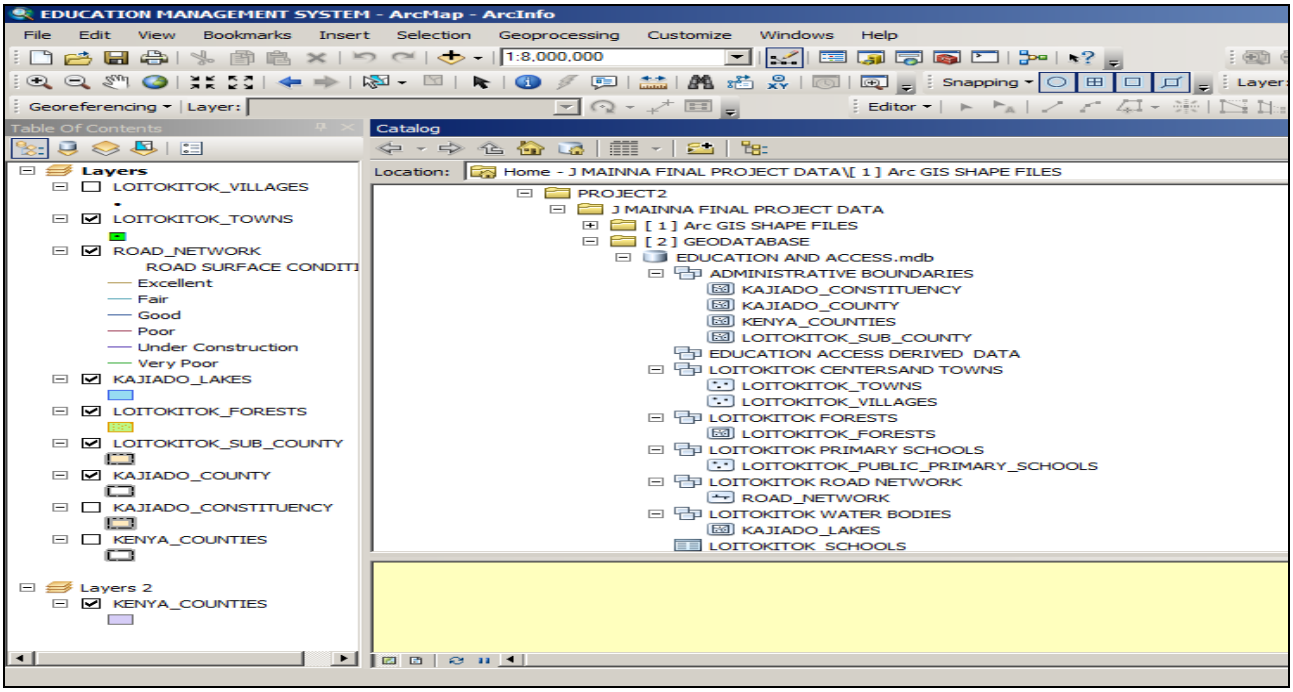


Figure 3.4: Screen shot of Arc Catalog view of personal geodatabase created.

3.5.2 Creation of feature datasets and feature classes

In the personal geodatabase feature datasets as a collection of related feature classes that share a common coordinate system were created to spatially or thematically integrate related feature classes. This was done to organize related feature classes into a common dataset for building a topology, a network dataset, a terrain dataset, or a geometric network. Roads, Towns, Centres, villages and Schools feature classes were then built in the new feature dataset. The feature classes used in the geodatabase were points, lines, and polygons. A line feature class represents

road centerlines; a point feature class represents towns, villages and centres while the polygons represent a spatial extent in area.

3.5.3 Vectorization

Georeferenced road maps were vectorized through on screen digitizing using ArcGIS 10.1 software. Interactive vectorization involving the manual creation of features assisted by the ability to snap to raster cells and utilization of the raster tracing and shape recognition tools was employed. The vector data derived from the digitizing process was then stored for further analysis. Figure 3.5 shows a screenshot that illustrates digitized roads in the area of study.

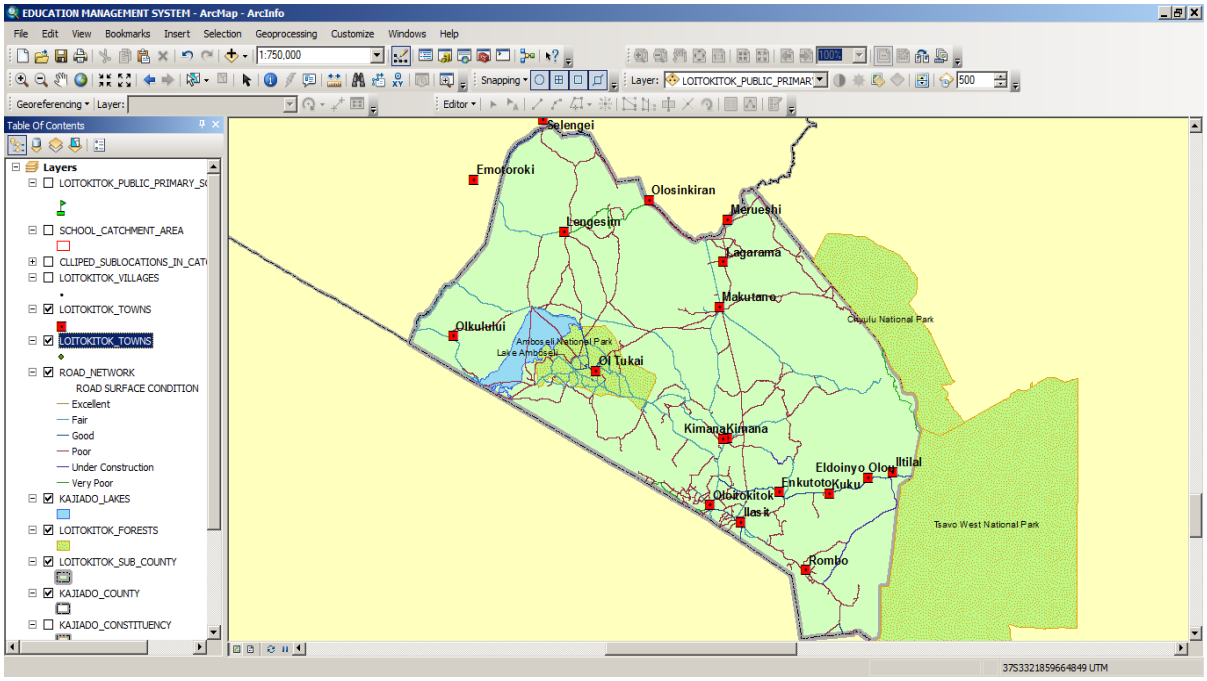


Figure 3.5: Screenshot illustrating digitized roads.

3.5.4 Spatial Data Editing and Validation

The spatial data collected was edited in order to detect and correct errors during spatial data capture. This ensured that gaps and overlaps between polygons were corrected and the labeling of polygons was done. It also ensured that all line features had network connectivity.

When the CLEAN command is used all these errors are highlighted. The editing capabilities in Arc info enabled feature snapping, automatic detection and identification and correction of the digitizing errors.

3.5.5 Proximity analysis

Proximity analysis was done to determine the distance to the nearest road from the school and also determine the road condition and class. This was necessary since they constituted the physical access elements which were the subject of the study. A road surface condition code was assigned to the different road surfaces ranging from values of 1 for excellent condition to value 6 for very poor condition. A physical access factor was then determined as a product of multiplying surface code and nearest distance to road. Thus the higher the physical access factor the poorer the physical access to the school. Figure 3.6 illustrate the proximity analysis in the determination of the distance from the nearest road to a school using NEAR tool in the proximity toolset in ArcGIS while figure 3.7 illustrates the proximity analysis for determination of nearest distance from school to nearest road with a sample of generated attribute table .

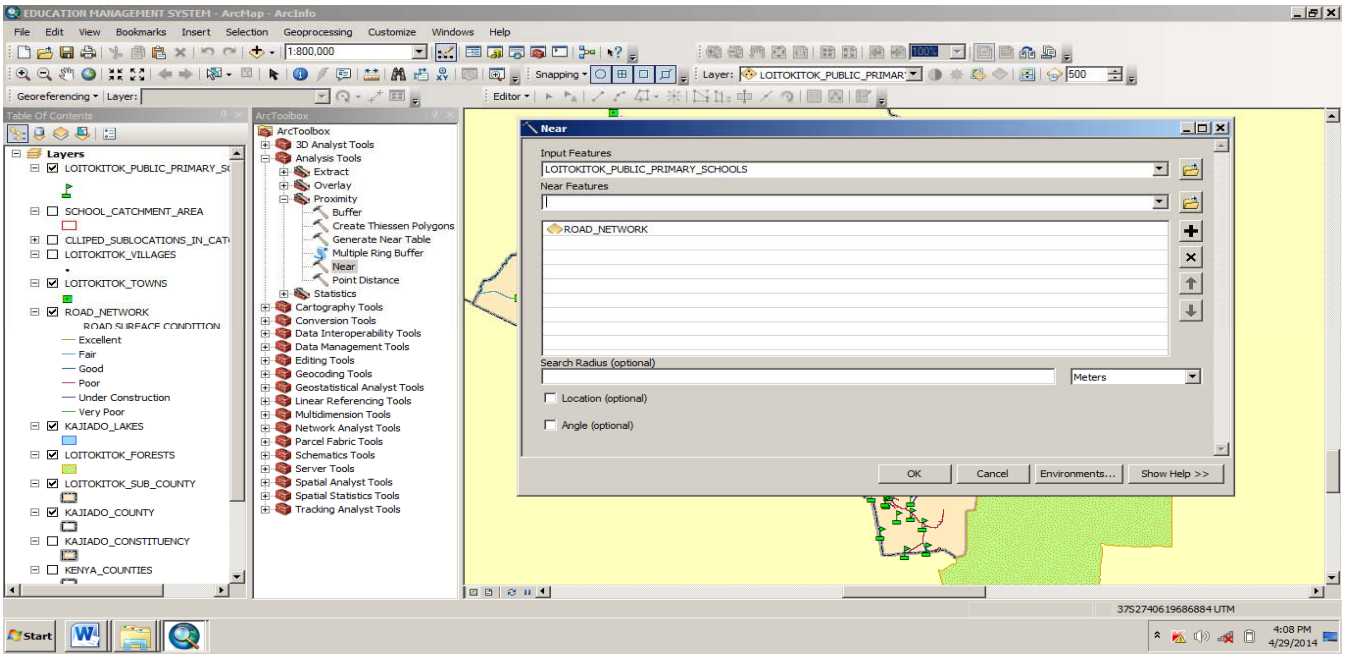


Figure 3.6: Screenshot illustrating determination of distance from school to nearest road.

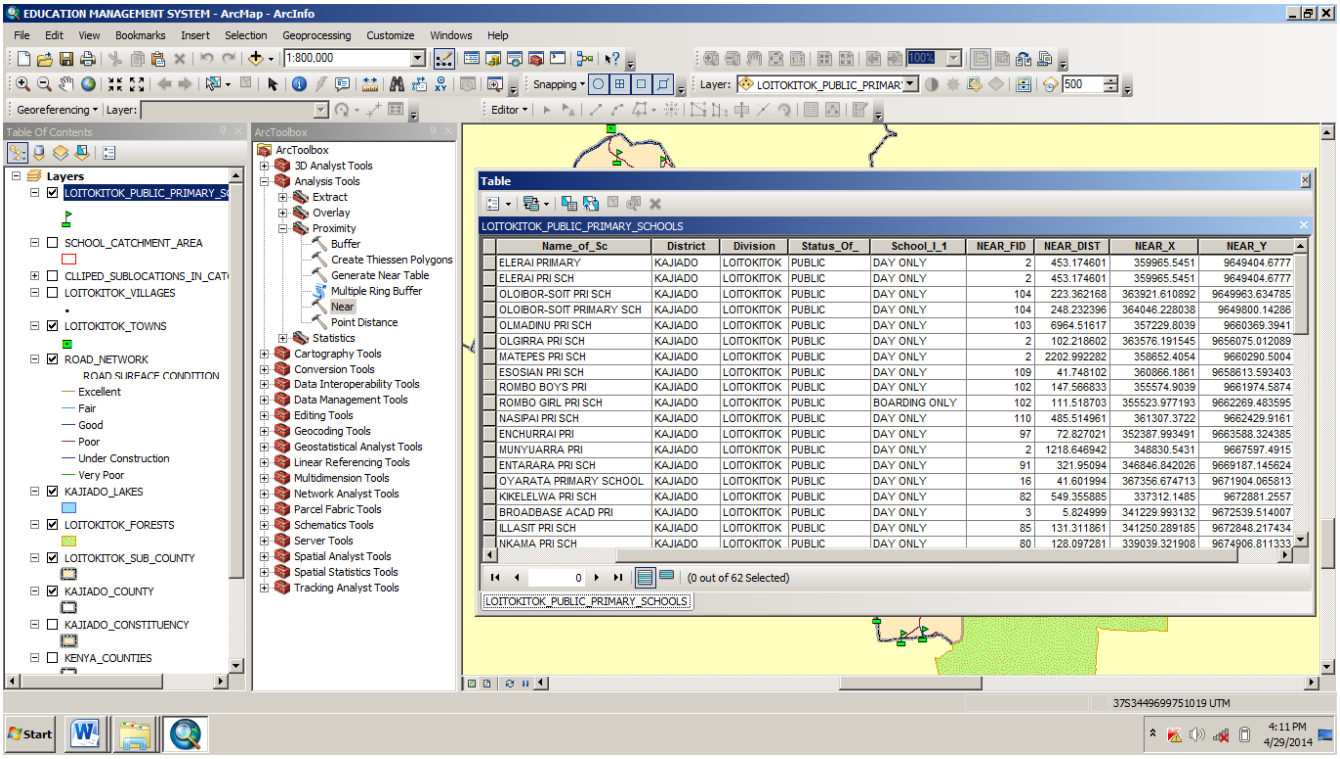


Figure 3.7: Screenshot illustrating sample attribute table of school and road proximity analysis.

3.5.6 School catchment area and projection of school going children

Thiessen polygons were created using school locations as point input features. The locations of the schools were used as the label points for the thiessen polygons. Each thiessen polygon contains only one school as a single point input feature. Thus any location within the Thiessen polygon is closer to its associated school than to any other school. The proximal zones or the thiessen polygons defined the catchment area of the associated school.

The map showing locations and their school going children population was overlaid with the map containing the thiessen polygons. This enabled the estimation of the population of school going children in the catchment area. Assuming a uniform population density in each location, the proportionate area of each location covered within a thiessen polygon was used to estimate the number of school going children from the location that contribute to the total number in the school catchment area. The area of segments from the location that comprises the catchment area of school was determined by clipping the polygons in ArcGIS. The number of projected school going children from the segment was then estimated as a product of multiplying projected

population density by the segment area. The total number of projections from the segments of all the locations comprising the catchment area was then added up to get the total projected population of school going children for the catchment area. Figure 3.8 is a screenshot illustrating creation of thiessen polygons in Arc GIS with a sample generated attribute table while Figure 3.9 illustrates the estimation of the population of school going children from overlays of population densities in the locations and the generated thiessen polygons forming catchment areas.

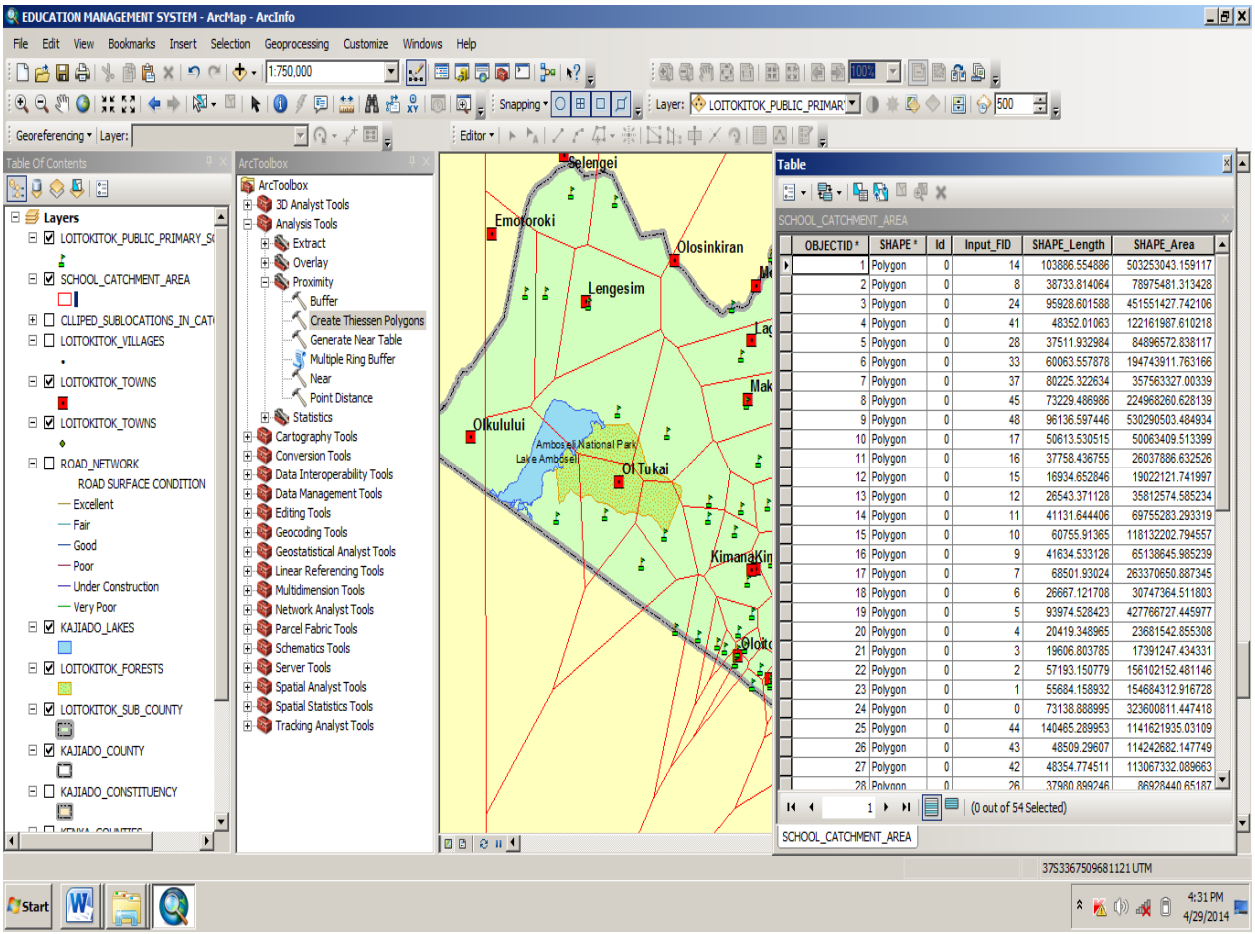


Figure 3.8: Screenshot illustrating creation of thiessen polygons.

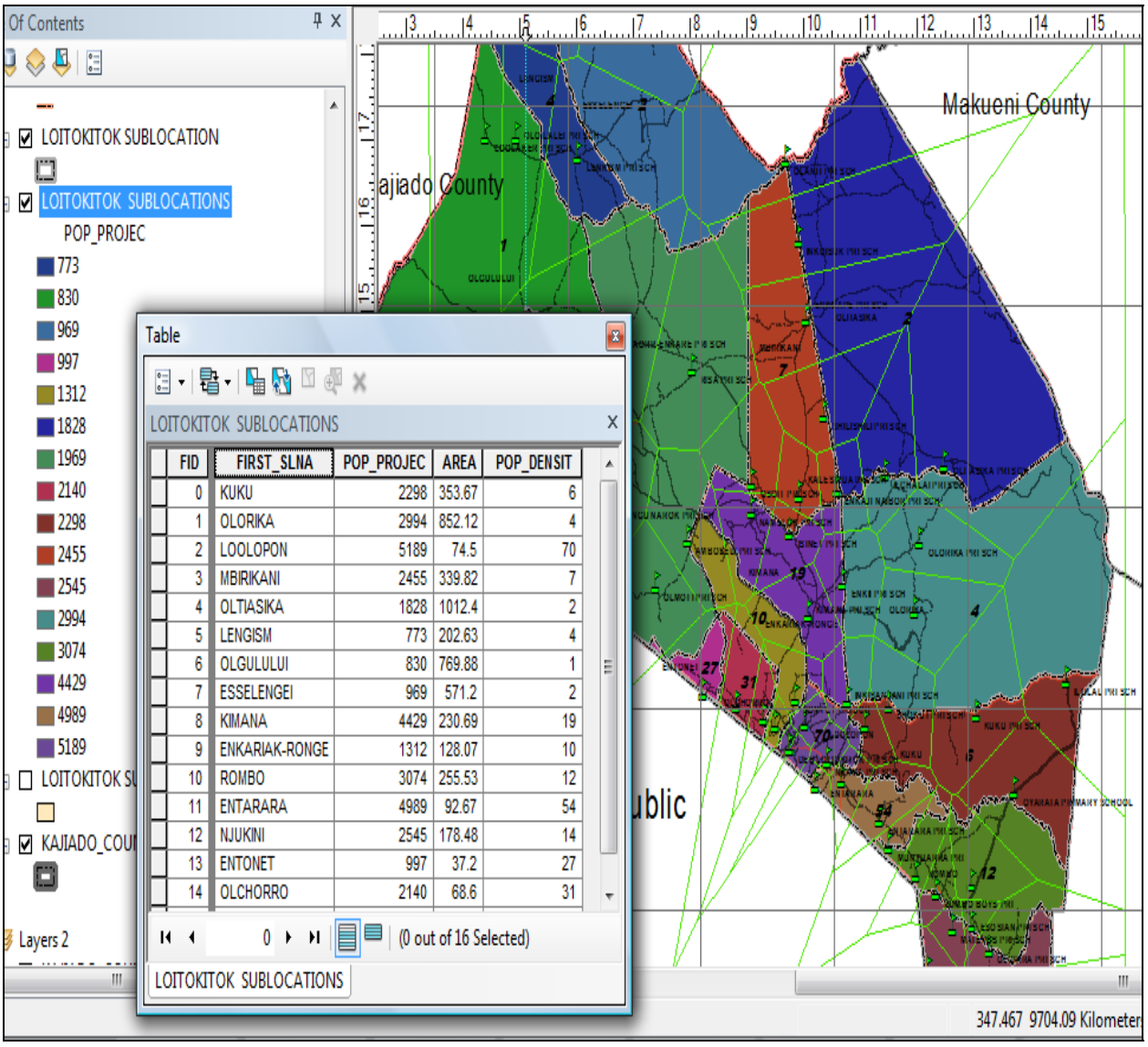


Figure 3.9: Screenshot illustrating estimation of school going children in the catchment area.

CHAPTER 4

RESULTS AND ANALYSIS OF RESULTS

4.1 Public primary schools in Loitokitok Sub County

Figure 4.1 shows the spatial distribution of public primary schools in Loitokitok Sub County, in a GIS environment.

Figure 4.1: Public primary schools in Loitokitok Sub County.

4.2 Roads in Loitokitok Sub County

Figure 4.2 shows the spatial distribution of roads in Loitokitok Sub County, Kajiado County in a GIS environment.

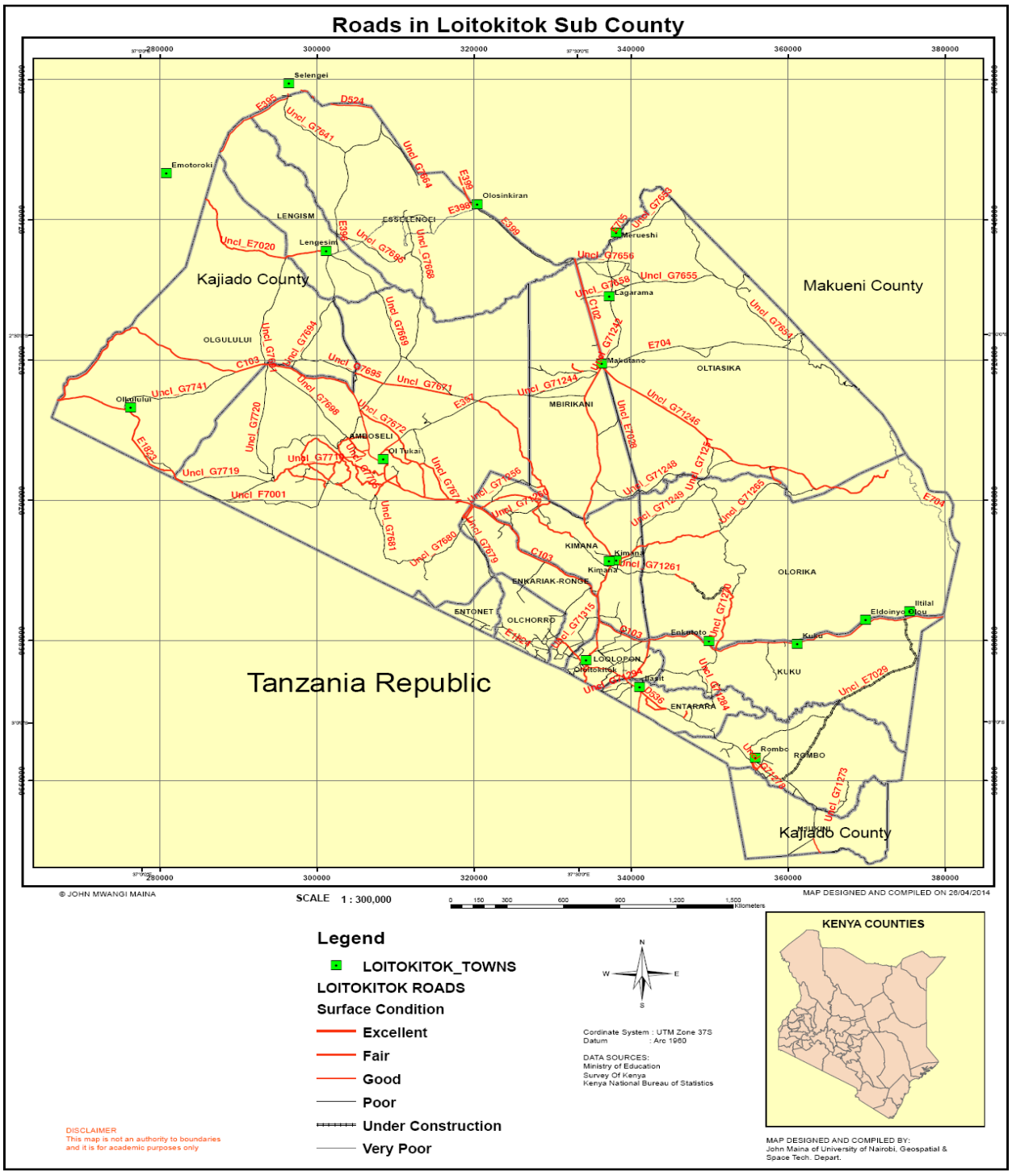


Figure 4.2: Roads in Loitokitok Sub County

4.3 Enrolment with respect to road network

Figure 4.3 is a spatial representation of actual and projected enrolments with respect to road network in Loitokitok Sub County, in a GIS environment.

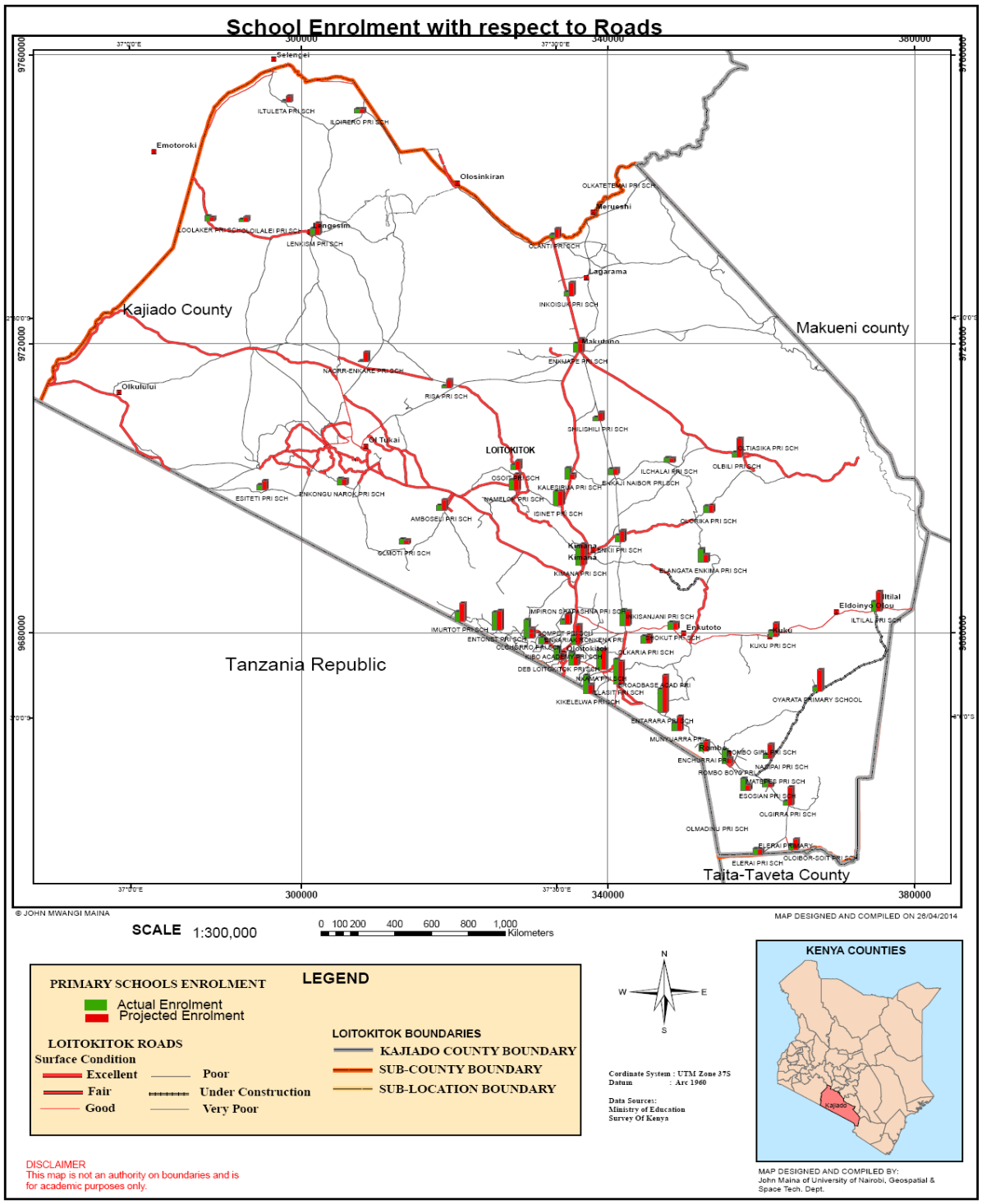


Figure 4.3: Net enrolment with respect to road network

4.4 School Catchment Area Generated from Thiessen Polygons

Figure 4.4 is a spatial representation of School catchment areas as generated from Thiessen Polygons in Loitokitok Sub County.

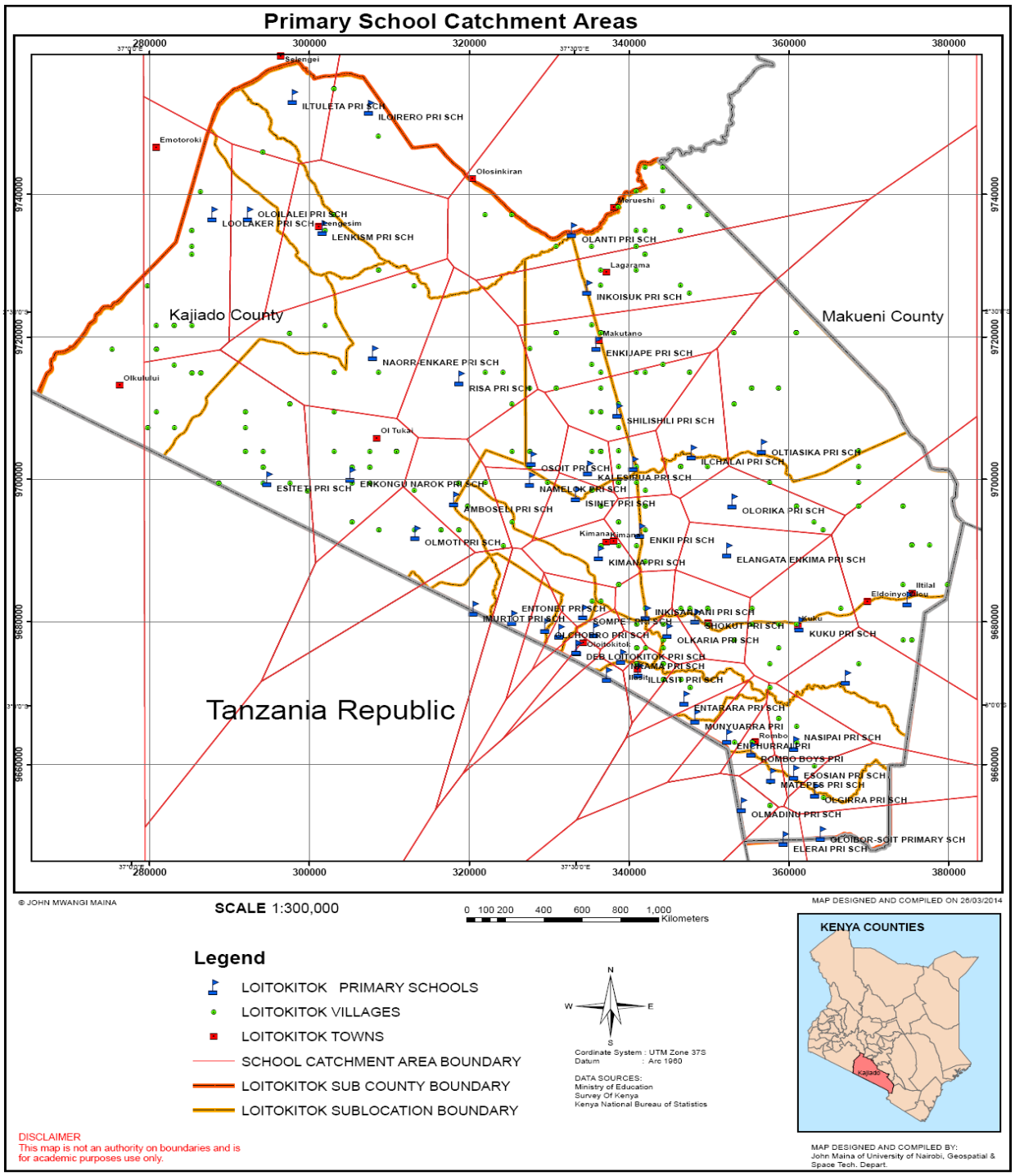
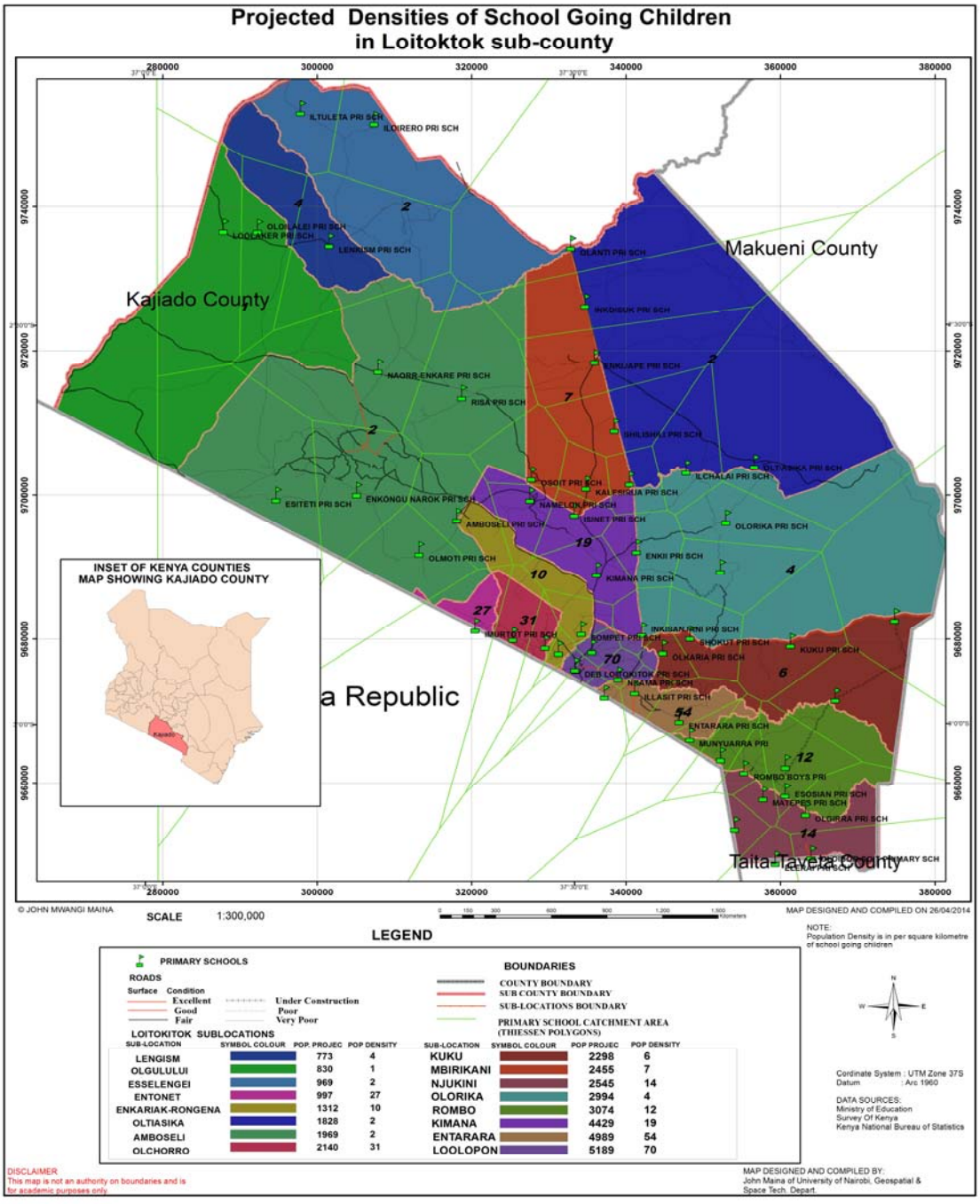


Figure 4.4: School catchment areas

4.5 Projected Population Densities

Figure 4.5 is a spatial representation of the Projected Population Densities of school going children in Loitokitok Sub County while table 4.1shows the projected potential population in the catchment area as derived from the analysis. The densities are presented as number of school going children per square Kilometre.



SUB-LOCATION	SYMBOL COLOUR	POP. PROJEC	POP DENSITY	SUB-LOCATION	SYMBOL COLOUR	POP PROJEC	POP DENSITY
LENGISM		773	4	KUKU		2298	6
OLGULULUI		830	1	MBIRIKANI		2455	7
ESSELENGEI		969	2	NJUKINI		2545	14
ENTONET		997	27	OLORIKA		2994	4
ENKARIAK-RONGENA		1312	10	ROMBO		3074	12
OLTIASIKA		1828	2	KIMANA		4429	19
AMBOSELI		1969	2	ENTARARA		4989	54
OLCHORRO		2140	31	LOOLOPON		5189	70

Figure 4.5: Projected Population Densities

Table 4.1: Projected Population of school going children within the school catchment area

No	NAME OF SCHOOL	POTENTIAL POPULATION
1	DEB LOITOKITOK PRI SCH	375
2	KALESIRUA PRI SCH	313
3	INKISANJANI PRI SCH	941
4	NKAMA PRI SCH	1304
5	ENCHURRAI PRI	641
6	NAMELOK PRI SCH	1064
7	OLTIASIKA PRI SCH	1222
8	CHIEF OLE MUTURY PRI SCH	1268
9	ENKONGU NAROK PRI SCH	377
10	OLGIRRA PRI SCH	1190
11	ENTONET PRI SCH	1286
12	AIC LOITOKITOK PRI SCH	593
13	ENTARARA PRI SCH	2383
14	KUKU PRI SCH	871
15	ENKII PRI SCH	735
16	ILTILAL PRI SCH	1281
17	SHOKUT PRI SCH	418
18	INKOISUK PRI SCH	857
19	LOOLAKER PRI SCH	250
20	ESOSIAN PRI SCH	216
21	ROMBO BOYS PRI	366
22	ENKAJI NAIBOR PRI SCH	365
23	KIMANA PRI SCH	1371
24	OLORIKA PRI SCH	452
25	ENKIJAPE PRI SCH	882
26	ILLASIT PRI SCH	1455
27	AMBOSELI PRI SCH	690
28	OSOIT PRI SCH	567
29	KIKELELWA PRI SCH	575
30	OLOIBOR-SOIT PRIMARY SCH	663
31	ENKARIAK RONKENA PRI	145
32	IMURTOT PRI SCH	1170
33	ILCHALAI PRI SCH	289
34	OYARATA PRIMARY SCHOOL	1378
35	SHILISHILI PRI SCH	543
36	LENKISM PRI SCH	778
37	ILTULETA PRI SCH	407
38	ISINET PRI SCH	904
39	OLCHORRO PRI SCH	650
40	RISA PRI SCH	532
41	ILOIRERO PRI SCH	299
42	OLANTI PRI SCH	571
43	ELERAI PRI SCH	331
44	ESITETI PRI SCH	593
45	NASIPAI PRI SCH	912
46	SOMPET PRI SCH	688
47	OLMOTI PRI SCH	279
48	NAORR-ENKARE PRI SCH	637
49	ELANGATA ENKIMA PRI SCH	489
50	MUNYUARRA PRI	929
51	OLOILALEI PRI SCH	303
52	OLKARIA PRI SCH	536
53	MATEPES PRI SCH	325

4.6 Physical Access and school enrolment

Table 4.2 shows the distance from school to nearest road, surface type, condition and enrolment.

Table 4.2: Physical access and primary school enrolment

Name of School	Nearest Road Distance to school (m)	Road surface Type	Road surface condition	Projected potential Population	Actual Enrolment
AIC LOITOKITOK PRI SCH	87.7	Earth	Poor	593	872
AMBOSELI PRI SCH	244.8	Earth	Poor	690	325
CHIEF OLE MUTURY PRI SCH	57.4	Earth	Poor	1268	551
DEB LOITOKITOK PRI SCH	17.6	Earth	Poor	375	850
ELANGATA ENKIMA PRI SCH	907.8	Earth	Poor	489	854
ELERAI PRI SCH	544.4	Gravel	Poor	331	385
ENCHURRAI PRI	51.9	Earth	Poor	641	450
ENKAJI NAIBOR PRI SCH	185.0	Earth	Poor	365	360
ENKARIAK RONKENA PRI	284.6	Earth	Poor	145	417
ENKII PRI SCH	102.4	Earth	Poor	735	435
ENKIJAPE PRI SCH	211.6	Gravel	Fair	882	580
ENKONGU NAROK PRI SCH	58.7	Gravel	Poor	377	428
ENTARARA PRI SCH	96.9	Earth	Fair	2383	1509
ENTONET PRI SCH	65.8	Earth	Poor	1286	1176
ESITETI PRI SCH	565.5	Earth	Poor	593	348
ESOSIAN PRI SCH	163.1	Gravel	Poor	216	438
ILCHALAI PRI SCH	296.1	Earth	Poor	289	330
ILLASIT PRI SCH	232.9	Earth	Poor	1455	1590
ILOIRERO PRI SCH	519.2	Earth	Poor	299	282
ILTILAL PRI SCH	149.2	Gravel	Good	1281	643
ILTULETA PRI SCH	322.2	Earth	Poor	407	105
IMURTOT PRI SCH	288.8	Earth	Very Poor	1170	622
INKISANJANI PRI SCH	31.4	Earth	Poor	941	1019
INKOISUK PRI SCH	161.7	Gravel	Fair	857	250
ISINET PRI SCH	384.8	Earth	Poor	904	886
KALESIRUA PRI SCH	24.2	Gravel	Fair	313	710
KIKELELWA PRI SCH	269.0	Earth	Poor	575	1169
KIMANA PRI SCH	187.4	Earth	Poor	1371	1208
KUKU PRI SCH	98.7	Gravel	Good	871	380
LENKISM PRI SCH	320.4	Earth	Poor	778	419
LOOLAKER PRI SCH	162.5	Earth	Fair	250	336
MATEPES PRI SCH	1982.2	Gravel	Poor	325	762
MUNYUARRA PRI	997.7	Gravel	Poor	929	493
NAMELOK PRI SCH	52.4	Earth	Fair	1064	702
NAORR-ENKARE PRI SCH	877.9	Earth	Fair	637	75
NASIPAI PRI SCH	684.1	Earth	Construction	912	246
NKAMA PRI SCH	49.7	Earth	Poor	1304	1300
OLANTI PRI SCH	519.8	Gravel	Fair	571	200
OLCHORRO PRI SCH	385.1	Earth	Poor	650	1214
OLGIRRA PRI SCH	60.4	Gravel	Poor	1190	270
OLKARIA PRI SCH	1762.7	Gravel	Good	536	485
OLMOTI PRI SCH	839.3	Earth	Poor	279	336
OLOIBOR-SOIT PRIMARY SCH	277.6	Gravel	Good	663	283
OLOILALEI PRI SCH	1568.9	Earth	Fair	303	144
OLORIKA PRI SCH	196.2	Earth	Poor	452	420
OLTIASIKA PRI SCH	57.2	Earth	Fair	1222	310
OSOIT PRI SCH	264.9	Earth	Fair	567	298
OYARATA PRIMARY SCHOOL	300.7	Earth	Construction	1378	286
RISA PRI SCH	439.1	Earth	Poor	532	140
ROMBO BOYS PRI	167.3	Gravel	Excellent	366	900
SHILISHILI PRI SCH	313.7	Earth	Poor	543	228
SHOKUT PRI SCH	152.8	Gravel	Good	418	450
SOMPET PRI SCH	710.1	Earth	Poor	688	300

4.7 Derivation of access factors

Table 4.3 shows the school access factors derived from product of multiplying the road surface code and distance from school to nearest road. The higher the access factor the poorer the physical access to the school.

Table 4.3: School access factors

Name of School	School Type	Lat	Long	Nearest Road Distance to School (m)	Road surface Type	Road surface Condition	Road surface Condition CODE	Projected potential Population	Difference	Actual Enrolment	Access Factor
ROMBO BOYS PRI	MIXED	-3.05873	37.69956	167.3	Gravel	Excellent	1	366	534	900	167
OLTIASIKA PRI SCH	MIXED	-2.67483	37.71204	57.2	Earth	Fair	3	1222	-912	310	172
ENTARARA PRI SCH	MIXED	-2.99417	37.6242	96.9	Earth	Fair	3	2383	-874	1509	291
INKOISUK PRI SCH	MIXED	-2.47246	37.51528	161.7	Gravel	Fair	3	857	-607	250	485
NAORR-ENKARE PRI SCH	MIXED	-2.55505	37.27417	877.9	Earth	Fair	3	637	-562	75	2634
OLANTI PRI SCH	MIXED	-2.39956	37.49847	519.8	Gravel	Fair	3	571	-371	200	1559
NAMELOK PRI SCH	MIXED	-2.71621	37.45087	52.4	Earth	Fair	3	1064	-362	702	157
ENKIJAPE PRI SCH	MIXED	-2.54344	37.526	211.6	Gravel	Fair	3	882	-302	580	635
OSOIT PRI SCH	MIXED	-2.68984	37.45245	264.9	Earth	Fair	3	567	-269	298	795
OLOILALEI PRI SCH	MIXED	-2.37912	37.13408	1568.9	Earth	Fair	3	303	-159	144	4707
LOOLAKER PRI SCH	MIXED	-2.37855	37.09403	162.5	Earth	Fair	3	250	86	336	487
KALESIRUA PRI SCH	MIXED	-2.70174	37.51603	24.2	Gravel	Fair	3	313	397	710	73
ILTILAL PRI SCH	MIXED	-2.8681	37.87528	149.2	Gravel	Good	2	1281	-638	643	298
KUKU PRI SCH	MIXED	-2.89968	37.75411	98.7	Gravel	Good	2	871	-491	380	197
OLOIBOR-SOIT PRIMARY SCH	MIXED	-3.16595	37.77758	277.6	Gravel	Good	2	663	-380	283	555
OLKARIA PRI SCH	MIXED	-2.908	37.60528	1762.7	Gravel	Good	2	536	-51	485	3525
SHOKUT PRI SCH	MIXED	-2.89014	37.63684	152.8	Gravel	Good	2	418	32	450	306
OLGIRRA PRI SCH	MIXED	-3.11091	37.77142	60.4	Gravel	Poor	5	1190	-920	270	302
CHIEF OLE MUTURY PRI SCH	MIXED	-2.90707	37.52267	57.4	Earth	Poor	5	1268	-717	551	287
MUNYUARRA PRI	MIXED	-3.01724	37.63641	997.7	Gravel	Poor	5	929	-436	493	4989
RISA PRI SCH	MIXED	-2.58766	37.37154	439.1	Earth	Poor	5	532	-392	140	2195
SOMPET PRI SCH	MIXED	-2.88422	37.51036	710.1	Earth	Poor	5	688	-388	300	3550
AMBOSELI PRI SCH	MIXED	-2.74112	37.36542	244.8	Earth	Poor	5	690	-365	325	1224
LENKISM PRI SCH	MIXED	-2.39608	37.21746	320.4	Earth	Poor	5	778	-359	419	1602
SHILISHILI PRI SCH	MIXED	-2.62909	37.54908	313.7	Earth	Poor	5	543	-315	228	1568
ILTULETA PRI SCH	MIXED	-2.23001	37.18419	322.2	Earth	Poor	5	407	-302	105	1611
ENKII PRI SCH	MIXED	-2.78068	37.57462	102.4	Earth	Poor	5	735	-300	435	512
ESITETI PRI SCH	MIXED	-2.715196	37.15488	565.5	Earth	Poor	5	593	-245	348	2827
ENCHURRAI PRI	MIXED	-3.04287	37.67236	51.9	Earth	Poor	5	641	-191	450	259
KIMANA PRI SCH	MIXED	-2.80967	37.52834	187.4	Earth	Poor	5	1371	-163	1208	937
ENTONET PRI SCH	MIXED	-2.89139	37.43049	65.8	Earth	Poor	5	1286	-110	1176	329
OLORIKA PRI SCH	MIXED	-2.7439	37.6788	196.2	Earth	Poor	5	452	-32	420	981
ISINET PRI SCH	MIXED	-2.73468	37.5024	384.8	Earth	Poor	5	904	-18	886	1924
ILOIRERO PRI SCH	MIXED	-2.24375	37.26998	519.2	Earth	Poor	5	299	-17	282	2596
ENKAJI NAIBOR PRI SCH	MIXED	-2.69623	37.56679	185.0	Earth	Poor	5	365	-5	360	925
NKAMA PRI SCH	MIXED	-2.94063	37.55292	49.7	Earth	Poor	5	1304	-4	1300	248
ILCHALAI PRI SCH	MIXED	-2.68173	37.6326	296.1	Earth	Poor	5	289	41	330	1480
ENKONGU NAROK PRI SCH	MIXED	-2.70921	37.2489	58.7	Gravel	Poor	5	377	51	428	294
ELERAI PRI SCH	MIXED	-3.17259	37.73584	544.4	Gravel	Poor	5	331	54	385	2722
OLMOTI PRI SCH	MIXED	-2.78352	37.32164	839.3	Earth	Poor	5	279	57	336	4197
INKISANJANI PRI SCH	MIXED	-2.88543	37.58066	31.4	Earth	Poor	5	941	78	1019	157
ILLASIT PRI SCH	MIXED	-2.9584	37.57254	232.9	Earth	Poor	5	1455	135	1590	1165
ESOSIAN PRI SCH	MIXED	-3.08791	37.74766	163.1	Gravel	Poor	5	216	222	438	816
AIC LOITOKITOK PRI SCH	MIXED	-2.92959	37.50385	87.7	Earth	Poor	5	593	279	872	439
ENKARIAK RONKENA PRI	MIXED	-2.90853	37.4836	284.6	Earth	Poor	5	145	272	417	1423
ELANGATA ENKIMA PRI SCH	MIXED	-2.80615	37.67245	907.8	Earth	Poor	5	489	365	854	4539
MATEPES PRI SCH	MIXED	-3.09185	37.72177	1982.2	Gravel	Poor	5	325	437	762	9911
DEB LOITOKITOK PRI SCH	MIXED	-2.92889	37.50289	17.6	Earth	Poor	5	375	475	850	88
OLCHORRO PRI SCH	MIXED	-2.9015	37.46793	385.1	Earth	Poor	5	650	564	1214	1926
KIKELELWA PRI SCH	MIXED	-2.96373	37.53698	269.0	Earth	Poor	5	575	594	1169	1345
OYARATA PRIMARY SCHOOL	MIXED	-2.9678	37.80616	300.7	Earth	Under Construction	4	1378	-1092	286	1203
NASIPAI PRI SCH	MIXED	-3.05192	37.74794	684.1	Earth	Under Construction	4	912	-666	246	2736
IMURTOT PRI SCH	MIXED	-2.8799	37.3868	288.8	Earth	Very Poor	6	1170	-548	622	1733

4.8 Scatter plots for enrolments and nearest distance to roads

Figures 4.6, 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12 show different scatter plots used to determine the relationship between enrolment and physical access. Figure 4.6 is a scatter plot of the enrolment difference against the nearest distance from school to nearest road for roads with good surface conditions. Figure 4.7 is a scatter plot for the enrolment difference against nearest distance from school to roads for fair roads while figure 4.8 is a similar scatter plot for poor roads. Figure 4.9 is a scatter plot of the actual enrolment against the nearest distance from school to nearest road for roads with good surface conditions. Figure 4.10 is a scatter plot for the actual enrolment against nearest distance from school to roads for fair roads while figure 4.11 is a similar scatter plot for poor roads. Figure 4.12 shows a scatter plot for the actual school enrolment against nearest distance from school to nearest road for all roads irrespective of surface condition. A linear regression was used for ease of analysis.

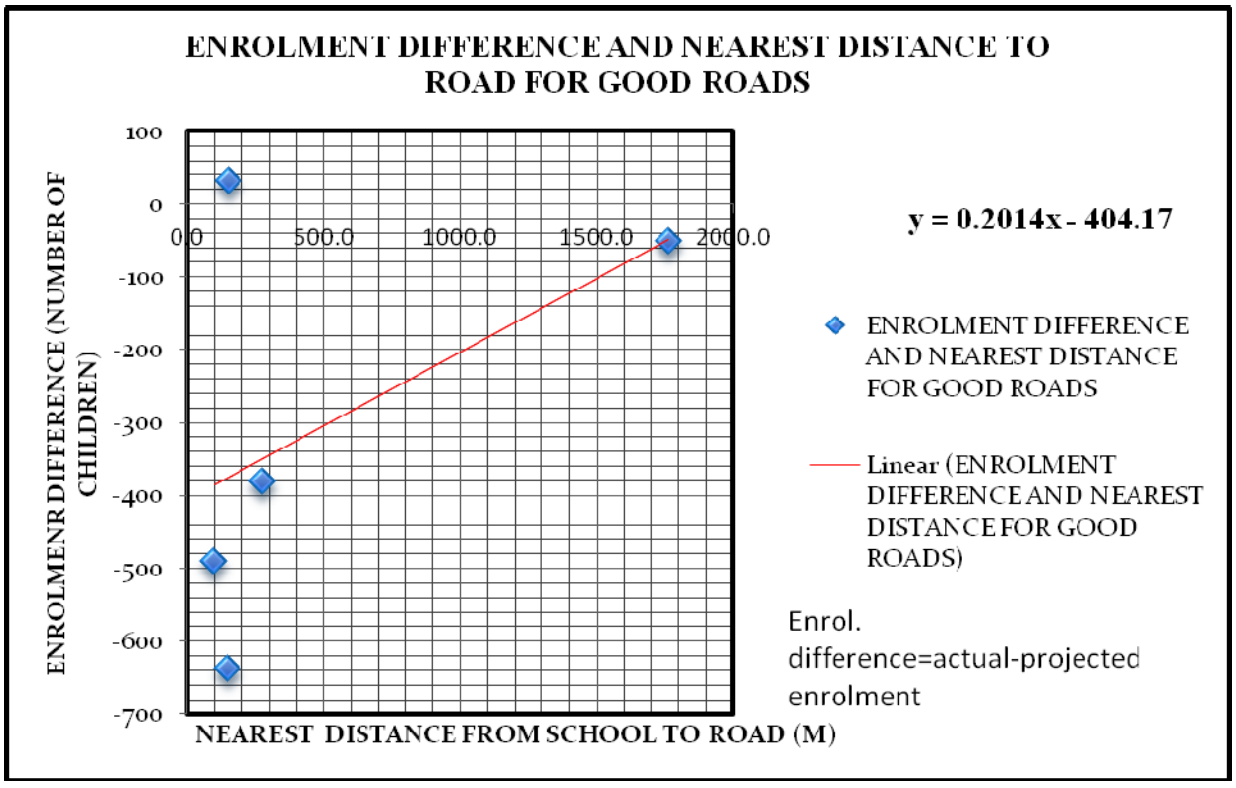


Figure 4.6: Scatter plot for enrolment difference and nearest distance for good roads

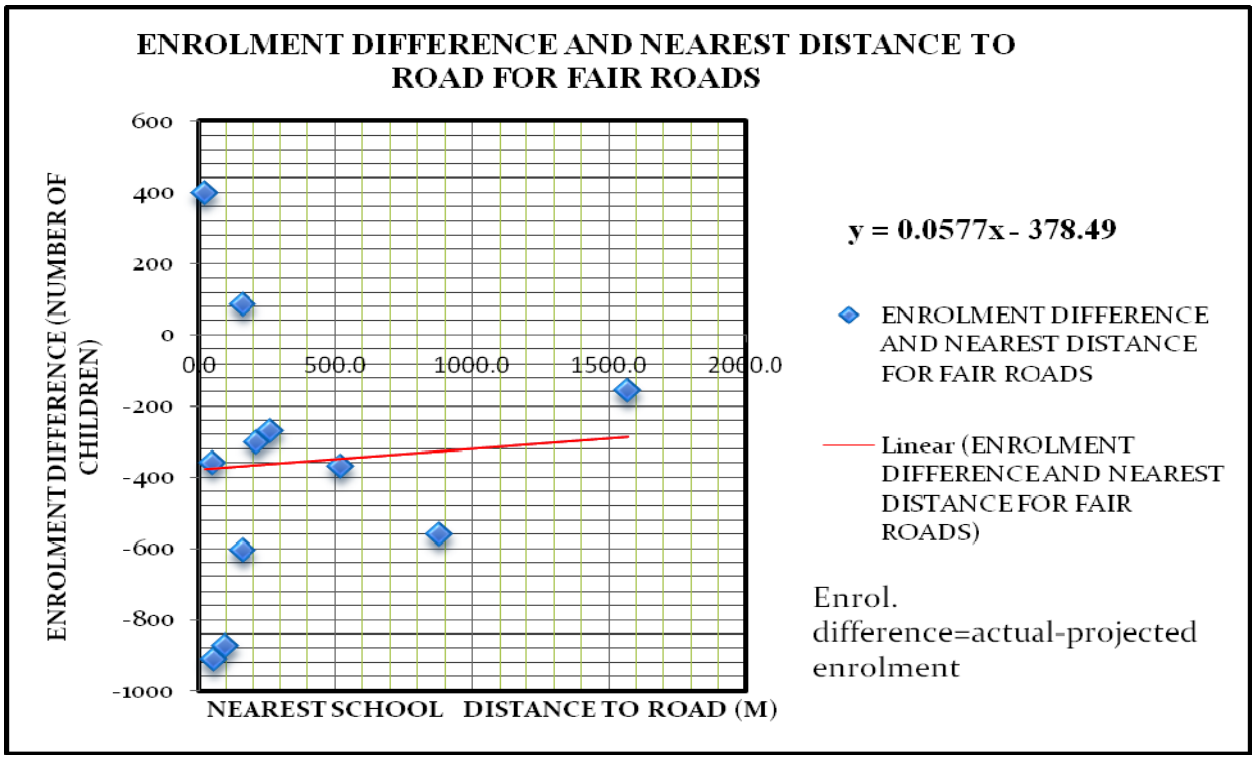


Figure 4.7: Scatter plot for enrolment difference and nearest distance for fair roads.

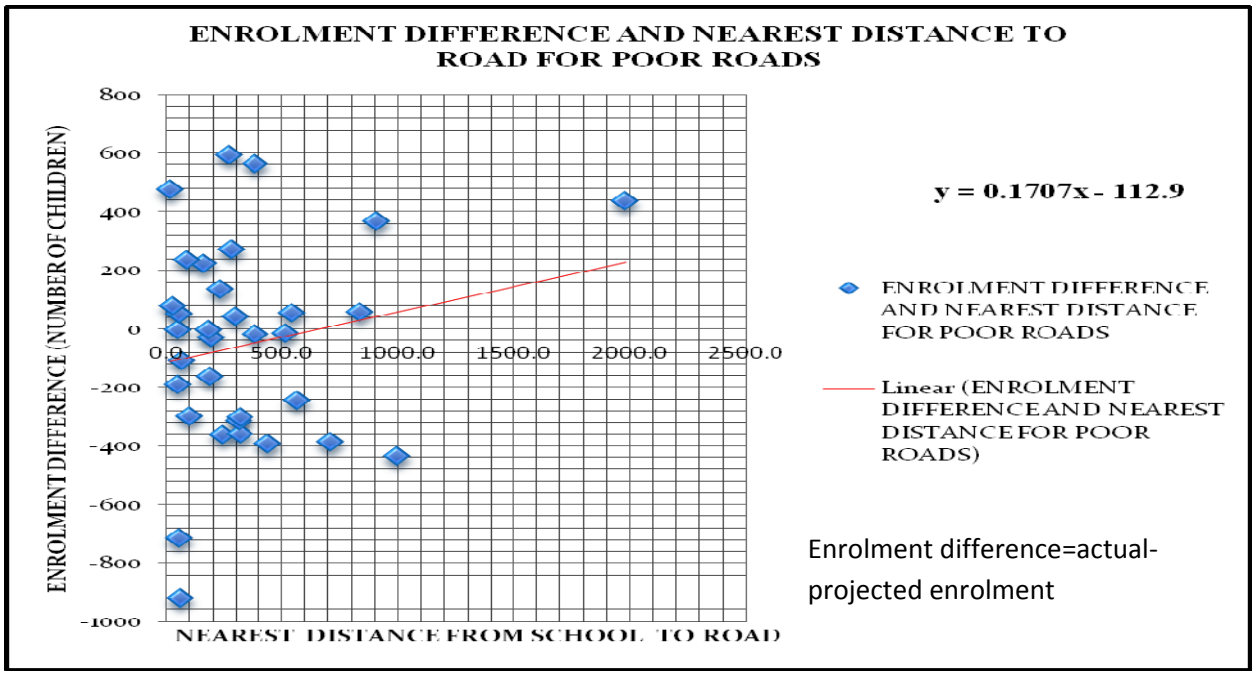


Figure 4.8: Scatter plot for enrolment difference and nearest distance for poor roads.

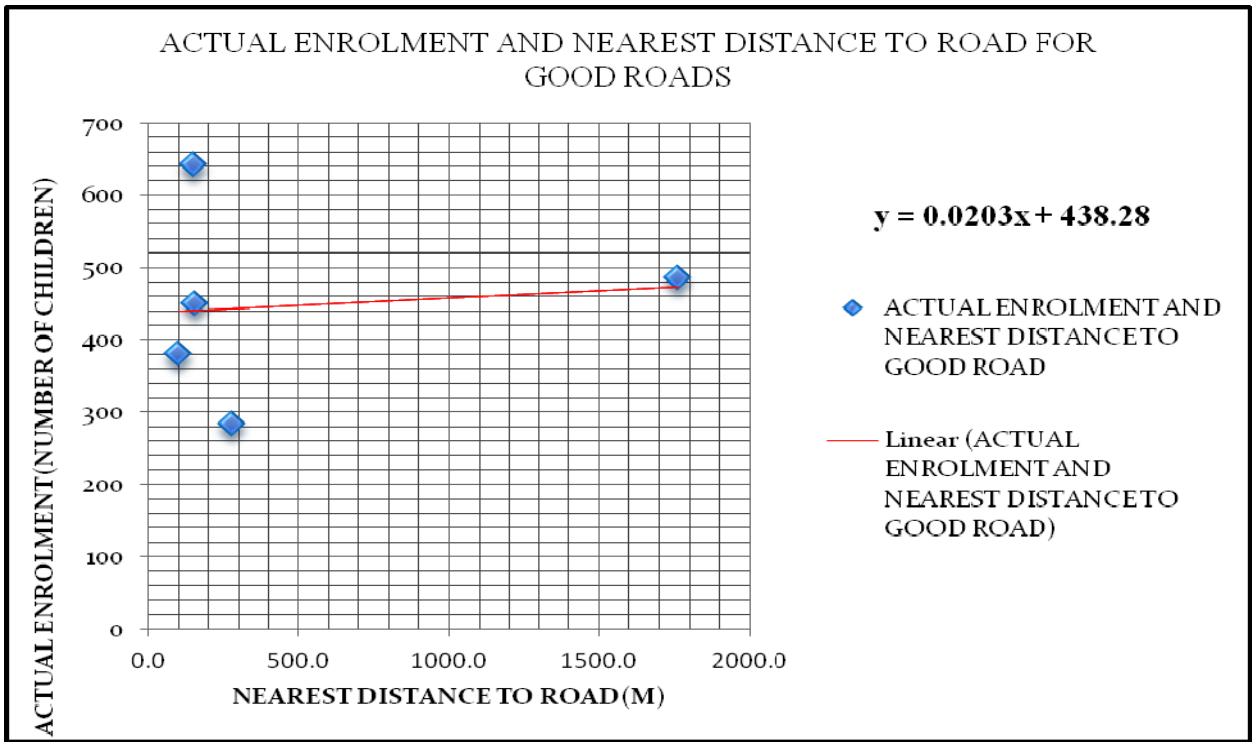


Figure 4.9: Scatter plot for actual enrolment and nearest distance for good roads.

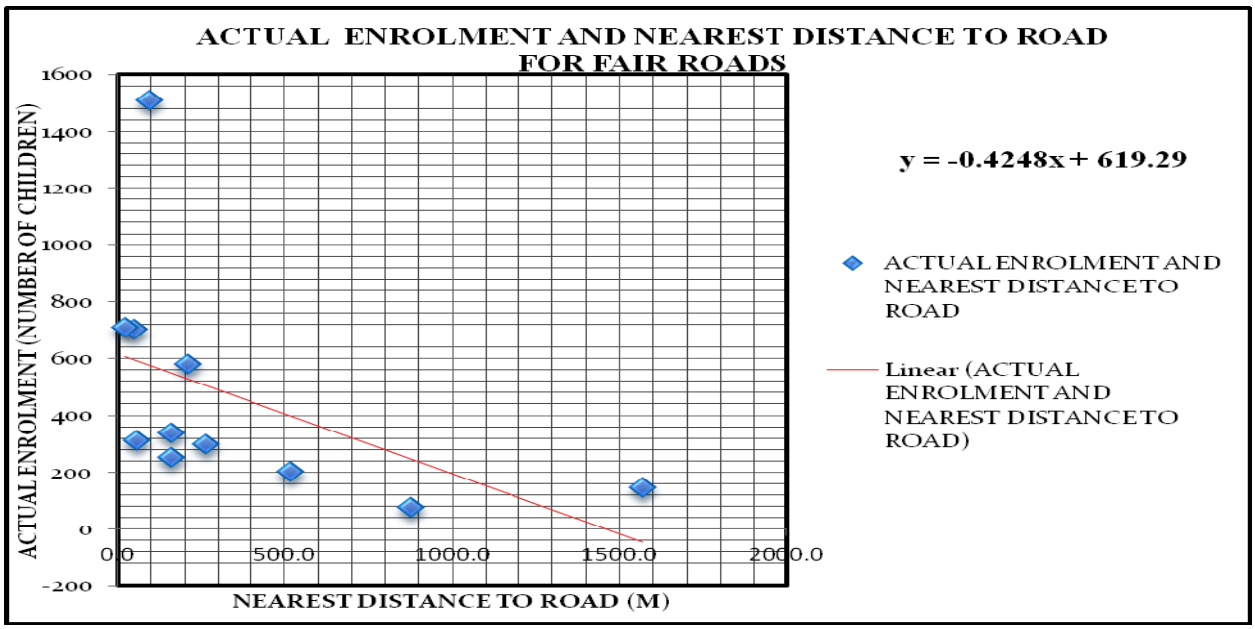


Figure 4.10: Scatter plot for actual enrolment and nearest distance for fair roads.

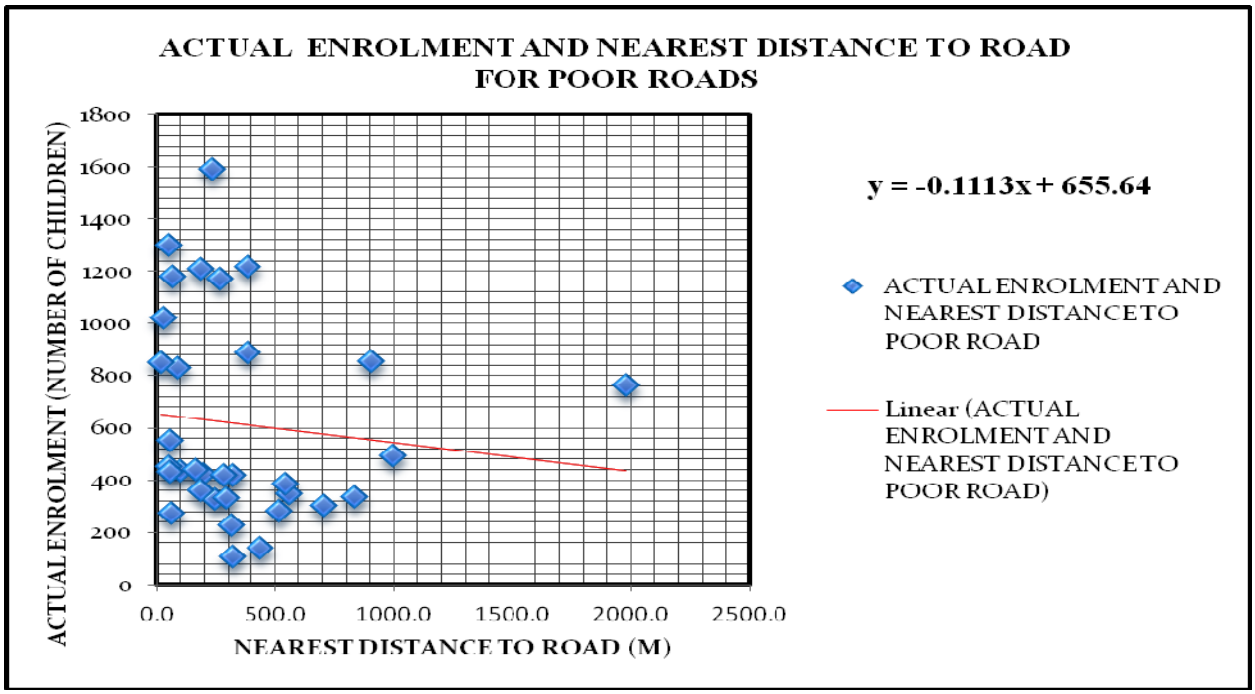


Figure 4.11: Scatter plot for actual enrolment and nearest distance for poor roads.

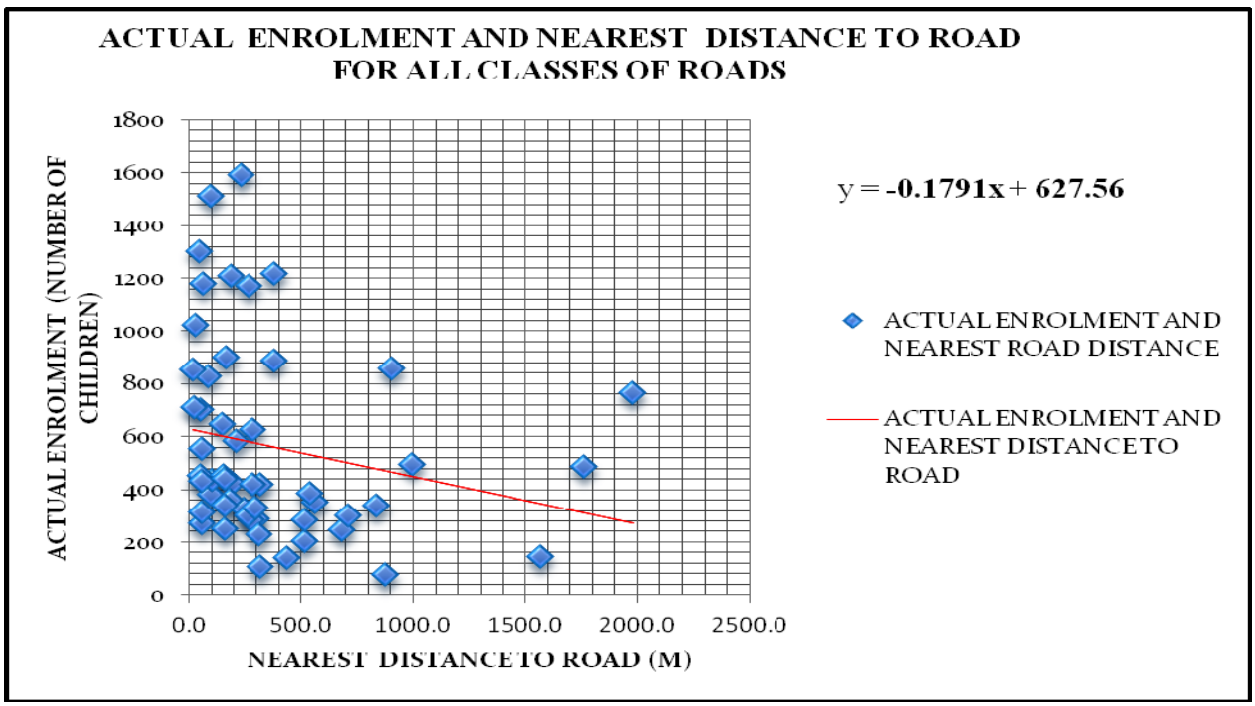


Figure 4.12: Scatter plot for actual enrolment and nearest distances to road for all schools.

4.9 Discussion of results

From the data collected and the results obtained, the following deductions are made:

- The results indicate that majority of roads nearest to schools are of poor surface condition; 32 out of the 53 sampled schools reveal this trend.

- There exists a weak relationship between the differences in actual and projected school enrolment and the proximity of schools to roads as depicted by the scatter plots. This difference increases with increased distance of schools from roads.

- The actual enrolment of school children decreases with increased distance from school to nearest road for roads with fair and poor surface conditions. This trend is slightly different for the roads with good surface conditions. This is revealed from the regression equations representing the relationships, $y=-0.11x+655$ for poor roads and $y=-0.43x+619$ for fair roads where the value for the rate of change of actual enrolment is negative while the rate of change has a positive value of 0.02 for good roads as per the regression equation $y=0.02x+438$ .This could be attributed to other factors influencing access to education. Transport to and from school in areas covered by good roads could be by vehicular carriage and therefore there could be a reliable public means of transport. For schools near good access roads, the other factors influencing access to education such as education facilities, safety, health, settlement patterns could explain the shift in trend.

- The spatial location of schools indicates that some schools are located far from roads. This implies that there are other factors affecting access to school other than the physical access, such as settlement patterns, environmental conditions, political and social factors.

- The actual enrolments in most of the schools are lower than the projected enrolments. High enrolments are also realised for schools near poor and fair roads. This could be attributed to other factors affecting school access such as household conditions, educational facilities, social cultural practices, settlement patterns and environmental factors.

- The results reveal a weak relationship between physical access and access to education and therefore not sufficiently reliable to make policy decisions before further research.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main objective of this project was to demonstrate the use of GIS in determining the relationship between physical access and primary school enrolment. This has been achieved and it is concluded that

- Access to education as indicated by school enrolments has a direct relationship with the physical access as measured by the proximity of schools to roads.
- The further the school is from the road the lower the enrolments.
- Distance increases the opportunity cost of schooling children and leads to an increase in the enrolment gap between the various schools in the area.
- Increasing the network of roads to reduce the minimum distance from school to road will increase the chances of school children accessing education.

5.2 Recommendations

From the study, it is recommended as follows:

- The network of roads serving schools should be increased to enhance access to education

- Further studies should be carried out on the effects of the other factors influencing access to education such as social-cultural practices, gender and institutional factors to further enrich the body of knowledge.

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APPENDICES

Appendix A: Public Primary School Locations in Loitokitok Sub-County .

Coordinates referred to WGS 1984.

No	NAME OF SCHOOL	SCHOOL TYPE	LATITUDE	LONGITUDE
1	DEB LOITOKITOK PRI SCH	MIXED	-2.92889	37.50289
2	KALESIRUA PRI SCH	MIXED	-2.70174	37.51603
3	INKISANJANI PRI SCH	MIXED	-2.88543	37.58066
4	NKAMA PRI SCH	MIXED	-2.94063	37.55292
5	ENCHURRAI PRI	MIXED	-3.04287	37.67236
6	NAMELOK PRI SCH	MIXED	-2.71621	37.45087
7	OLTIASIKA PRI SCH	MIXED	-2.67483	37.71204
8	CHIEF OLE MUTURY PRI SCH	MIXED	-2.90707	37.52267
9	ENKONGU NAROK PRI SCH	MIXED	-2.70921	37.2489
10	OLGIRRA PRI SCH	MIXED	-3.11091	37.77142
11	ENTONET PRI SCH	MIXED	-2.89139	37.43049
12	AIC LOITOKITOK PRI SCH	MIXED	-2.92959	37.50385
13	ENTARARA PRI SCH	MIXED	-2.99417	37.6242
14	KUKU PRI SCH	MIXED	-2.89968	37.75411
15	ENKII PRI SCH	MIXED	-2.78068	37.57462
16	ILTILAL PRI SCH	MIXED	-2.8681	37.87528
17	SHOKUT PRI SCH	MIXED	-2.89014	37.63684
18	INKOISUK PRI SCH	MIXED	-2.47246	37.51528
19	LOOLAKER PRI SCH	MIXED	-2.37855	37.09403
20	ESOSIAN PRI SCH	MIXED	-3.08791	37.74766
21	ROMBO BOYS PRI	MIXED	-3.05873	37.69956
22	ENKAJI NAIBOR PRI SCH	MIXED	-2.69623	37.56679
23	KIMANA PRI SCH	MIXED	-2.80967	37.52834
24	OLORIKA PRI SCH	MIXED	-2.7439	37.6788
25	ENKIJAPE PRI SCH	MIXED	-2.54344	37.526
26	ILLASIT PRI SCH	MIXED	-2.9584	37.57254
27	AMBOSELI PRI SCH	MIXED	-2.74112	37.36542
28	OSOIT PRI SCH	MIXED	-2.68984	37.45245
29	KIKELELWA PRI SCH	MIXED	-2.96373	37.53698
30	OLOIBOR-SOIT PRIMARY SCH	MIXED	-3.16595	37.77758
31	ENKARIAK RONKENA PRI	MIXED	-2.90853	37.4836
32	IMURTOT PRI SCH	MIXED	-2.8799	37.3868
33	ILCHALAI PRI SCH	MIXED	-2.68173	37.6326
34	OYARATA PRIMARY SCHOOL	MIXED	-2.9678	37.80616
35	SHILISHILI PRI SCH	MIXED	-2.62909	37.54908
36	LENKISM PRI SCH	MIXED	-2.39608	37.21746
37	ILTULETA PRI SCH	MIXED	-2.23001	37.18419
38	ISINET PRI SCH	MIXED	-2.73468	37.5024
39	OLCHORRO PRI SCH	MIXED	-2.9015	37.46793
40	RISA PRI SCH	MIXED	-2.58766	37.37154
41	ILOIRERO PRI SCH	MIXED	-2.24375	37.26998
42	OLANTI PRI SCH	MIXED	-2.39956	37.49847
43	ELERAI PRI SCH	MIXED	-3.17259	37.73584
44	ESITETI PRI SCH	MIXED	-2.715196	37.154884
45	NASIPAI PRI SCH	MIXED	-3.05192	37.74794
46	SOMPET PRI SCH	MIXED	-2.88422	37.51036
47	OLMOTI PRI SCH	MIXED	-2.78352	37.32164
48	NAORR-ENKARE PRI SCH	MIXED	-2.55505	37.27417
49	ELANGATA ENKIMA PRI SCH	MIXED	-2.80615	37.67245
50	MUNYUARRA PRI	MIXED	-3.01724	37.63641
51	OLOILALEI PRI SCH	MIXED	-2.37912	37.13408
52	OLKARIA PRI SCH	MIXED	-2.908	37.60528
53	MATEPES PRI SCH	MIXED	-3.09185	37.72177