EVALUATION OF THE LOCATION OF ELEMENTARY SCHOOL SITES USING INTEGRATED GEOSPATIAL TECHNOLOGIES: A CASE STUDY OF DEBRE BIRHAN TOWN, ETHIOPIA

Mulualem H/giorgis Agonafir

A Thesis submitted to the department of Geomatics Engineering
School of Civil engineering and Architect.
Presented in partial Fulfillment of the Requirement for the Degree of
Master's in Geoinformatics.

Office of Graduate studies
Adama Science and Technology University

Jun, 2023
Adama, Ethiopia

EVALUATION OF THE LOCATION OF ELEMENTARY SCHOOL SITES USING INTEGRATED GEOSPATIAL TECHNOLOGIES: A CASE STUDY OF DEBRE BIRHAN TOWN, ETHIOPIA

Mulualem H/giorgis Agonafir

Advisor Dr. Roba Gemechu

A Thesis submitted to the department of Geomatics Engineering
School of Civil engineering and Architect
Presented in partial Fulfillment of the Requirement for the Degree of Master's in Geoinformatics.

Office of Graduate studies
Adama Science and Technology University

Jun, 2023
Adama, Ethiopia

Approval Sheet

I/we, the advisors of the thesis entitled **"Evaluation of the Location of Elementary School Sites Using Integrated Geospatial Technologies: A Case Study of Debre Birhan Town, Ethiopia"** and developed by Mulualem H/giorgis Agonafir, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Dr. Roba Gemechu	_____	_____
Major Advisor	Signature	Date
_____	_____	_____
Co-Advisor	Signature	Date

Approval of Board of Reviewers

We, the undersigned, members of the Board of Examiners of the thesis by Mr. Mulualem H/giorgis Agonafir have read and evaluated the thesis entitled **"Evaluation of the Location of Elementary School Sites Using Integrated Geospatial Technologies: A Case Study of Debre Birhan Town, Ethiopia"** and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geoinformatics.

Chairperson	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head	Signature	Date
School Dean	Signature	Date
Office of postgraduate Studies, Dean	Signature	Date

Declaration

I hereby declare that this Master Thesis entitled **"Evaluation of the Location of Elementary School Sites Using Integrated Geospatial Technologies: A Case Study of Debre Birhan Town, Ethiopia"** is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation

Mulualem H/giorgis Agonafir	_____	_____
Name of student	Signature	Date

Recommendation

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled **"Evaluation of the Location of Elementary School Sites Using Integrated Geospatial Technologies: A Case Study of Debre Birhan Town, Ethiopia"** prepared under my guidance by Mulualem H/giorgis Agonafir submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Geoinformatics Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Dr. Roba Gemechu	_____	_____
Major Advisor	Signature	Date
_____	_____	_____
Co-Advisor	Signature	Date

ACKNOWLEDGEMENTS

First and foremost, I would like to thank the Almighty God, who gave me the commitment and strength to pass various obstacles and complete this research thesis. I would like to express my sincere gratitude to my advisor Dr. Roba Gemechu for his patient guidance, enthusiastic encouragement and useful critiques of this thesis work.

Last but not the least; I would like to thank my family and friends for their valuable support, constrictive recommendation and encouragement throughout my study.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

ACRONYMS

AHP	Analytical Hierarchy Process
CAD	Computer aided design
CSA	Central Statistical Agency
DB	Debre Birhan
DEM	Digital Elevation Model
DGPS	Differential Global positioning Systems
ERDAS	Earth Resources Data Analysis System
GCP	Ground control point
GNSS	(Global Navigation Satellite System)
KML	Keyhole markup language
LULC	Land use land cover
MOE	Ministry of Education
GIS	Geographic Information System
MCDM	Multi-Criteria Decision Making
RS	Remote sensing
RTK	Real-Time Kinematic
SGO	South Geomatics Office
SP	Structure plan
SPSS	Statistical package for social sciences
UTM	Universal Transverse Mercator

ABSTRACT

Though Site Suitability Analysis for Educational Sites of Primary school is a naturally complex multi-dimensional process, that involving multiple criteria and actors. One of the most important fields that contributes to building the future, achieving the renaissance, and general progress is education. Schools in strategic locations are critical for play an important role in improving students' performance and excellence. Debre Birhan schools placement and distribution are inappropriate some schools are located close to a major road and others is close to hazards, students are exposed to road noise, air pollution, and car accidents as they enter and leave the school and Various dangers, like high-voltage electric power and gas stations, are close to other schools. This thesis is to investigate suitability of the current elementary school locations and proposed new suitable primary school site in Debre Birhan town by using integration of geospatial technologies evaluation methods. The study use literature review and schools directors, geospatial experts and educational officers to identify criteria, pairwise comparison method is systematic way use the study to select the best available alternatives based on different opinions. However, geospatial technology software integrated with Analytical Hierarchy Process (AHP) provide more reliable, flexible and accurate information to the decision making by evaluating the criteria and factors for performing identify new suitable area for elementary schools and to evaluate the existing sites of elementary schools of Debre Birhan. This study is develop a environmentally, safety, and accessibly suitable sites selection category approach for primary school site selection using integration of geospatial technology based on multi criteria evaluation, AHP. Using ArcGIS modelbuilder, a model was created to analyze the final suitability map, evaluate the suitability of the current schools, and provide a map for each criterion. Elementary schools suitability analysis of the area indicates that only 6.05% of the area has more suitability condition. The remaining 63.4%, and 0.8% of the area are Suitable and less suitable for elementary school The Debre Birhan Education Bureau is thought to benefit most from this research. The study will help the Debre Birhan Urban Land Management Office, and the Debre Birhan Plan Implementation Office make decisions about the locations of the current schools and propose or construct new ones in the future the thesis recommended to improve the teaching and learning environment in schools, regulations should be created criteria and implemented.

Key Words: Geographic Information System, Analytical Hierarchy Process.

CHAPTER ONE

1. INTRODUCTION

1.1 Background

The number of educated people in the globe today is one of the indications of a civilized society or nation, especially African nations particularly focused on the learning process. However, the excellent learning outcomes that educational systems often seek take place in surroundings that are conducive to learning. The performance and excellence of pupils are greatly improved when schools are situated in strategic and secure areas. Ethiopia as one of the developing countries, the country schools location is either in city or rural area are not safe for students and learning process, because of not located using integration of geospatial technologies multi criteria analysis methods. According to Federal democratic republic of Ethiopia ministry of education statistics annual abstract the total number of primary schools in Ethiopia is 37,750 in 2019/20 and schools in amhara region is 9080.

Primary Education in Ethiopia consists of 8 grades, implemented in two cycles: Primary 1st cycle (Grades 1-4), and Primary 2nd cycle (Grades 5-8). The official primary school age is 7 – 14 years old. Since the introduction of Education Policy in 1994, government has steadily increased its share of primary education through the construction of new schools, availing facilities in schools and carrying out inspection among others. For this reason, the greatest numbers of learners have been absorbed in primary schools compared to any other level of education. Primary Education acts as a bench mark for other proceeding education levels of education and thus takes the largest share of government spending on education in Ethiopia. (MOE, 2020)

Schools location found in Debre Birhan town are not selected by developing criteria and integration of geospatial analysis technologies. Today, site selection and land appropriateness are processed by the development of integration Geospatial technology software and sophisticated computer technology. Land suitability study, broadly interpreted, tries to determine the most suitable spatial pattern for the future location of a site in accordance with specific requirements and preferences of various activities. Suitability analysis is an effective method to select appropriate site location for school development based on various selected criteria.

Therefore this research paper is intended to assess and to show in map the suitability/unsuitability of current locations of the elementary schools in Debre Birhan town using apply integrated geospatial technologies software based on multi criteria evaluation and propose new optional sites.

1.2 Problem Statement

According to the Ethiopian Ministry of Education, the ministry builds, manages, and consults both public and private primary schools throughout the nation. The ministry of education working in large to achieve universal primary education in line through the Education for All goals. Substantial improvements has been made through school construction by decreasing the distance between students living homes and schools.

The distribution and location of schools in Debre Birhan is somehow not appropriate. Some schools are situated close to the main road like atse Zeraykob elementary schools, modal number two. For that reason at entering and exiting the school students are exposed to car accident, to traffic noises and air pollution. Some schools are also exposed to different noises such as music shops, people and animals, and small and tiny factory noises etc.

Other schools are close to hazards such as high voltage electric power, gas station etc. Those problems can have negative impact on quality of education as well as safety of the students. Therefore this research paper is intended to assess and to show in map the suitability/unsuitability of current locations of the elementary schools in Debre Birhan town using integration of geospatial technology based on multi criteria evaluation and propose new suitable sites.

1.3 Objective

1.3.1 General objective

General objective of this study is to investigate suitability of the current elementary school locations and to propose optional suitable sites in Debre Birhan town by using integration of geospatial technologies.

1.3.2 Specific objective

The specific objective of this project are:

1. To evaluate the existing sites of elementary schools.
2. To identify the factors that determine appropriate site of school from Ethiopian Context and other countries.

3. To analyze appropriate site of school using the integration of Geospatial technologies.
4. To identify new suitable area for elementary schools.

1.4 Research questions

1. What are the main criteria and factors used to evaluate site of elementary school?
2. How geospatial technologies are integrated in school suitability analysis?
3. How many elementary schools are fell in moderate and above suitability level according to criteria?
4. How many new suitable area of elementary schools are fell in moderate and above suitability level according to criteria?

1.5 Significance of the Research

This research is believed to be primarily important for Debre Birhan education bureau. Besides, the project could also be applied by the bureau to other Zones and Woreda. Debre Birhan Education office, Debre Birhan urban land management office and Debre Birhan plan implementation office is also beneficiary from the study to take action on the current school locations and for future to proposed and build new schools. The thesis would also contribute other researchers that would investigate scientific methods for site suitability analysis of various social services in cities.

1.6 Scope of the Research

This research is conducted at Debre Birhan elementary schools. It mainly focuses on the identification suitability of the current elementary school locations according to criteria, analysis and process using integration of Geospatial technology.

- Identify the criteria to support determine appropriate site of school at Ethiopian and additional countries Framework.
- To sets the existing site location into suitable classes and map new suitable schools site location in Debre Birhan town.
- Show the main rule of integration of Geospatial technology play in site suitability analysis procedures.

The thesis is conducted from January-May 2015 E.C.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 General over view of school site suitability

School sites are a key factor in the educational process, and children spend most of their time at school when they are outside their homes. Schools that are well-located, designed within a systematic plan, safe, and operated in an efficient manner contribute to the development of society, (Baser, 2020).

Educational service is one of the essential public services that must be provided to residents. Where the education considers one of the most significant associated sectors with the construction of the future and the achievement of the renaissance and overall development, because of its direct links to political reality and the economic, social and cultural sectors (Waleed lagrab, 2017).

The elementary education is important at the age 7-16, this period configures the child's personality. Unquestionably, the skills and information are gained in this age.

Site selection is a complex problem that involve, technical, political social, environmental and economic demands that are difficult to satisfy via one method which may be in conflict with others. Schools need be located on safe places; these safe locations should also be optimal and economical to the public in terms of accountability (Ngigi, 2015).

Identifying a suitable site for development of an urban area is one of the most appraising task of planning. Site suitability is the technique to understand the quality of an existing site and also the factors that determine the location for an activity (Mukhopadhaya, 2016).

Schools which are located in a strategic area play an important role in improving students' performance and excellence. Generally, every student in Malaysia spends 5 to 8 hours at school (from 7.30 a.m. to 3.30 p.m.) daily. They need to attend academic classes in the morning and co-curriculum activities in the evening. They spend almost half of their age in the school environment since five or six years old (kindergarten level) until 18 years old (when almost all of them complete their secondary level) (Zubaidah Bukhari A. R., 2010).

The research begin from reviewing, exploration and assessment of guidelines used by other countries to find a complete and reliable of criteria for school site selection focusing on safe

location ,therefore not all criteria have equal important some are high significant while others less important depending on the objectives of the study (A. Hussaini, 2018).

2.2. Suitability of school location

Educational area has a characteristic educational function that supports the improvement of knowledge, physical, and morals so that students can achieve their highest goals and ideals (Harun Din Haq, 2023).

Several studies have focused on school sites issue. However, there are still lacks of research for school site selection modeling that can safeguard school children safety. This study is intended to improve the quality of the school location's decision and solution by integrating the multi-criteria decision analysis and Geographic Information System (GIS) into the decision making process (Zubaidah Bukhari A. R., 2010).

Educational services is one of the most important public services that must be provided to members of any locality, as the education sector of the most associated with the construction of the future and the achievement of the renaissance and overall development sectors, because of its direct links to political reality and the economic social and cultural sectors, so governments are striving to provide educational institutions of all levels (kindergartens, kindergarten, universities) in order to accelerate progress and prosperity, where the Progress and people's development are measured by available services to the population (Waleed Lagrab, 2015).

Land suitability study, broadly construed, tries to determine the most suitable spatial pattern for the future location of a site in accordance with specific requirements and preferences of various activities. School locations have a lasting impact for students, teachers, and the communities they are located in unsuitable area.

2.3. Major factors that determine school site selection

The criteria were based on the study area reality. Determination of the relative weight of the standards. The relative weight of each criterion was given based on its importance in determining the location of the school. This done by extrapolating the opinions of the academics and specializes in the distribution of public services, planning, public works, and education to select the weight for each criterion (Marwah M. Al-khuzaie, 2018).

Each criterion was normalized to a common scale ranging from 1- not suitable, 2-less suitable, 3-suitable, 4-most suitable. A pairwise comparison was performed for each of the sub-criteria in the categories above and a weight assigned to each sub-criteria (Jamal, 2016).

From an analysis of previous research employing spatial technology to assess the development in the education sector, a suitable method can be developed (Anjar Dimara SaktiAnjar, 2022).

This thesis compares many international guidelines, rules, and standards with Ethiopian standards in order to produce appropriate and accurate criteria:

United States environmental protection agency (EPA), (2011) suggested potential sites can be evaluated by the following general criteria topics:

(1) Size,
(2) Access/traffic,
(3) Utilities,
(4)Shape,
(5) Security/safety,
(6) Costs,
(7) Location
(8) Noise levels,
(9) Topography/drainage, and
(10) Soil conditions/plant life.

According to Queensland government department of education a school must be protected from potential adverse impacts from off-site activities (e.g. infrastructure, land uses) which could adversely affect the health and safety, wellbeing and amenity of the school and its students. It is preferred that school sites which are situated within existing or planned residential areas.

The site is not:

1. Situated in or adjoining a zone or land use that is incompatible with the use of the site as a school
2. Within 100m of major overhead electrical transmission lines
3. Within a defined buffer area and/or close proximity of existing or future infrastructure which may pose a risk to the safety and wellbeing of future users of the school (i.e. defined sensitive use buffer areas for hazardous infrastructure such as gas pipelines or storage facilities for fuel or hazardous chemicals)
4. Adversely impacted by industrial or emission generating activities
5. Impacted by noise or odor from a waste facility, sewerage treatment plant or sewerage treatment pump station, or intensive animal industry
6. Located in close proximity to a current or future major transport corridor (including a heavy rail corridor or highway) and the noise and vibrational impacts cannot be buffered from internal and external learning areas sufficiently to meet requirements set out in the Design principles and technical standards for Department of Education facilities
7. Located in close proximity to uses that create a real or perceived threat to school security or student safety. Specific uses such as adult store, detention facility, drug and alcohol rehabilitation facility or brothel or the like, must not be within 100m walking distance of a school site (Queensland goverment, 2022).

Other researchers use to analysis site suitability considerable more proximity to airports, proximity to high-voltage power transmission lines, health hazards, proximity to railroads, proximity to gas station, noise, proximity to main roadways, and safe routes to school.
Debre Birhan Education bureau, discussed and listed criteria's for suitable school location in the standard quality of education book as follows:

- Students should get a school with in a distance 1.5 km for primary school and from 3-5km for secondary school.
- The school should have access to road, or it should be built near roads.
- The school should be far from disturbing busy road, bars, and commercial areas.
- The school should locate on plane space, and it should not have proximity to flood, stream or Dum.

- It should have free space for different facilities and activities such as for sport and vegetation.
- Area for elementary school should be 15,000- 25,000 m^2 and it can be differ in rural and urban.

The above criteria's which are taken from different guides, have common characteristics among them on suitability of school locations. These common criteria's are safety/security, accessibility, soil & topography, free from noise, size, and environmental hazards. Therefore from the common characteristics it is possible to categorize as safety factors (proximity to industries, proximity to high voltage, proximity to hazardous substance etc.), environmental factors (noise, proximity to commercial area), accessibility factors, and physical factors (access to road, proximity to residential).

2.3.1. Safety factors

i. Distance from industry area

Schools must be located away from industrial areas because of the safety risk caused by the heavy traffic of the route. Factories emit fumes and are also noisy and surrounding it may be residential area for the workers and unplanned center is bound to sprout. Expert recommends a minimum distance of 500 meters from the factory as a safe distance for a school location (Philip Kiprono Talam Moses Murimi Ngigi, 2015).

ii. Proximity to main road

Road is a very important criteria in site suitability as the need of transportation and connectivity mainly relies on the road network within a city. So, efforts are taken to make the site closure to the road. And, also to avoid accidents buffer zone of 1000 m (SayanMukhopadhaya, 2016).

iii. Distance from High power transmission line

Schools should be located far from electrical transmission line to ensure students and schools staffs are protected from the high voltage electrical effect (Bukhari Z. et al., 2010).

2.3.2. Environmental Factors

i. Distance from commercial areas

Schools should be located far from the commercial area because of the heavy traffic that contributes to air and noise pollution. This is also to avoid school children to waste their time playing in the arcade section. For this study, the acceptable distance from the commercial area to schools was at least 1 km (Bukhari).

ii. Distance from stream

Distance from streams – distances between 0m – 500m are unsuitable and distances greater than 450m are most suitable (IrshadAmirJamal, 2016).

iii. Proximity to the existing high school

Proximity to the existing high school is the most important criterion in site selection for the new high school. In accordance with rational resource allocation, the new high school location should be at a suitable distance from the existing high school (Dadfar, 2014).

2.3.3 Accessibility factors

a) Proximity to residents

The accessibility analysis was based on a new government regulation (Minister of Education Regulation no. 23/2013) regarding a maximum school distance from the residential area. These 12 regulations suggest that a primary school must exist ≤3 km from a residential, urban area, whereas secondary schools must be within ≤6 km (Geo-Information, 2021).

b) Access and Traffic

The site is serviced by a minimum of two road frontages (three road frontages preferred). These must be usable, formed road frontages of sufficient length (including one road frontage of at least 130m suitable for bus bays) that can provide vehicle access to the school site. Primary schools must be located with direct access (i.e. no road crossing) to ovals or other suitable outdoor play space where it cannot be delivered as part of the school site (Department of Education queensland government, 2022).

c) Slop

Based on the Ministry of Education (MOE) and Department of Town and Country Planning (JPBD) guidelines, schools should not be built on the slope that more than 100 (Ahmad Z. B., 2010).

Proposed site for school

The proposed site must allow for cost-effective delivery and operations of a school site and minimize any constraints that may delay or complicate the delivery of the school site.

The site is a useable lot that:

- Is regular in shape,
- has a maximum slope less than 1:20,
- does not rely on excessive on excessive earthworks (e.g. large retaining walls, batters) with sufficient area to accommodate flat land for ovals and play space,

- does not encroach into areas affected by hazards (natural or otherwise),
- The orientation provides appropriate solar access, with preference given to sites
- that promote road frontages with a north/south orientation, and
- Ensure any required cutting, filling, retaining walls and earthworks minimizes adverse impacts to vegetation, natural features and topography.

From the different factors stated above that determine suitability of school location the following criteria's are summarized.

Table 1: Criteria's from literature

No	Factors/constraints	criteria	source
1	Proximity to large Industry Small industry	Identify and evaluate all large industrial facilities within 0.8 km Identify and evaluate other small sources within 300 m of prospective school locations.	(EPA, 2011)
2	Proximity to residence	Students should get a school with in a distance 1.5 km for primary school and from 3-5 km for secondary school.	(Amhara education bureau)
3	Road access	A school should have access to road for transportation.	(Department of Education queensland government, 2022)
4	Proximity to commercial area	For this study, the acceptable distance from the commercial area to schools was at least 1 km.	(Zubaidah_Bukhari, 2010)
5	High voltage line	Proximity to high voltage power lines – distance buffer between 0m – 150 m are unsuitable whereas buffer distance greater than 450m were most suitable.	(AmirJamal, 2016)
6	Gas station	Identify and evaluate gas stations and other fuel dispensing facilities within 304.80 meter of prospective school locations.	(EPA,2011)
7	River/stream	Indiana State Board of Education (2002) clearly states no school can be built within 500 feet (152.4 meter) of a	(Zubaidah Bukhari A. R.)

		stream. For this study, the acceptable distance from the school site to the nearest stream was at least 300 m.	
8	slope	The overall slope of the site must be flat enough to allow for ease of construction. To build on, a flat terrain is the least expensive and easiest.	(Ali, 2018)
9	Proximity to high ways, Main road	Identify and evaluate all high traffic roads and highways within 804.67 meter.	(EPA, 2011)
10	Health centers	A school should have health access or should be near health centers.	(EPA, 2011)
11	Solid waste/land fill	Identify and evaluate all facilities within 1609 meter of prospective locations.	(EPA, 2011)

2.4 Analytic Hierarchy Process AHP

The problem is separated into different levels when a hierarchical structure is used for problem solution in AHP. Analytic Hierarchy Process (AHP) is a method that allows the consideration of both objective and subjective factors in ranking alternatives.

To apply all the criteria in decision making process, Analytic Hierarchy Process (AHP) method was used. AHP which was developed by Thomas L. Saaty in the 1970s is a process for ranking alternatives. A numerical score need to be developed to rank each alternatives based on how good each alternative suits the decision maker's criterion. (Ahmad Z. B., 2012) Analytical hierarchy process (AHP) to support the decision-making process on selecting an appropriate site for development urban green spaces (Gelan, 2021).

2.5 Multi-Criteria Decision Making

Multi-Criteria Decision Making (MCDM) is systematic way to select the best available alternatives based on different opinions, conflicting priorities and values. Spatial multi-criteria decision making involves a set of geographically-defined alternatives (events) from which a choice of one or more alternative is made with respect to a given set of evaluation criteria (Merga, 2014).

2.6 Pairwise comparison matrix

The pairwise comparison matrix was applied to determine the weight and consistency of each criterion at each level of hierarchy by relative rating. The nine point rating scale was used where 1 represents equal importance (i.e., two factors contributing equally to the objective), 3 represents moderate importance (one factor slightly favored over another), 5 indicates strongly important, 7 stands for very strongly important, and 9 stands for extreme importance (Mustafa, 2011).

Table 2: The fundamental scale for pairwise comparison

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgment slightly favor one over the other.
5	Much more important	Experience and judgment strongly favor one over the other.
7	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favoring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed.
Reciprocals of above nonzero	If activity has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

Source: adapted from “Saaty” (2008)

The comparison's findings (for each factor pair) were expressed in terms of integer values ranging from 1 (equal value) to 9 (extreme difference), where a higher number indicates that the factor of choice is seen as being more significant than the other component.

Additionally, AHP offers tools to identify mathematical judgment discrepancy in order to guarantee the validity of the relative significance utilized.

2.7 Integration of Geospatial technology

Today a new generation of scientists and researchers are making the history of Geospatial Technology. They are using science-based approaches and the powerful tools of geospatial measurement, data collection, data management, spatial analysis and modeling, and geospatial visualization. They are accelerating the creation of geographic knowledge and its application to nearly every problem confronting society today (Niels van Manen, 2009).

The Integrated Geospatial Information Framework is a first-of-its-kind global guide that provides concrete recommendations on establishing national geospatial information infrastructure and management – and putting that information to use. The guide also calls for partnerships with the private sector, civil society, businesses, and academic institutions who have access to relevant data and technology (Worldbank, 2019).

Geospatial technology (also known as Geomatics) is a multidisciplinary field that includes disciplines such as surveying, photogrammetry, remote sensing, mapping, geographic information systems (GIS), geodesy, and global navigation satellite system (GNSS) (pun-cheng,2001 Cited in (Aina, 2012)).

Physical land suitability for aquaculture was assessed using geospatial technology and a multi-criteria evaluation. For this study, ArcGIS 10.3 was used to reclassify and map numerous thematic layers such as slope, soil types, rainfall, LST, road, river, lakes and reservoir, market, LULC, river density, and road density to identify land suitability for aquaculture (Muleta, 2022).

2.8 Application of integration of Geospatial technology

Establishing control point

Improving accuracy

Suitability analysis

Extraction new information

Analysis information

To fill gaps of one’s technology

To secure data and to update

- **Global navigation satellite system**

Latitude, longitude, and elevation with respect to a geoid are determined using the GNSS (Global Navigation Satellite System). This feature can be utilized to locate the precise measurement locations and gather surface topography. The GNSS locates itself by figuring out how far away the receiver is from various satellites orbiting the planet. The satellite radio waves' phase and travel times are measured to gain this information. These positions are utilized to pinpoint the receiver on the earth's surface because each satellite's precise location is known. Additional correction signals may be required, depending on the level of accuracy required, to obtain precise measurements.

- **Geographic information systems (GIS)**

Geographic information systems (GIS) play a significant role in analyzing spatial data such as school location when the data is integrated into spatial database (Ogba J. U., 2016).

ArcGIS 10.1 was used to perform all vector data processing such as shape file creation by digitization of points, and lines features and also performing suitability analysis using weighted overlay tool (J. U. Richard, 2016).

A Geographical Information System (GIS) is a system for capturing, storing, analysing and managing data and associated attributes, which are spatially referenced to the Earth. The geographical information system is also called as a geographic information system or geospatial information system. It is an information system capable of integrating, storing, editing, analysing, sharing, and displaying geographically referenced information. In a more generic sense, GIS is a software tool that allows users to create interactive queries, analyse the spatial information, edit data, maps, and present the results of all these operations. GIS technology is becoming essential tool to combine various maps and remote sensing information to generate various models, which are used in real time environment. Geographical information system is the science utilizing the geographic concepts, applications and systems. Geographical Information System can be used for scientific investigations, resource management, asset management, environmental impact assessment, urban planning, cartography, criminology, history, sales, marketing, and logistics. For example, agricultural planners might use geographical data to decide on the best locations for a location specific crop planning, by combining data on soils, topography, and rainfall to determine the size and location of biologically suitable areas. The final output could 2

include overlays with land ownership, transport, infrastructure, labour availability, and distance to market canters (www.manage.gov.in, n.d.).

- **Euclidean Distance**

The Euclidean Distance using to measure the distances traveled of students to their schools based on the Euclidean distance. In other words, it measures with straight-line distances between home and nearest school, and not the actual distance traveled. Estimating accurate distances using roads network analysis would be possible. (WALEED LAGRAB, 2017)
Euclidean distance which is a measure of distance from every cell to the nearest source was model for both the settlement and secondary school data. Euclidean distance calculates straight line distance to a source cell and this model are mostly applied in suitability studies for selecting optimum site, (Ogba J. U., 2016).

The concerns all above studies are describing site suitability with the concept of integration of geospatial technology use and GIS based Multi-Criteria Decision Making. In order to find potential places for a public school, a geographic information system (GIS) was combined with a multiple criterion decision making (MCDM) method. Suitability assessment incorporated both analytical planning and geographically relevant data using MCDM and GIS. Environmental effects, safety issues, and accessibility were the three key themes that were divided up into the chosen criteria.

Urban planning proclamation

Ethiopian Urban Planning Proclamation No. 574/2008 define plans in hierarchy and urban plans recognized structure plan and neighborhood development plan.

Hierarchy of Plans

Based on the national and regional development strategies and schemes the following hierarchy of plans shall be considered:

1/ National urban development scheme;

2/ Regional urban development plan;

3/ Urban plans.

Types of Urban Plans

The following types of urban plans are hereby recognized:

1/ city wide structure plan; and

2/ local development plan (Urban Planning Proclamation No. 574/2008, 2008).

Social Service Definition: - Social Services are services which society provides to all citizens through the agency of the state. Education, Health care and family planning services are the most critical social services for the urban poor. In addition to these, services such as housing, worship places and cemeteries, sport and recreation are also considered here (Federal Urban Planning Coordinating Bureau, 2004).

Details of the Points to be Considered when Evaluating Urban Plan Reports

Evaluation of Text Report

Under the Regional Study does the report include

1. Physical and Environmental Characteristics
2. Geological Aspect
3. Demographic Characteristics
4. Basic Characteristics of the Rural Economy
5. Physical Infrastructure (DB Zone urban plane implimentaton office)

According to Debre Birhan zone urban plan implementation office guide line for prepare structure plan basically address some of their contents are:-

Environmental Aspects

- environmental pollutions
- existing number, type and physical distribution of recreational facilities
- land degradation, vegetation/ forest, etc
- Natural and Man-made Constraints and Urban Expansion Areas
- Formulation of alternative strategies to address the problem identified thorough the assessment.

Physical Aspects

Assess physical features of the town

- Altitude /elevation
- Slope/ gradient in percent and classification of their respective area
- Sewerage and other fields mainly focus the study is related for may be youth to factors field to suitability analysis of primary schools.

The elementary school site selection guide line or criteria are note prepared specifically for select appropriate primary schools location according to plan implementation office.

CHAPTER THREE

3. MATERIALS AND METHOD

3.1. Description of the study area

Debre Berhan town was established in 1454 by Emperor Zerayaeqob. It is located in Amhara National Regional State and currently, the town has been serving as the seat of Northern Shewa Zone Administration, political Debre Birhan town Administration have 39 total kebeles with in five sub city 24 urban kebelas and 15 rural kebeles. The structural plan covered or incorporate Tebasa, Zerayekob, Lecha and Minilik sub city and they have 24 kebeles the study focus this planed sub city area. The Town is situated 130 kilometers northeast of Addis Abeba along the highway between Dessie-Mekele. The town is known for its cold climatic temperature and is located at 9°38' N latitude 39°40' E longitude, 9°43' N latitude 39°33' E longitude, 9°38' N latitude 39°33' E longitude, 9°35' N latitude 39°29' E longitude extension. The majority of Debre Berhan developed sections are located at a height of 2750 meters above mean sea level. Generally, the topography is classified as 86% flat, 10% sloppy and 4% mountainous. The total area of the city is 9056.167 hectares of land.

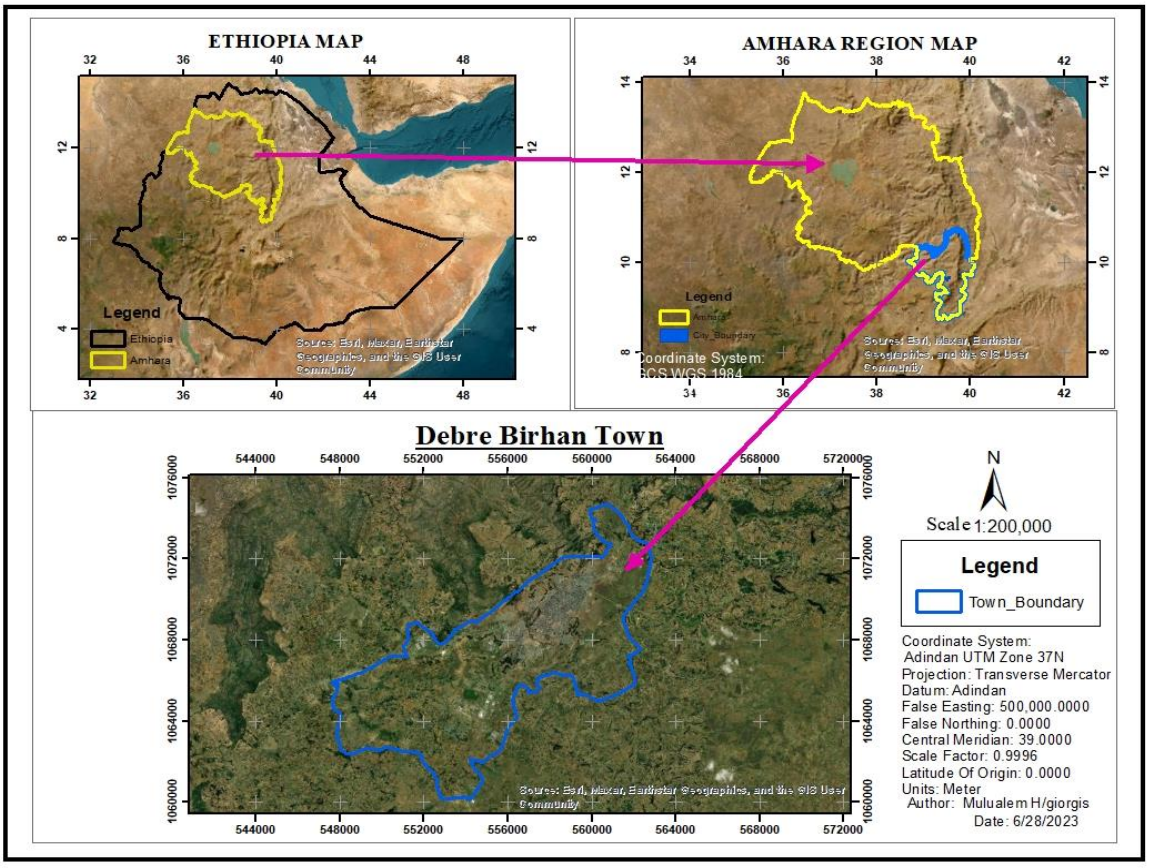


Figure 1: Debre Birhan location Map

Temperature and Rainfall

The annual average temperature of the town ranges between 55°F in the coldest month (Dec) to 60°F in the hottest month (May).Average annual rainfall ranges in Debre Birhan town is between 0.5 to 5.1 mm.

Table 3: Temperature and Rainfall data in Debre Birhan town

Months	Jan	Fe	Ma	Ap	May	Jun	Jul	Aug	Sep	Oct	No	Dec
Average(°F) Temperature	55	57	59	59	60	60	57	57	58	58	56	55
Average (in) rainfall	0.9	1.7	2.9	4.0	2.0	1.6	4.7	5.1	2.9	1.1	0.5	0.5

https://weatherspark.com/y/101155/Average-Weather-in-Debre-Birhan

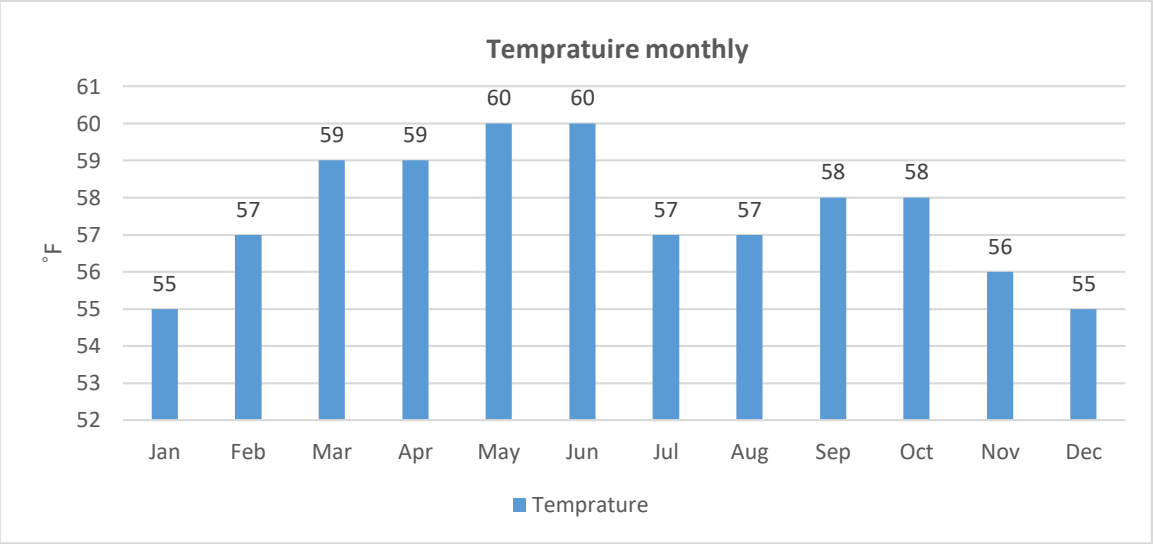


Figure 2: Debre Birhan Temperature

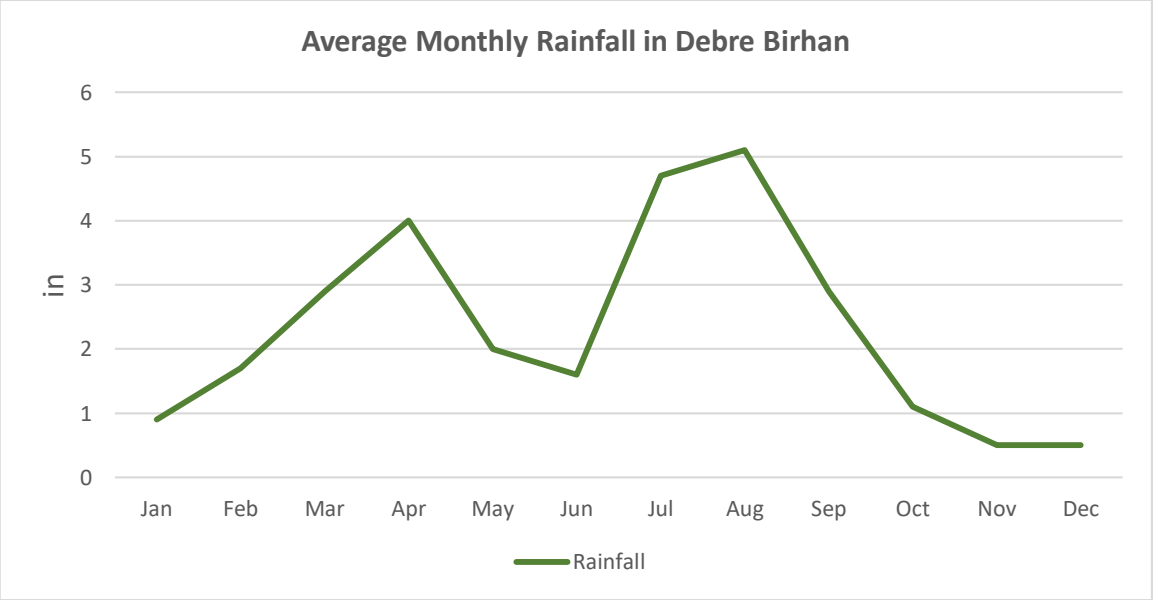


Figure 3: Average Monthly Rainfall in Debre Birhan

Infrastructure

In comparison with the past few years both the coverage and the quality of services are improved in Debre Birhan. The asphalt road from Addis Ababa via desse to Mekela passes through the town. The Debre Birhan town is connected to its neighboring Woredas by asphalt like Debre Birhan juru and Debre Birhan Ankober road project and all-weather road networks. However, the road networks joining the city with rural Kebeles are dry weather roads Debre birhan have 18 primary schools schools.

Economic Activities

The dominant economic activities in the town are tanneries and blanket factories. Agriculture on the suburbs provides livelihood to a large section of society. In the town there exist one Government University, various colleges, schools, banks, hospitals both public and private, various clinics and higher secondary and preparatory schools.

Population and Demography

The population of the city based on the 2008 national census is 79,832 (CSA, 2008) but currently according town administration the town population is almost 350,000.

Schools

In Debre Birhan town there are 18 primary schools in total. 8 are governmental and 10 are nongovernmental schools. They all schools have total 10820 student's 5105 male and also 5715 is female students.

Table 4: Schools no of Debre Birhan

	No of School	No of student		Total student
		Male	Female	
Governmental	8	2948	3503	6451
Non-Governmental	10	2157	2212	4369
Total	18	5105	5715	10820

According to the above table information more student's number in Debre Birhan elementary schools is females.

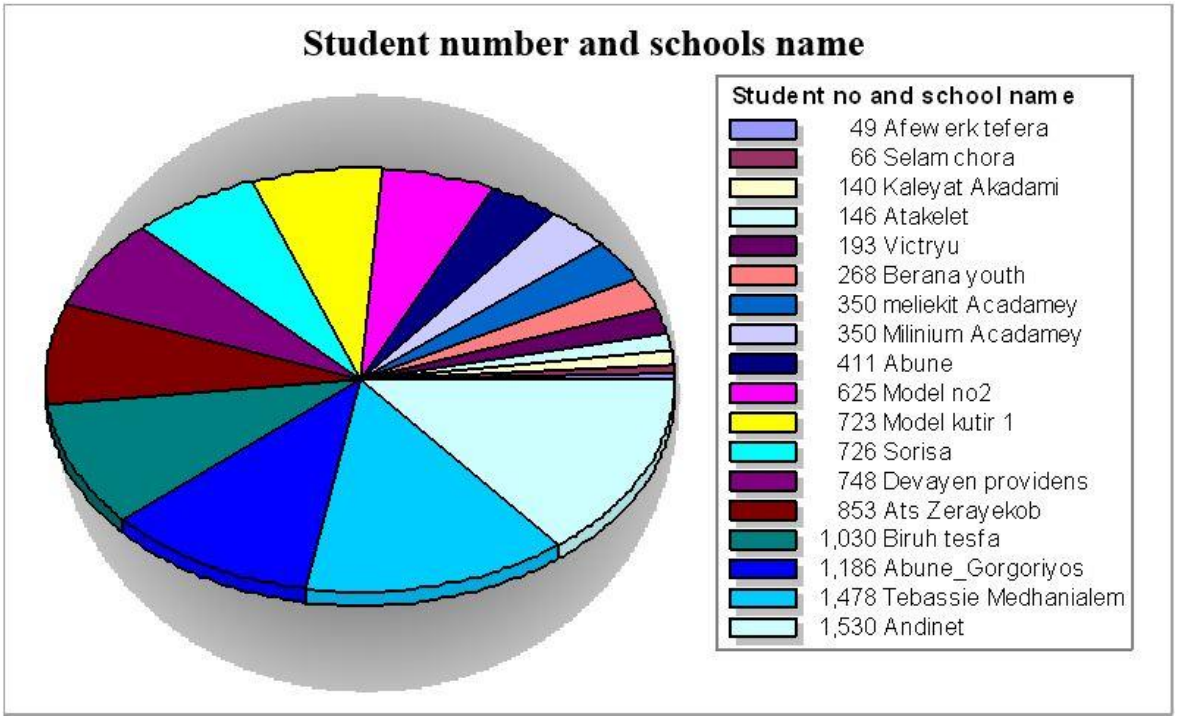


Figure 4: Student number and schools name

3.2 Data Sources

Multiple data sets, including primary and secondary, raster and vector data, were gathered and used to address the objective of this study. Secondary sources are those that are repurposed from previous research or acquired from other systems, whereas primary sources are that are directly measured and collected usage in geospatial technology for analysis.

Ground control points use to for reference and gather features data on filed before collecting ground data first check the Ground control points (GCPs) accuracy closeness.

collect features data or information using south GNSS receiver, the data collection methods is real time kinematic (RTK), the objects collect when the features not visible and new construction sites of the factors of suitable primary schools site selection, or the features are not on ortho photo or structural plan. Questionnaire is other primary data sources to achieve the objectives of this thesis.

Secondary data gathered from governmental concern body office and various sources.

Table 5: Secondary data type and sources

no	Data type	sources
1	Structure plan (sp)	Debre Birhan town plan implementation office
2	Base map	Debre Birhan plan implementation office

3	2nd order control points	Debre Birhan urban land directive
4	3rd order control point	Debre Birhan urban land directive
5	Debre Birhan Ortho photo	Debre Birhan land management office
6	Town population data	CSA, Town administration
7	Schools and student no	Debre Birhan educational office

3.3 Materials

During the fieldwork, SOUTHE GNSS satellite receivers are employed to collect initial data. Additionally, various related data and Ortho photo have been used. The materials used in this study are summarized here.

Table 6: Data have been used

no	Type	Desicription	Source
1	Software	ArcGIS 10.8.2, ERDAS-Imagine 2015, IDRISI, AUTO cad, extAHP multi criteria analysis, Google Earth pro, SPSS, SGO South Geomatics Office, Microsoft Excel, Microsoft Word	ASTU,GIS Lab, open source, DB town land district
2	South GNSS	GNSS satellite receiver, post process office	DB town land district
3	Total station	Collect data at filed	DB town land district
4	Handheal GPS	Satellite receiver GARMIN handheld 72 GPS for navigation only	DB town land management office
5	Debre Birhan Ortho photo	The ortho photo is recently can crate feature information	DB town land district
6	Base map	Debre Birhan line feature	DB town plan implementation office

3.4. Research Methodology and procedures

3.4.1 Data collection

This Site Selection Criteria Handbook was developed with flexibility in mind and can be used by school districts to perform a site selection analysis for any school facility by carefully selecting the appropriate criteria and weighting factors. Districts can use this guide for analysis of site opportunities for elementary schools, secondary schools, charter schools, alternative schools and special purpose facilities. (Alaska, 2021)

In this study, questionnaire is one of the primary methods to collect standardized data from a number of stakeholders in the education system and geospatial experts. The questionnaire's questions were systematically designed in such a way that all necessary variables for suitability criteria.

3.4.2. Sampling Size and sampling Techniques

The town have 18 total primary governmental and nongovernmental schools. The town plan implementation office experts, Debre Birhan Town land management officers, Schools director and teachers were chosen expert member a stratified sampling technique used in the study, from population select samples size by using slovins formula the accuracy level is 95%, and fill out a questionnaire.

$$n = \frac{N}{1 + (N * e^2)}$$

$$n = \frac{260}{1 + (260 * 0.05^2)}$$

$$n = \frac{260}{1.65}$$

$$n = 158$$

Where: n = sample size; N = the total number of director and teachers, educational experts and geospatial expert's members and ε = error tolerance

158 respondents were taken from director and teachers, educational experts and geospatial expert's members.

Table 7: Sample Distribution

stake holders	No. of population	Sample
Directors and teachers	205	125
Geospatial officers	20	12
Educational officers	35	21

Education and land management information desk

Stratified Random sampling techniques were used in order to include sample respondents from all the target parties. Then after, a simple random sampling technique is used in order to take sample respondents.

3.4.3. Topography data collection and Methodology

To achieve the objectives of the research the following approaches of analyzing data are implemented.

- Reconnaissance survey;
- Read statics DGPS data;
- Adjustment of DGPS data;
- collect the data at site not visible on Ortho photo
- Digitizing the new feature

Reconnaissance Survey

Before starting the field work, reconnaissance survey of the area will be carried out. This will help in understanding the research area and boundary. In addition all necessary data that needs to be surveyed will be identified and registered.

Surveying Requirements

The main requirement of the surveying work is to give as much as possible for the next phase of surveying works. In this aspect shall be ready to undertake the following major activities in the preparation of topographic survey of proposed site.

- The coordinate readings of control points or bench marks will conform to the given 2^{nd} and 3^{rd} order Gcp coordinates, Differential GPS (south) reading taken at the site.
- Post process the static data and check the accuracy
- Using the fixed permanent control points and bench marks, the detail topography surveying work of the proposed site and its surrounding will be surveyed.

The ultimate outcome of the survey to be made feature when not visible in Ortho photo and line feature.

Topographic Surveying works

This stage is the main activities to be collect the data. Initially make a site visit to locate and all relevant data information considered relevant to the project. Such data and information include, but not limited to:

- New data Collection or surveying work of
    - Existing Elementary school
    - Survey of all infrastructure (gas station, roads, electric lines, river and etc…

  In general locating all important data and features of the site will be considered in topographic surveying.

Digitization of features

In Arc-Catalog and prior to digitizing, a file or personal geo-database is created to provide for space to store and analysing the various feature classes. Then a feature dataset is then created within the geo database. This allows for the definition of the projection and datum parameter that are going to be assumed by all the features in it. New feature classes are then created.

The ortho photo image is loaded in Arc Map. The target feature class is also loaded. Digitization is done on-screen by tracing over the feature boundaries.

Adding data of Auto CAD base map

Adding data which is an existing Auto CAD base map of the project area in to Arc GIS in order to overlay with other Arc GIS data to fill the gap of the surveyed data and vice versa.

3.5. Procedures

This study focuses on the primary schools site suitability analysis for evaluate existing primary schools and proposed new suitable site selection with respect to criteria components and based on the primary data. This study the integration Geospatial methodology was established. This research strategy applies formal systematic and scientific approaches to examine spatial data, with a focus on choosing an appropriate location for a primary school in the town of Debre Birhan.

To identify the main environmental, safety, accessibility, and other factors supports to identify and appropriate site of primary schools, various reviews of the literature were compared and discussed. Review the best practices from other countries and the Ethiopian context for choosing appropriate sites for primary schools.

Various international guidelines and policies, as well as Ethiopian guides, were used to develop an appropriate school site selection and evaluation criterion. Surveys of several school stakeholders, including the school director, teachers, and education officers, as well as surveyors from urban planners were done to increase the reliability of the criterion.

The pairwise comparison matrix was applied to relative importance, factors of environmental, safety, accessibility, suitability maps measuring variables using a pairwise comparison method of Analytical Hierarchy Process (AHP). Actual factor weight and class weight (or rating) for parameters involved in the study were determined systematically based on the AHP. The priority of each factor involved in the AHP analysis is determined based principally on different literatures review were compared and discussed and also the town geospatial officers, school stakeholders, including the school director, teachers, and education officer's opinions. The method is implemented using the pairwise comparison technique that simplifies preference ratings among decision criteria.

Develop analysis model builder to perform the spatial operation. This study proposed using integration of geospatial technology and GIS-based multi-criteria suitability analysis to ArcGIS Model builder was used to create models for each factor. The final suitability map is obtained by aggregating all the factor results using a single model.

After processing propose new suitable schools site location the suitability map, alternative new suitable site maps were created. To ensure that the new suitable locations are developed accurately, measurement and checking were carried out using the ArcGIS measuring tool. The measures are used to determine the new site's area, distance from restricted areas, and distance from the old site.

The generalized process of this research is identify the main criteria and environmental, safety, accessibility and other factors that determine appropriate site of school, different literatures review were compared and discussed. The study concludes with a system that has been improved using geospatial technologies.

Give weight by using Analytic Hierarchy Process (AHP) as a multi-criteria decision analysis (MCDA) technique.

For the well-developed criteria's, factor criteria (opportunity criteria) and constraint criteria (restriction criteria), weight is determined of each factor by using Analytical Hierarchy process (AHP).

AHP is employed for rating/ranking a set of alternatives or for the selection of the best in a set of alternatives (Saaty TL., 1977). The pairwise comparison, concerning the relative importance of the two criteria involved in determining the suitability for the stated objective, is the basic measurement mode employed in the AHP process. (AHP were calculated using excel).

The AHP procedure involves six essential steps (Lee, A.H.I., W.C. Chen and C.J. Chang, 2008).

- Define the unstructured problem
- Developing the AHP hierarchy
- Pairwise comparison
- Estimate the relative weights
- Check the consistency
- Obtain the overall rating

This study proposed the application of integration of geospatial technology. For each factors models were developed using ArcGIS Model builder. Collect the data at site not visible on ortho photo by using GNSS RTK methods, for weight calculate and process use IDRIS and extAHP multi criteria analysis weighted calculator. All the factors result are aggregated using one model to get final suitability map.

And from the spatial operation result new map layer is produced. The existing schools are overlaid in to the new map. And they are classified in to different categories based on the suitability location they lay, such as more suitable, suitable, less suitable, and not suitable. To each criterion maps are produced too. Categorize the existing schools site location in to suitable classes. Finally proposed new appropriate site for elementary school using final suitability map and the town structural plan land use the selected site is most verify in filed so convert the data in to KML and approved the proposed site in filed.

Technological scheme of the study.

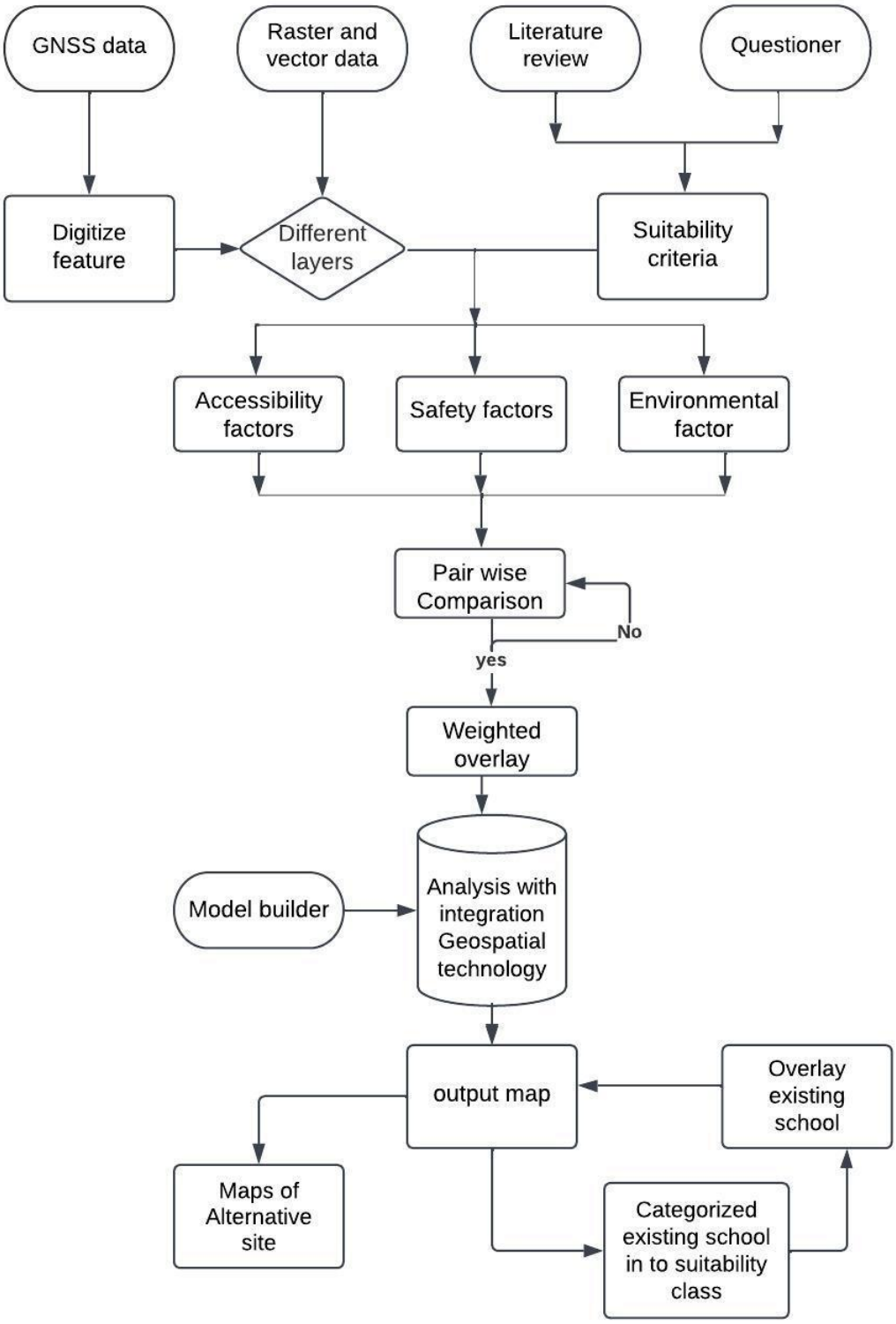


Figure 5: Technological scheme of the study

3.6 Data analysis method

The questionnaire includes two types of data: explanatory data used to test hypotheses and descriptive data used to measure respondents' opinions and attitudes. The information was created in tables, a pie chart, and a bar graph after the data were initially evaluated using SPSS. It was decided to rate some of the independent factors. By creating eligibility criteria and organizing the dependent variables according to relevance, the questioner was able to accomplish their main goal. The spatial data information extracted by appropriate integration of Geospatial technology software. The pair wise comparison, concerning the relative importance of the two criteria involved in determining the suitability for the stated objective, is the basic measurement mode is the AHP process.

3.6.1. Categories and Analytic Hierarchy Process AHP

In this research twelve suitable criteria's are organized in to three main categories. Each category has its own pairwise comparison to have weight. After organizing the appropriate criteria into a hierarchy, it is essential to weigh the criteria since the model builder weight overlay tool uses the weight for GIS analysis.

The factors need to be classed to a standard measurement scale to give them a degree of influence based on weighting in order to establish the weight of each factor and apply it in the overall suitability of a school location.

3.6.2. Pair wise comparison method

The pairwise comparison method involves the following steps

Development of a pairwise comparison matrix.

Then rate for factors range from 1-9.

The method uses a scale with values range from 1-9 to rate the relative preferences for two criteria.

3.6.3 Computation of the criterion weights

The normalized pairwise comparison matrix is the result of three operations: first, the values in each column of the matrix must be added; next, each element in the matrix must be divided by its column total. The average of the components in each row of the normalized matrix should then be calculated. To do this, divide the sum of the normalized scores for each row by the total number of criteria. An estimation of the relative weights of the compared criteria is given by these averages.

Estimation of the consistency ratio

Determine whether or not the comparisons are consistent by estimating the consistency ratio. There are 3 steps to arrive at the consistency ratio:

1, Calculate the consistency measure.

2 Calculate the consistency index (CI).

$$CI = \frac{hmax - N}{N - 1}$$

3. Calculate the consistency ratio (CI/RI where RI is a random index).

$$CR = \frac{CI}{RI}$$

Table 8: Table of random index (RI).

1	1	2	3	4	5	6	7	8	9	10
2	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49

Source: Saaty (1980)

The table below presents pairwise comparisons for evaluating the relative importance of safety, accessibility, and environmental aspects for school appropriateness. The raw value increase going to the right because all criteria are sorted hierarchically based on the stakeholders input. For each table consistency ratio (CR) should be less or equal to 0.01 to be valid comparison.

Safety factor

Table 9: Pairwise comparison for safety factors

Safety	industries	Main Road	gas station	High voltage
industries	1	2	3	5
Main Road	1	1	3	3
gas station	0.333333333	0.333333333	1	2
High voltage	0.2	0.333333333	1	1
total	2.533333333	3.666666667	8	11

Using integrated geospatial technology calculate weights and consistency ratio by extAHP multi criteria analysis Geospatial weighted analysis calculator and integrated with ArcGis 10.8.2 software computed the criteria weights and outcomes of the consistency ratio are the safety is blow.

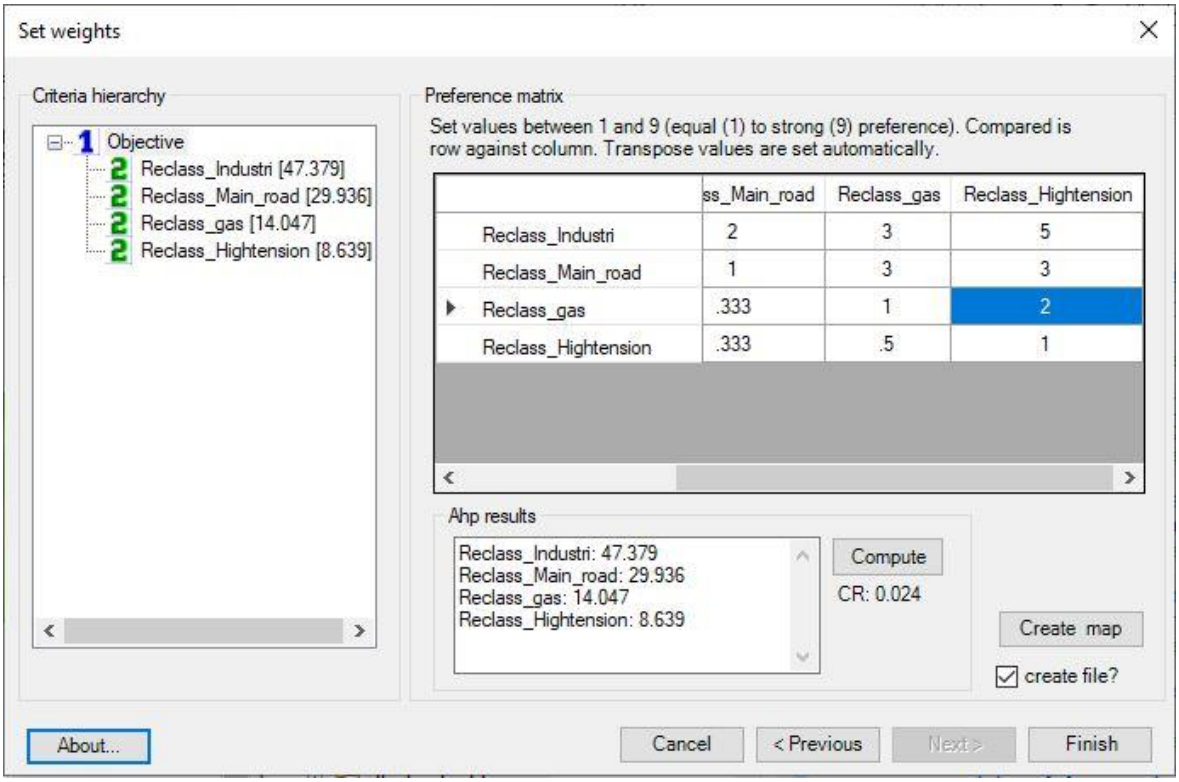


Figure 6: Criteria weights and estimate the consistency ratio of safety.

The consistency ratio values shall be less than 0.1. For the elementary school safety criteria, CR was also calculated and determined to be 0.024, which is acceptable for use in the appropriateness analysis. The weight of industry is 47%, main road 30%, gas station 14% and high voltage 9%.

Accessibility factors

Table 10: Pairwise comparison for Accessibility factors

Accessibility	Residence	Road	Health	slope
Residence	1	2	2	3
Road	0.5	1	3	4
Health	0.5	0.333	1	2
slope	0.333	0.25	0.5	1
Total	2.333	3.583	6.5	10

Using extAHP multi criteria analysis Geospatial weighted analysis software Computed the criteria weights and estimate of the consistency ratio are the following.

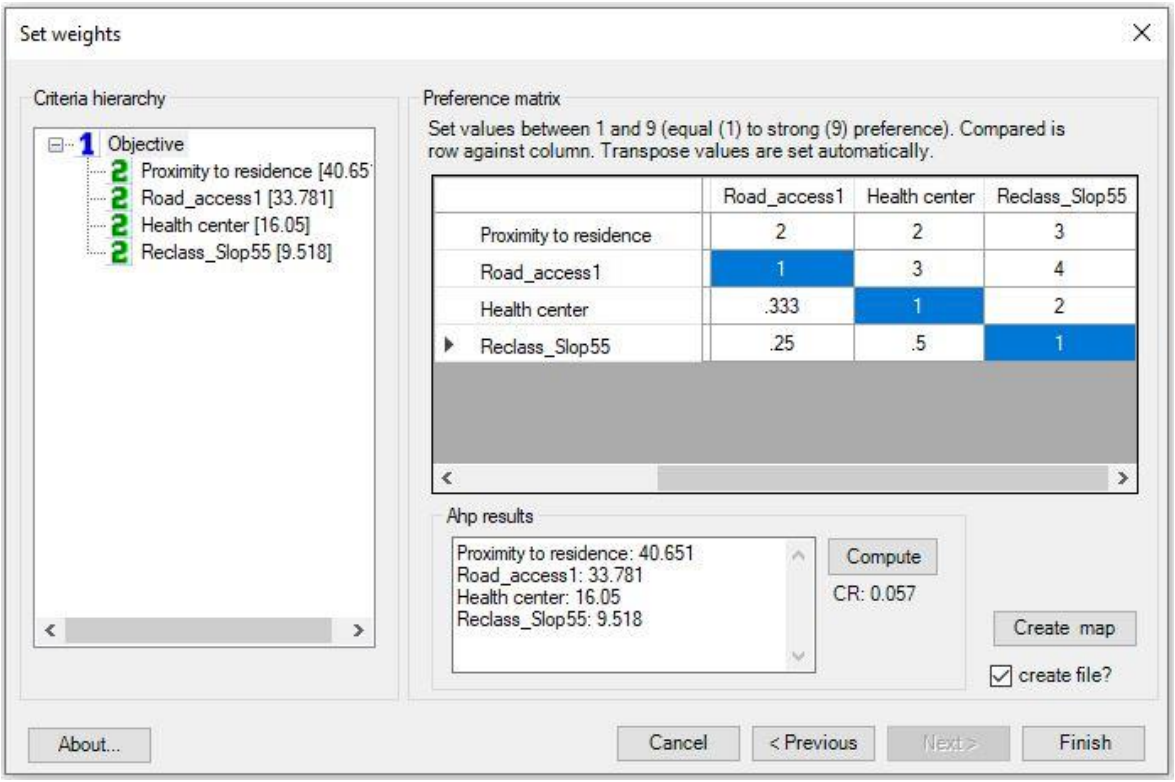


Figure 7: Criteria weights and estimate the consistency ratio of Accessibility.

The consistency ratio presents values below 0.1. CR was also calculated and found to be 0.057 for Accessibility factors suitability for schools, of primary which is acceptable to be used in the suitability analysis. The weight of proximity to residence 40% Road access is 34%, health center 16%, and slop is 10%.

Environmental factors

Table 11: Pairwise comparison of environmental factors

Environmental	Waste disposal	Commercial	River	Existing School
Waste disposal	1	2	2	4
Commercial	0.5	1	2	2
River	0.5	0.5	1	3
Existing School	0.25	0.5	0.333	1
Total	2.25	4	5.333	10

Analysis software computed the criteria weights and estimate of the consistency ratio are the environmental is blow.

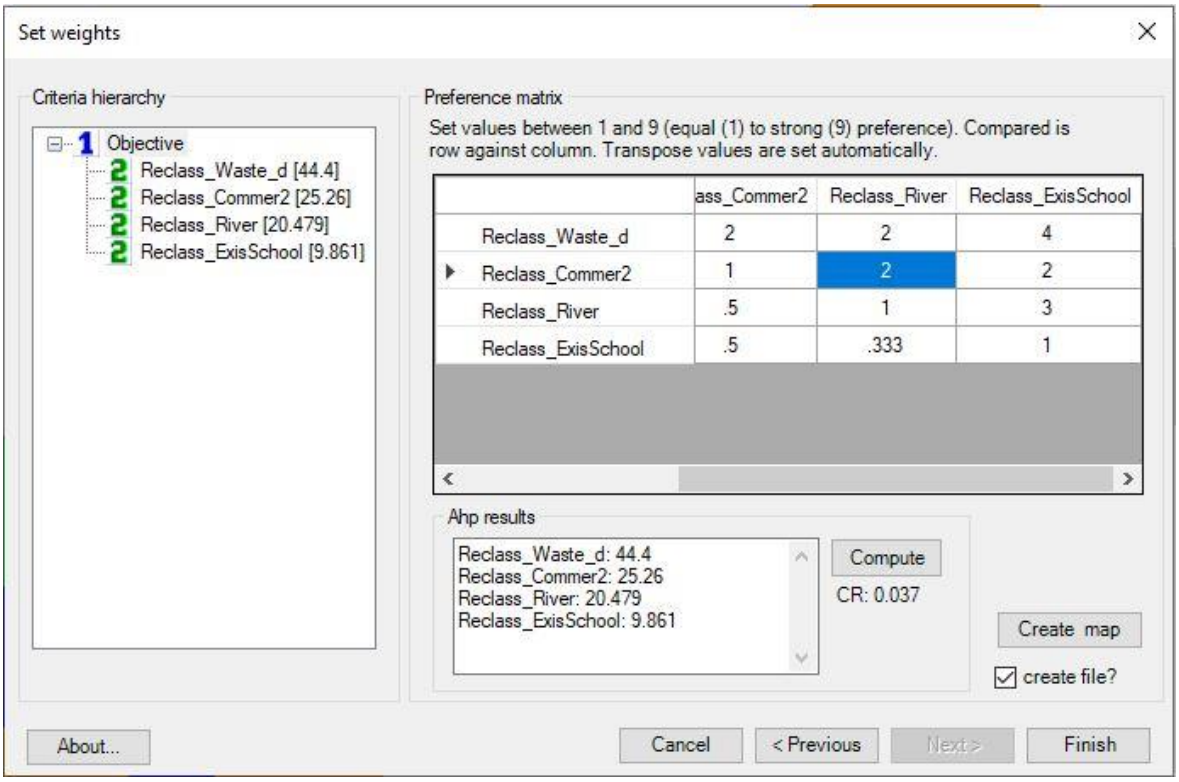


Figure 8: Criteria weights and estimate the consistency ratio of environmental.

The consistency ratio shows values that are less than 0.1. For the environmental criteria suitable for primary schools, CR was also calculated and determined to be 0.037, which is acceptable for use in a primary school study. The weight of Waste disposal is 44%, Commercial 26%, River is 20% and existing schools are 10%.

Final suitability

Table 12: Pairwise comparison of all categories

Final suitability	Accessibility	Safety	Environmental	Land use
Accessibility	1	3	3	4
Safety	0.333333333	1	2	2
Environmental	0.333333333	0.5	1	3
Land use	0.25	0.5	0.333333333	1
Total	0.916	5	6.333	10

Weight

For analysis the categories of safety, Accessibility, Environment and land use weight is analyzed by IDRIS 17.0 software.

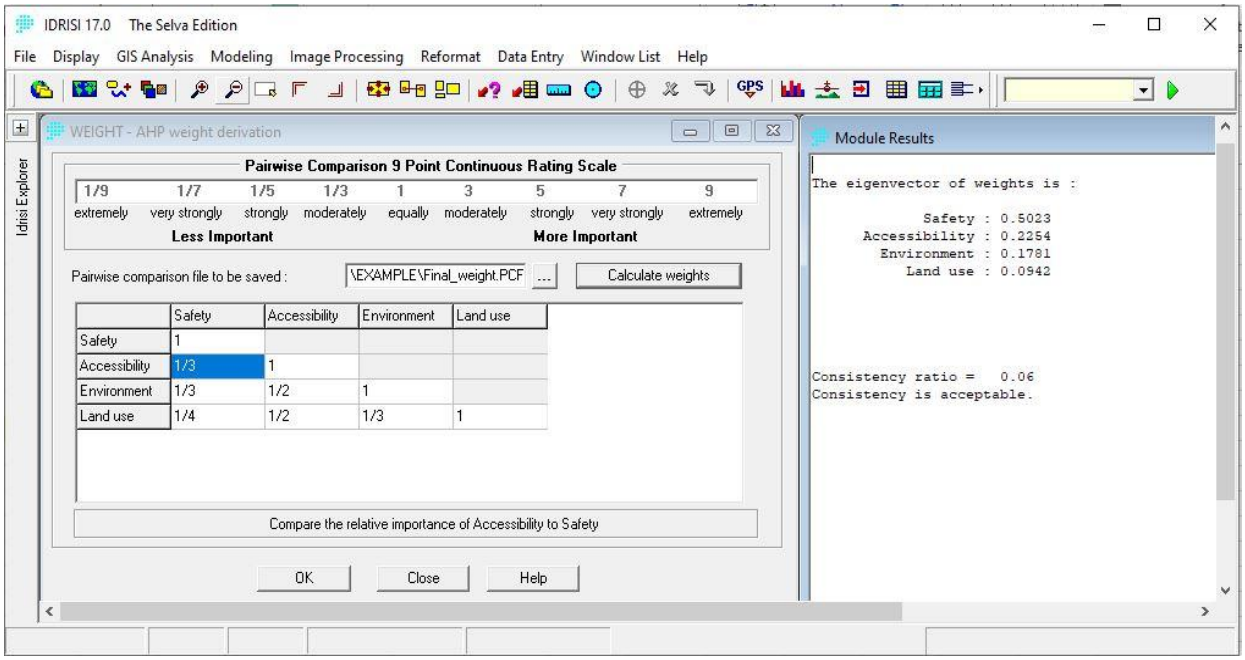


Figure 9: Weight of all categories

According to IDRIS weight calculator the result of category is, safety 50%, Accessibility 23%, Environmental 18% and land use is 9% CR was also calculated and determined to be 0.06 that intent less than 0.1 so Consistency is acceptable.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. Results

Using questioners, information was gathered from each sub city, eight governmental and ten nongovernmental schools, from a total of 18 schools. All elementary schools engage in the plan, according to the plan use stratified random sampling from 260 population select 158 samples using slovins formula the accuracy level is 95%, seven director and teachers each school totally 125, 12 educational officers and 21 geospatial experts distributed to fill the questionnaires. The total number of distributed and collected questioners is displayed in the table below.

Table 13: Questioners sample size: distributed and collected questioner

No	Stake holders	Distributed	Collected	Percent
1	Educational officers	12	12	100
2	Geospatial experts	21	20	95.24
3	Director or teacher	125	120	96.80
4	Total	158	153	96.84

I. Result from respondents

How do you evaluate Generally Suitability of Debre Birhan school locations?

Table 14: Result from respondents Suitability of Debre Birhan Schools

How do you evaluate Generally Suitability of Debre Birhan school locations?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unsuitable	48	31.6	31.6	31.6
	suitable	13	8.6	8.6	40.1
	more suitable	91	59.9	59.9	100.0
	Total	152	100.0	100.0	

Source (SPSS, output)

Table information indicate 59.9% of the total responses, or more than half, concur that the site is more suitable. Of the total, 8.6% believe they are suitable. 31.6% respondents unsuitable with the statement. The below table show detail rate of each stake holders about Generally Suitability of Debre Birhan school locations.

Table 15: Result from respondents Generally Suitability locations.

How do you evaluate Generally Suitability of Debre Birhan school locations? * Stake holders Crosstabulation

			Stake holders			
			Educational officers	Geospatial experts	Director and teachers	Total
How do you evaluate Generally Suitability of Debre Birhan school locations?	Unsuitable	Count	2	5	41	48
		% within How do you evaluate Generally Suitability of Debre Birhan school locations?	4.2%	10.4%	85.4%	100.0%
		% within Stake holders	16.7%	25.0%	34.2%	31.6%
	suitable	Count	1	2	10	13
		% within How do you evaluate Generally Suitability of Debre Birhan school locations?	7.7%	15.4%	76.9%	100.0%
		% within Stake holders	8.3%	10.0%	8.3%	8.6%
	more suitable	Count	9	13	69	91
		% within How do you evaluate Generally Suitability of Debre Birhan school locations?	9.9%	14.3%	75.8%	100.0%
		% within Stake holders	75.0%	65.0%	57.5%	59.9%
Total		Count	12	20	120	152
		% within How do you evaluate Generally Suitability of Debre Birhan school locations?	7.9%	13.2%	78.9%	100.0%
		% within Stake holders	100.0%	100.0%	100.0%	100.0%

Source (SPSS, output)

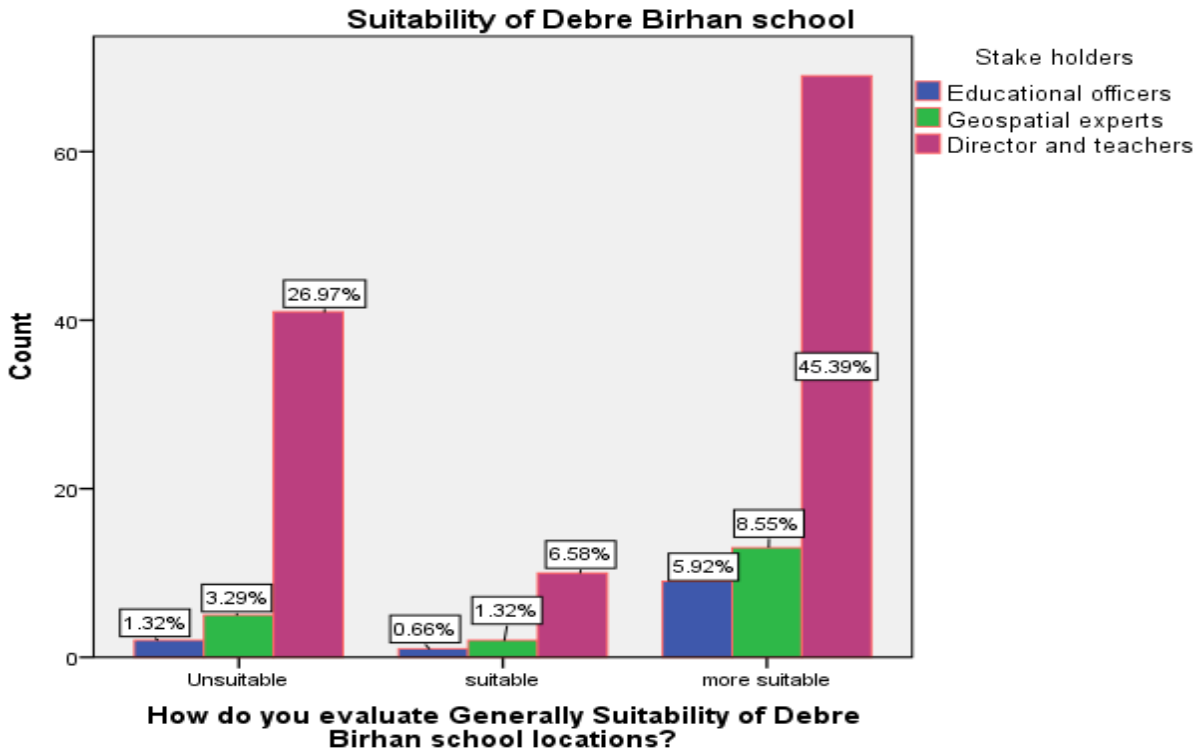


Figure 10: Result from respondents Suitability of DB School.

The figure information is 26.97%, 3.29%, 1.32% director and teachers, geospatial experts and educational officers respectively is say unsuitable. 6.58% director and teachers, 1.32% geospatial experts, and 0.66% educational officers say suitable and also 45.39% director and teachers, 8.55%, 5.92% geospatial experts and educational officers respectively is say more suitable.

II. Result from respondents

Sites of school locations in Debre Birhan are selected by developing criteria?

Table 16: Result from respondents

Sites of school locations in Debre birhan are selected by developing criteria?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	87	57.2	57.2	57.2
	disagree	26	17.1	17.1	74.3
	agree	39	25.7	25.7	100.0
	Total	152	100.0	100.0	

Source (SPSS, output)

Table information shows the majority of 57.2% of respondent strongly disagree with the equations, while 17.1% disagree and 25.7% agree.

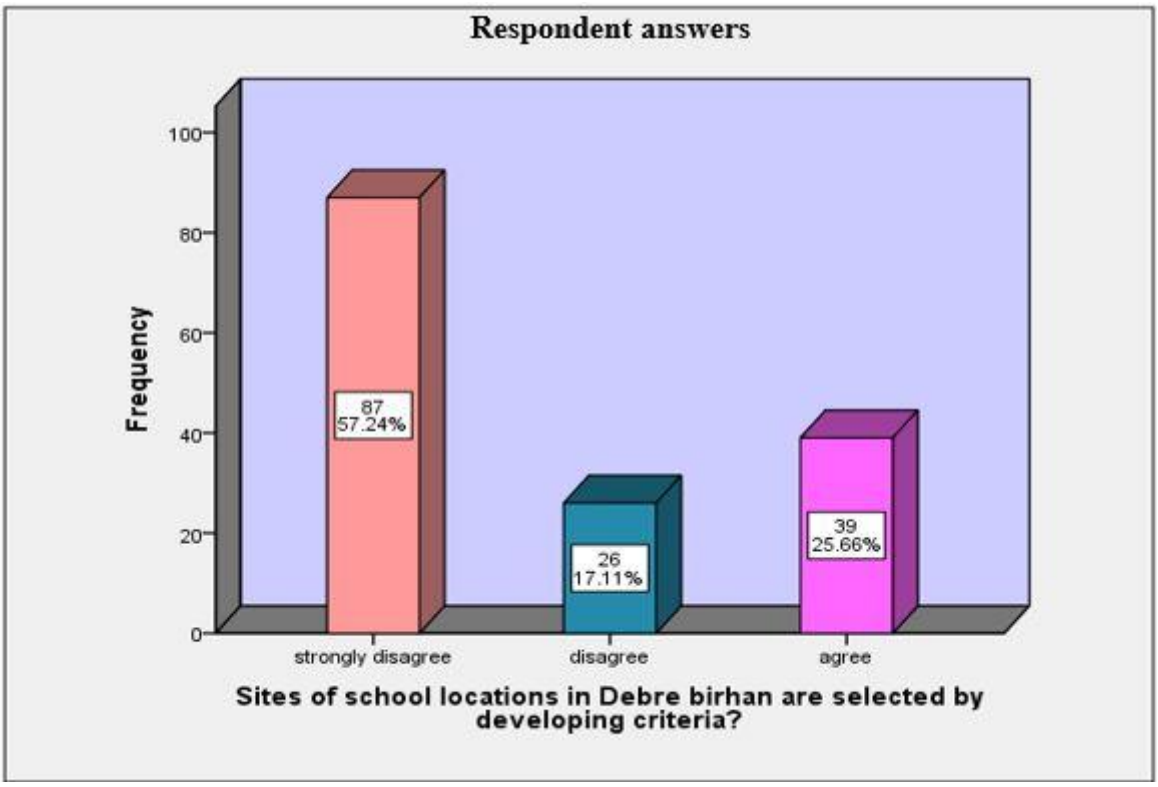


Figure 11: Result from respondents DB schools are selected by developing criteria

III. Result from respondents

Unsuitable school location can have negative impact on quality of education?

Table 17: Result school location can have negative impact in education

Unsuitable school location can have negative impact on quality of education?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	agree	2	1.3	1.3	1.3
	Strongly agree	150	98.7	98.7	100.0
	Total	152	100.0	100.0	

Source (SPSS, output)

The respondent of 98.7% present strongly agree and 1.3% are agree the result indicate the school location is mandatory for education.

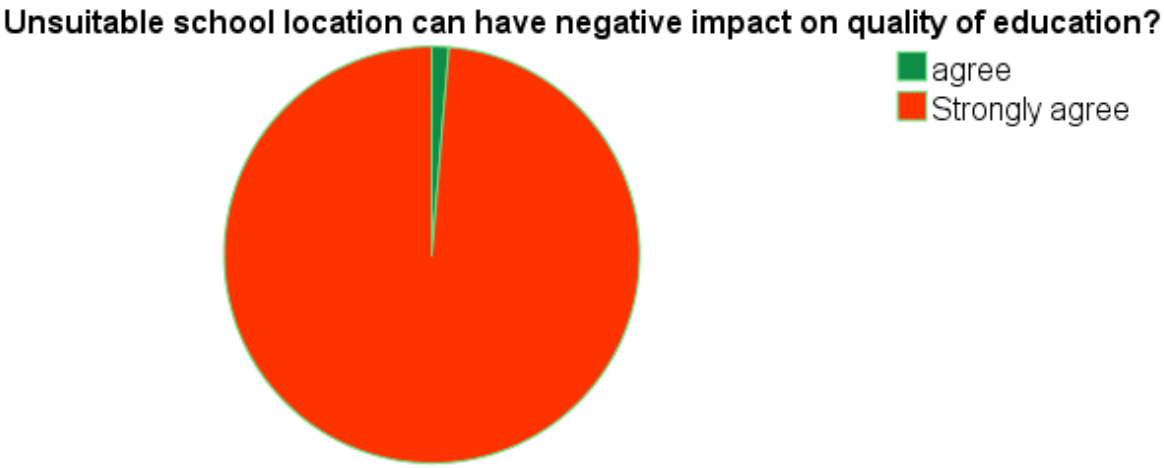


Figure 12: Result school location can have negative impact in education

The other main request is do you want to evaluate your school site suitability they all schools director and teachers are permit to evaluate the school suitability.

For all education officer schools directors and geospatial expert information was gathered about importunacy of the factor and criteria the result is show more experts says most important.

Experts rate for factors and constraints according to their importance

1= not important 2 = Moderately Important 3= Important 4 = Very Important

For the GIS analysis, the elements and limitations indicated below must be categorized and made manageable.

Table 18: Experts rate factors according to their importance

No	Factors	Level	
		states	Scour
1	Proximity to residence	Very Important	147
2	Proximity to road	Very Important	143
3	Far from commercial area	Very Important	150
4	Far from waste disposal	Very Important	151
5	Far from factory	Very Important	152
6	Far from river	Very Important	143
7	Far from Main road	Very Important	149
8	Gas station	Important	141
9	high voltage	most important	145
10	Proximity Health center	Important	143
11	slope	Important	145

These results indicate how important each of the above criteria is. Including Proximity to existing school twelve of the most crucial criteria will be used in this study.

Schools distance determinants

The experts were asked to respond to this query so that they might provide several guides to support the analysis. 68% concur that elementary schools are better suited to locations that are 400–500 meters from homes. 77% Experts agree that primary schools are >3km away from industry and 70% experts rats more than 3 km away from trash disposal.

Table 19: Proposed distance of constraints from a school

No	Factors	states	%
1	Proximity to residence	400-500 m	68
2	Proximity to road	100-200 m	79
3	Far from commercial area	300-400 m	86
4	Far from waste disposal	>3km	70
5	Far from industry	>3km	77
6	Far from river	200-300 m	65
7	Far from Main road	300-400 m	69
8	Gas station	200-300 m	56
9	high voltage	400-500 m	58
10	Proximity Health center	1km – 4km	63

When comparing the results from several guides and literature reviews, they appear to be fairly similar, however the distance between some criteria is slightly overstated. For example distance of health center according to questioners information the health center not close to elementary schools but the some way not highly far from schools to conform this two logic the stakeholders say 0-500m and >4000 not suitable and 1000m – 4000m is more suitable.

Rating three main categories

Three key criteria are rated by professionals, school administrators, and instructors. Teachers, directors, and education specialists were asked to respond to this question. Safety, accessibility, and the environment are the categories. The outcome displays the opinions of the school's director and instructors for the three major areas. They rank safety first, then accessibility, then the environment.

The experts in education's opinions on how to rank the three main groups of factors come next. They receive the same rating from schools directors and instructors. They put safety first, accessibility second, environmental third.

The third is an assessment of the three main groups of factors by geospatial professionals. They are rated equally by educational experts, teachers and school administrators. They prioritize safety, then accessibility, then the environment.

Table 20: Rate three main categories?

Please rate three main categories? * Stake holders Crosstabulation

			Stake holders			
			Educational officers	Geospatial experts	Director and teachers	Total
Please rate three main categories?	1, Environmental 2, Safety 3, Accessibility	Count	1	3	8	12
		% within Stake holders	8.3%	15.0%	6.7%	7.9%
		% of Total	0.7%	2.0%	5.3%	7.9%
	1,Safety 2,Environmental 3,Accessibility	Count	0	1	11	12
		% within Stake holders	0.0%	5.0%	9.2%	7.9%
		% of Total	0.0%	0.7%	7.2%	7.9%
	1,Accessibility 2,safety 3,Environmental	Count	2	2	33	37
		% within Stake holders	16.7%	10.0%	27.5%	24.3%
		% of Total	1.3%	1.3%	21.7%	24.3%
	1,Safety 2,Accessibility 3,Environmental	Count	9	14	68	91
		% within Stake holders	75.0%	70.0%	56.7%	59.9%
		% of Total	5.9%	9.2%	44.7%	59.9%
Total		Count	12	20	120	152
		% within Stake holders	100.0%	100.0%	100.0%	100.0 %
		% of Total	7.9%	13.2%	78.9%	100.0 %

Source (SPSS, output)

Based on the above table information 8.3% of Educational officers give first level for environmental 16.7% for accessibility and 75% for Safety, Geospatial experts rate 15% first level for environmental, 10% for accessibility and 75% geospatial experts give first level for

safety, and Director and teachers also 6.7% give to environmental first level, 65.8% is given to safety, 27.5% is give first level to accessibility. Totally 67.8 Stake holders give first level elementary schools factors for is safety.

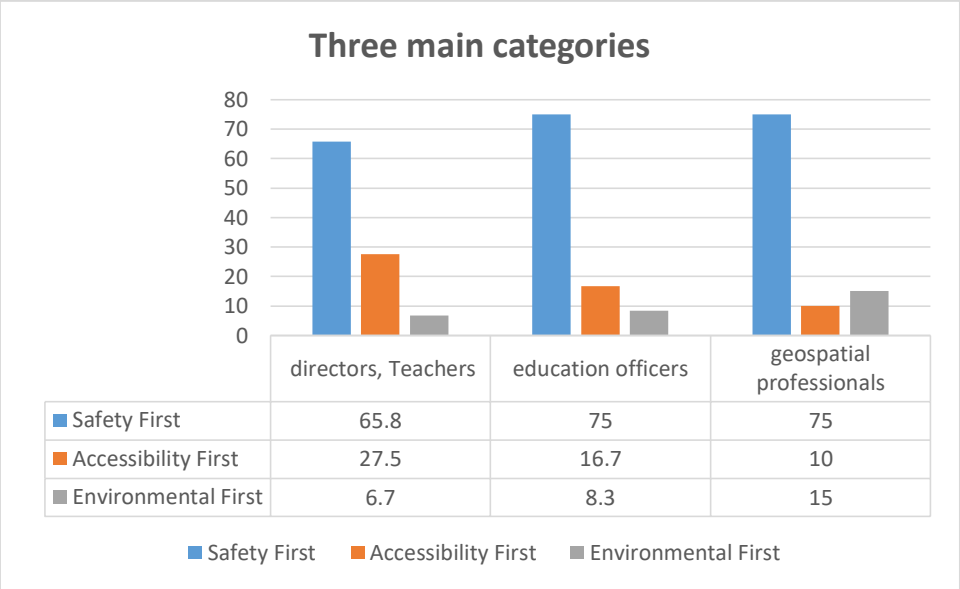


Figure 13: The level of evaluated by Stake holders

Finally all rater agree with more first level is safety that miens safety is more influenced category from others and second influenced is accessibility the rating information indicate accessibility category is medium weighted from others and also the low level is environmental category.

The total result shows in collected from stake holders fills output summary total sample is N=158 from total samples, 152 samples is valid and 6 is missing the data percent indicate 96.2% and 3.8% respectively.

Table 21: Stake holders processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Result from respondents	152	96.2%	6	3.8%	158	100.0%

Source (SPSS, output)

The table indicate from total sample distributed questioner is 158 and collected or valid is 152 in percent 96.2% and missing is 6 questioner that is 3.8%.

4.2. Final selected criteria

The identification of appropriate criteria using references from various works of literature and the Ethiopian environment was one of the goals of this study.

To get the following Suitability criteria's combined from Criteria's from literature and stakeholder's survey that are going to be used in integration. In geospatial analysis.

Table 22: Final Suitability criteria's for primary school

Factors	Units	Factors suitability rating			
		1	2	3	4
		Not suitable	Less suitable	Suitable	more Suitable
Proximity to residence	m	>2000	1500 - 2000 m	500 - 1500	0-500m
High voltage line	m	0 -150 m	150 – 300 m	300 – 450 m	>450m
Gas station	m	0 – 100 m	100 -200 m	200 – 300 m	>300 m
Industry area	m	0-500 m	500 - 1000 m	1000 -1500 m	>1500 m
Road access	m	>450m	300 m -450 m	150 – 300 m	0 -150 m
Health center	m	0 – 500 m	500 m -800 m	800 m -1000 m & >4000 m	1000 m - 4000 m
Main road	m	0 -150 m	150 -300 m	300 – 450 m	> 450 m
Existing schools	m	-	-	0-1000 m	>1000 m
Commercial area	m	0-300 m	300- 500 m	500 -700 m	>700 m
Proximity to river	m	0-50 m	50- 150 m	150 -250 m	> 250 m
Waste Disposal	m	0 – 1000 m	1000-2000 m	2000 – 3000 m	>3000m
Slope	Degree	>20	10 – 20	5-10	0 - 5

These results evaluated each other's than crate Euclidian distance analysis according to the factors criteria and categorized in to three safety, accessibility and environmental groups for used geospatial technology analysis after crate Euclidian distance analysis resale the weight calculated by AHP and give the weight each category's by the pairwise comparison method to produce finale suitability map. To proposed new suitable site for elementary schools additionally incorporate the Debre birhan structural plan land use for select more reliable and implemented schools site.

4.2.1. Evaluate defined criteria

Hierarchical structures served as the foundation for the model structure used to determine potential locations for schools. Hierarchical structures divide each criterion into more manageable categories. The most broad goal is found at the highest levels, and it can be further defined at lower levels.

4.2.2. Create criteria feature with integration of Geospatial technology

One of objective this theses is show haw integrated geo spatial software are integrated Factors of suitability is not have the data in SP, feature line, base map, and also ortho photo this feature collected by surveying. One of factor for suitability elementary school are gas station so prepared the map for analysis must be selected from geo database but one of gas station located in Tebasa sub city that feature shape is note have in line feature and ortho photo so collect the data at filed by using South GNSS instrument, RTK system the RTK job reference system is Adindan UTM Zone 37 before collect topography data first believed that reference bench mark (BM) are not have error. The collected gas station topography data downloads from south controller in format of CSV for integrated GNSS data in to ArcMap 10.8.2.

Table 23: Point coordinate data

Point ID	X (Easting)	Y (Northing)
1	554876.837	1064019.827
2	554924.18	1064034.076
3	554933.745	1063974.296
4	554886.401	1063960.049

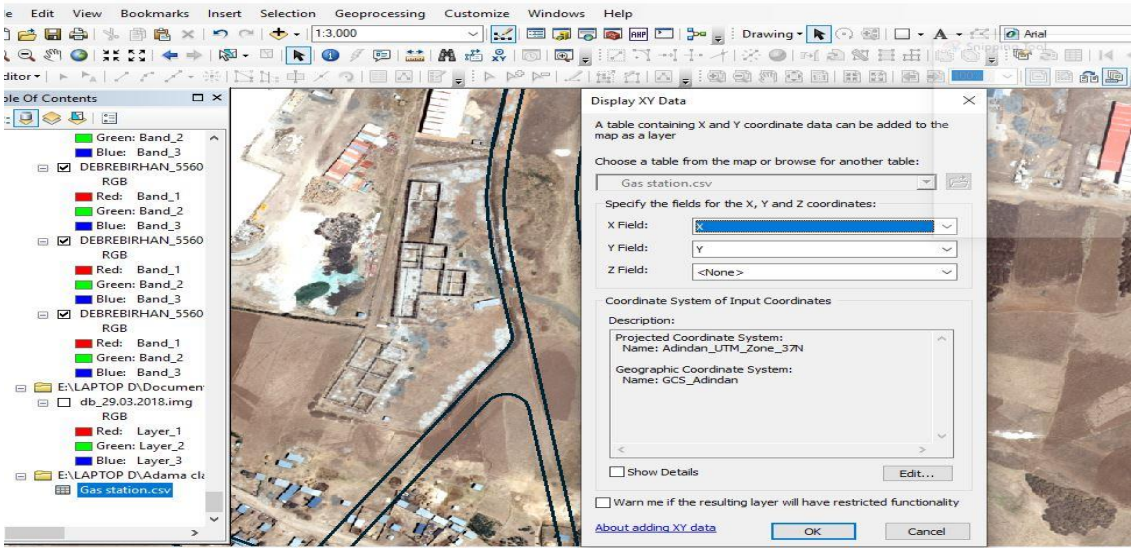


Figure 14 : Display excel X,Y data on GIS.

The above figure is showed in ArcMap and on personal Geodatabase crate feature dataset and fixed on reference system is Adindan UTM Zone 37 then crate feature class by name gas station add on ArcMap the CSV file format point data final stapes.

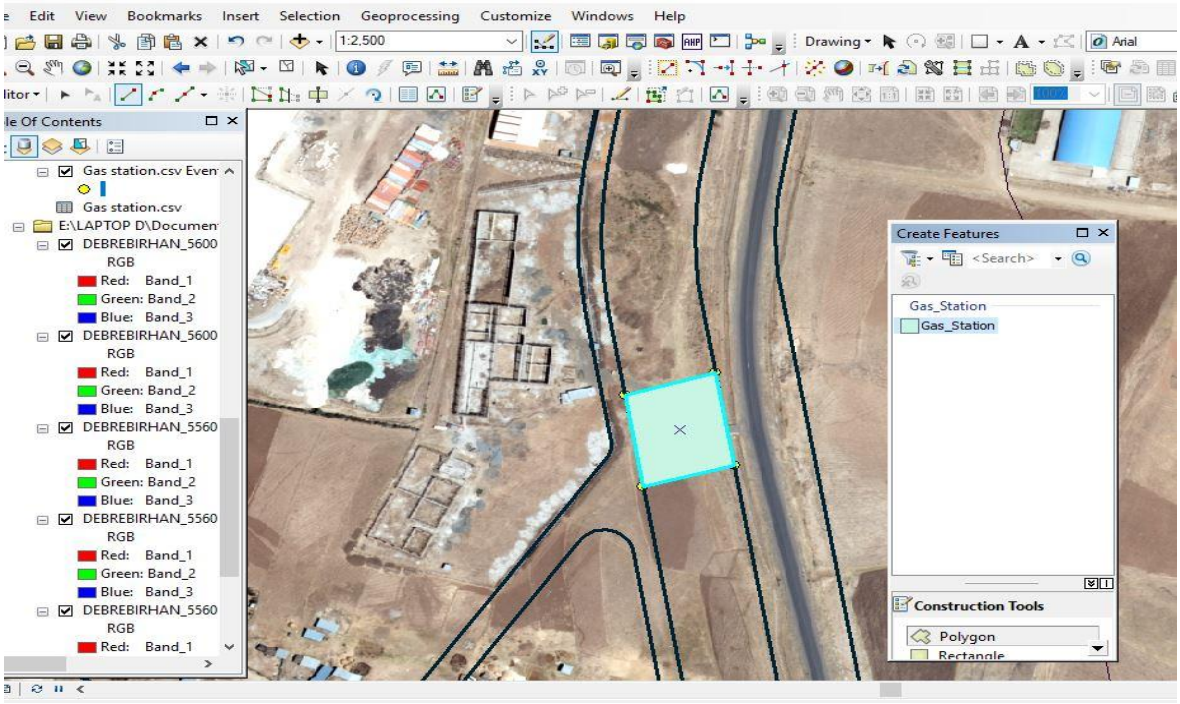


Figure 15 :Digitayezed by polygon

The figure shows the point is label in ArcMap display window when after assayed easting and northing field finally using feature class of gas station digitayezed by polygon the gas station area is looks in light gray.

4.3. Data processing

Each layer is processed in accordance with the appropriateness criteria in ArcGIS by creating a model using ModelBuilder after computing the weight using AHP in pair-wise comparison. A map is then generated for each layer. ArcGIS receives all of the suitability criteria as layers.

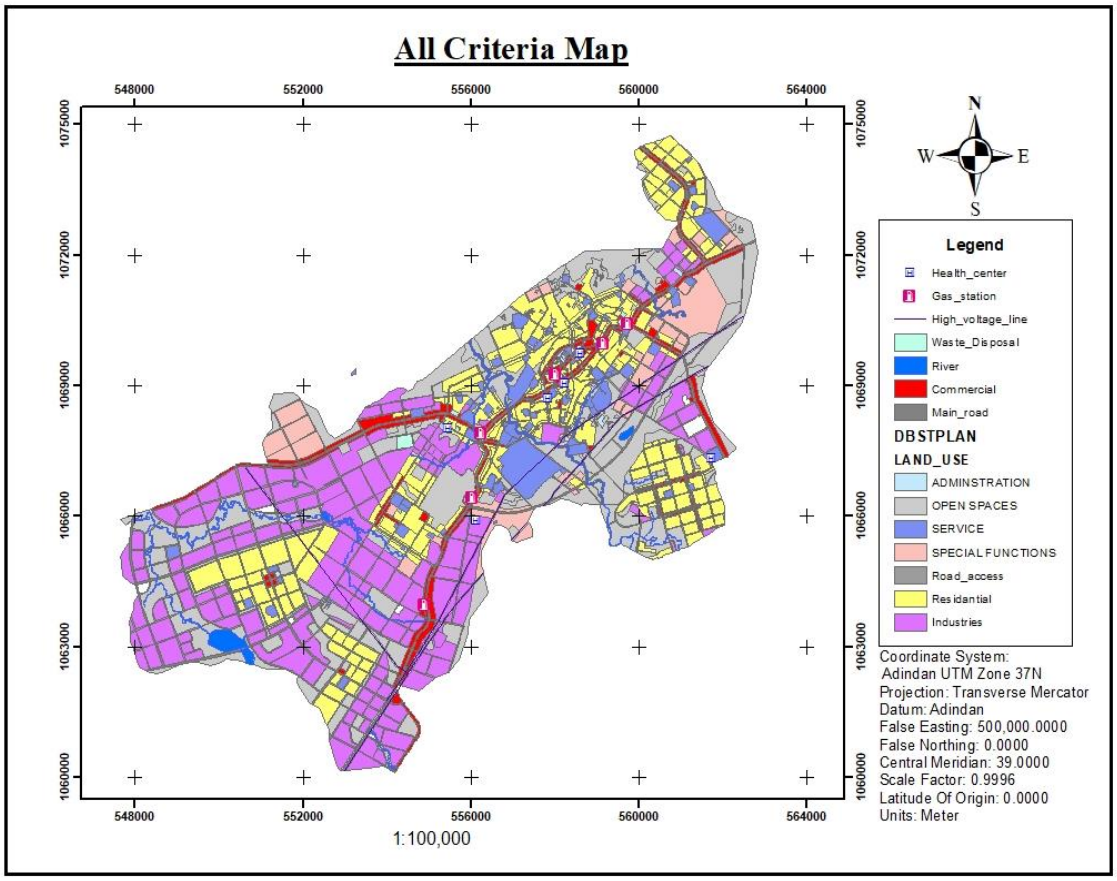


Figure 16: Criteria Map

The map contains all health center, gas station, high voltage line, waste disposal, river, commercial, access road and main road from the town structure plan land use are contains this all features are factures of elementary schools the map coordinate system is adindan UTM zone 37N.

Distance from industrial area

A school should be located far from industrial area. Noise, air prolusion, heavy vehicular traffic, ground water and surface water contamination, accidental release of hazardous chemicals are the some of the safety risks to the school (EPA, 2011).

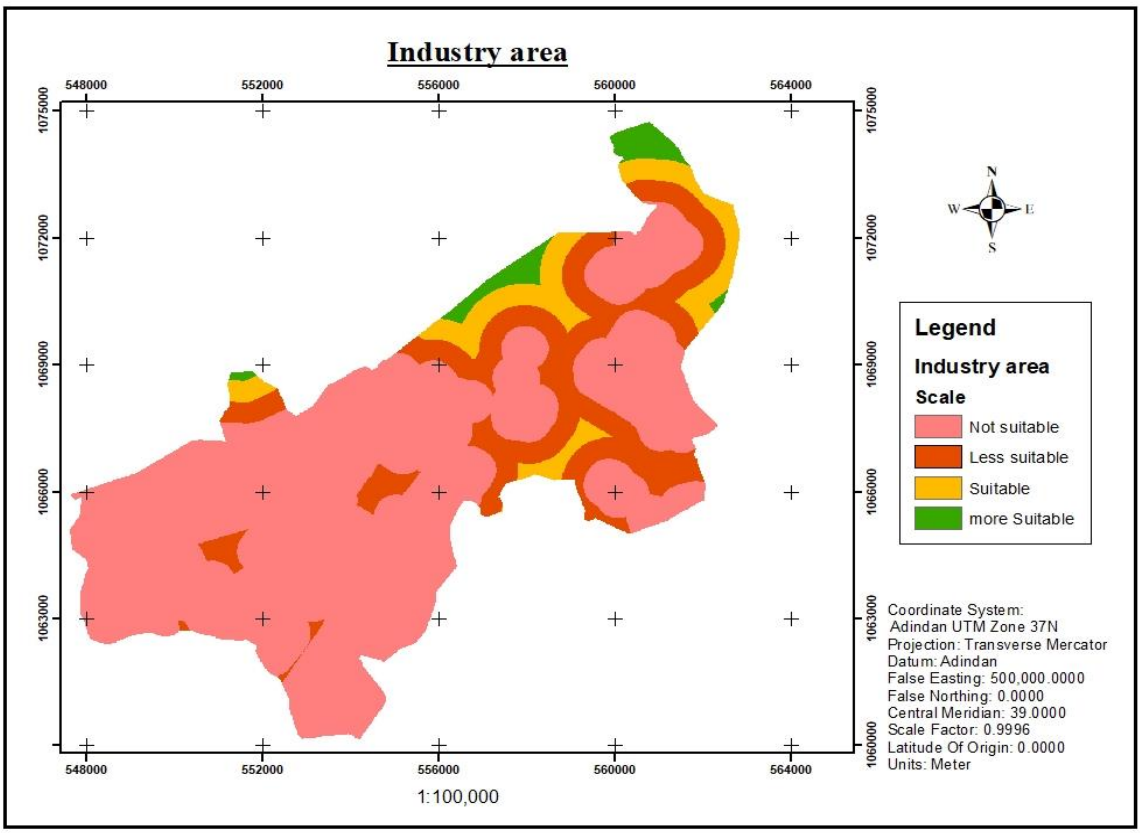


Figure 17: Industry Suitability Map of Debre Birhan.

Distance from main roads

Busy road is a constraint for suitable school location. Because heavy tracks as well as small cars could make unwanted noise, air prolusion, and students could be vulnerable to car accident (EPA, 2011). A more suitable and suitable school should be located >450 m and 300-450m far from main road respectively. 0-150m and 150 - 300 m are classified under not suitable and less suitable respectively.

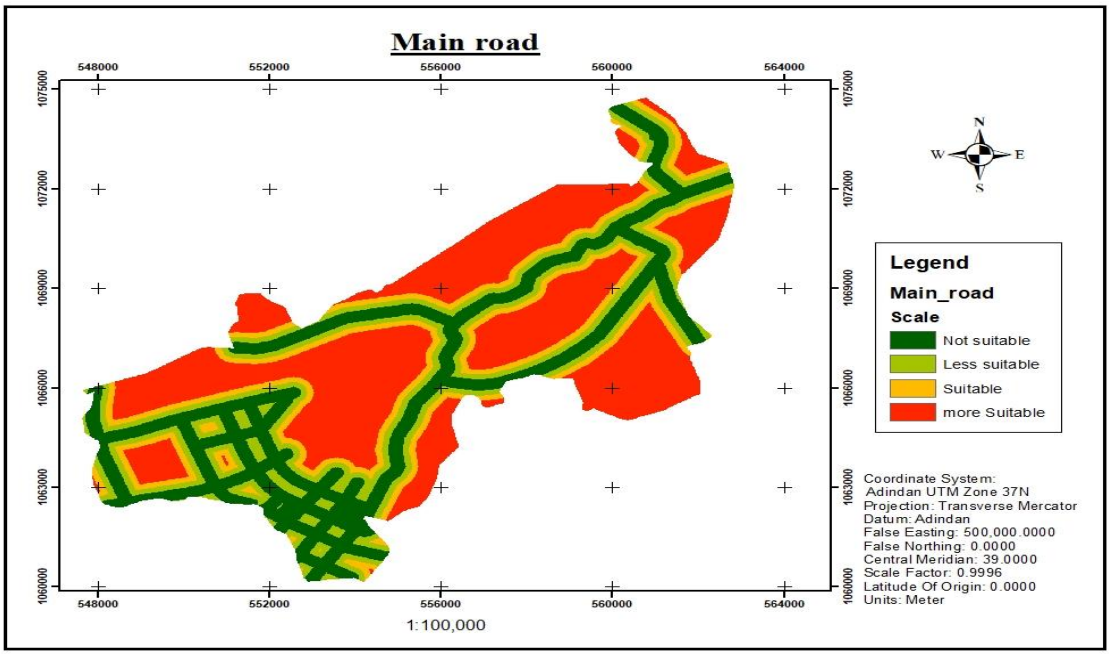


Figure 18: Main road Suitability Map of Debre Birhan.

Distance from gas stations

A school should be located as much as far from the gas station. The risks are: air prolusion, soil and water contamination, heavy traffic noise, explosion and others (EPA, 2011). As in the school suitability criteria table mentioned more suitable and suitable school should be far from the identified gas station greater than 300m and 200 – 300m respectively.

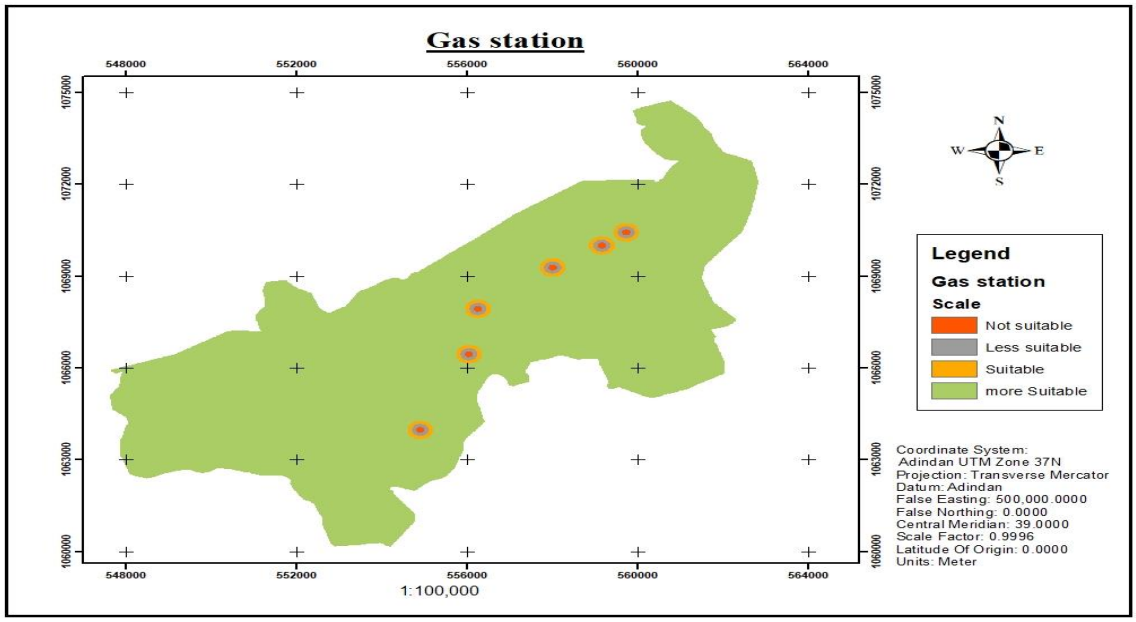


Figure 19: Gas station Suitability Map of Debre Birhan.

Distance from high voltage line

Risks from high voltage transmission lines exist for kids, faculty, and other school personnel. The risks include exposure to electromagnetic fields and abrupt power line failures. Therefore as in different guides mentioned school should be far > 450 m and 300 -450 m from high tension power line to be most suitable and suitable respectively.

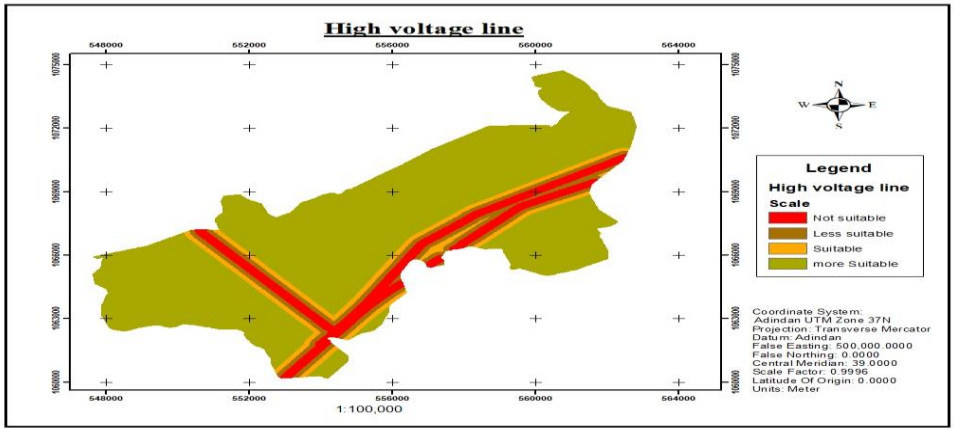


Figure 20: High voltage Suitability Map of Debre Birhan.

Proximity to residence

The location of elementary schools in relation to residences is an important consideration for parents who want to ensure the safety and accessibility of their children's education. Most parents prefer an elementary school that is close to home, as it reduces the time and costs associated with commuting. Additionally, schools that are closer to home make it easier for parents to be involved in school activities and events.

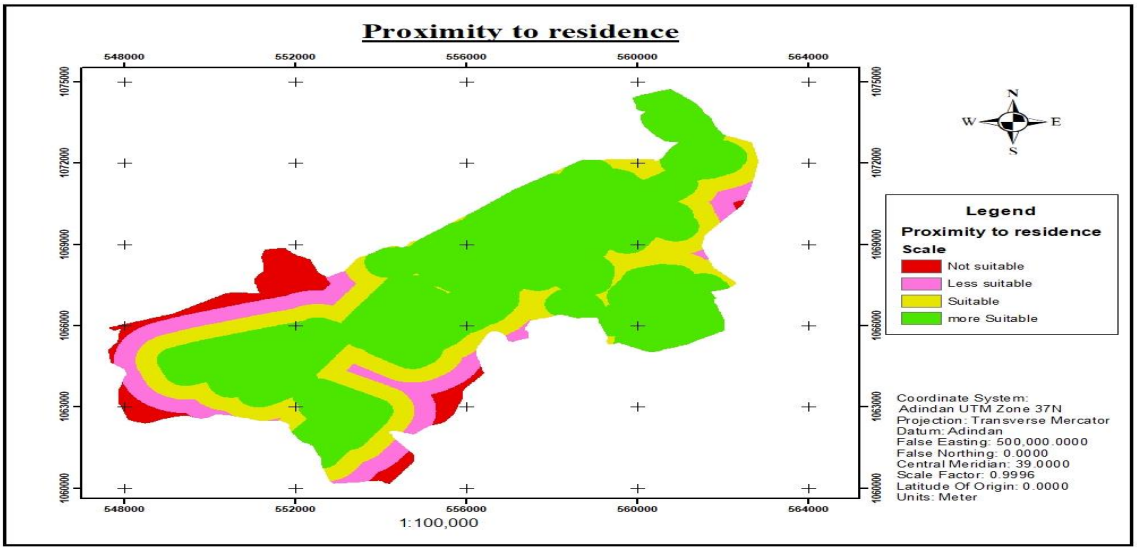


Figure 21: Proximity to residence Suitability Map of Debre Birhan.

Proximity to road

Evaluate site access options. Access to the school site from minor arterials and collectors is more compatible than access from high speed or high volume road corridors or a low volume neighborhood residential street. Consider traffic speed and volume at the point of driveway access. (State of Alaska, Site Selection Criteria and Evaluation Handbook, 2021)

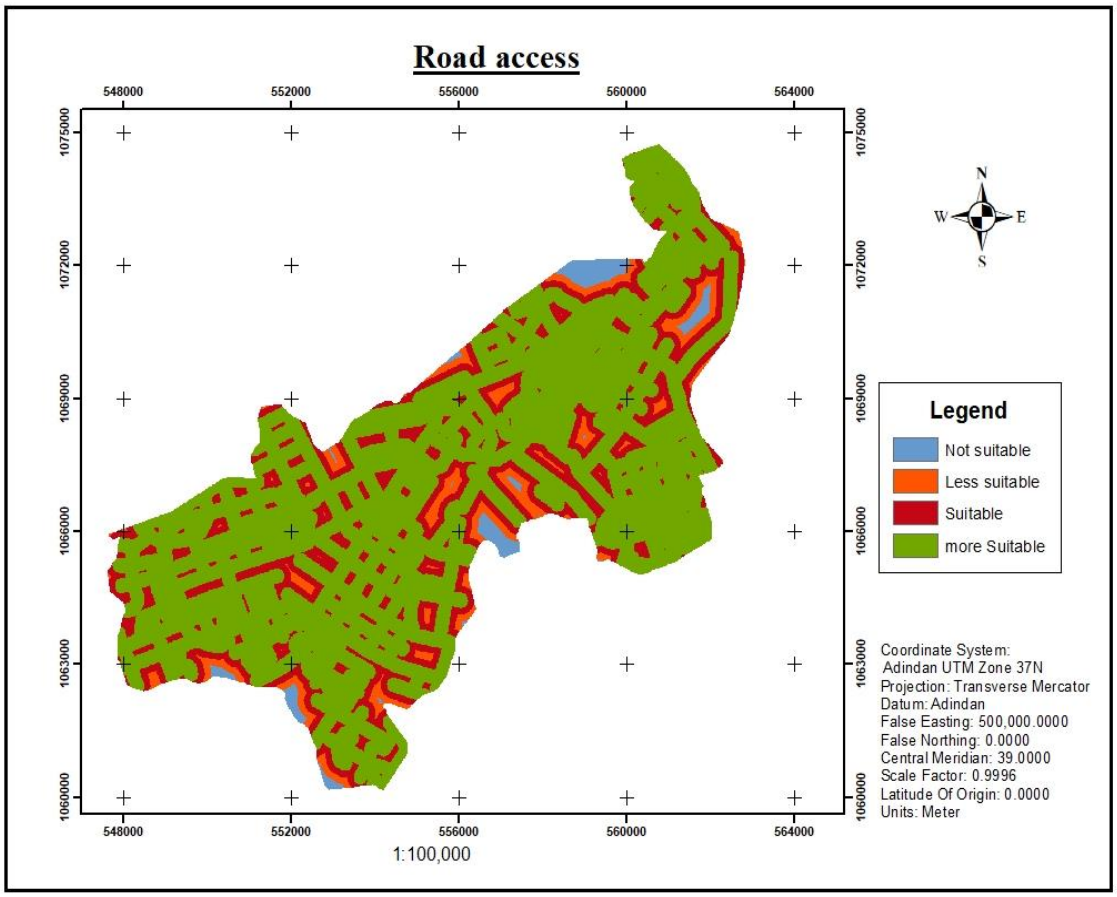


Figure 22: Road access Suitability Map of Debre Birhan.

Proximity to Health centers

It is recommended that schools should be located within easy reach of a health center in case of any health emergencies or for regular checkups. Health centers also not close to elementary schools and not also far fearless from schools location is that health center may be close the students' opened to accident for air transfer disease and also may be far fearless the students not arrived on time in emergencies. In this thesis from 1000m-4000m are more suitable and 800 m -1000 m & >4000 m are suitable.

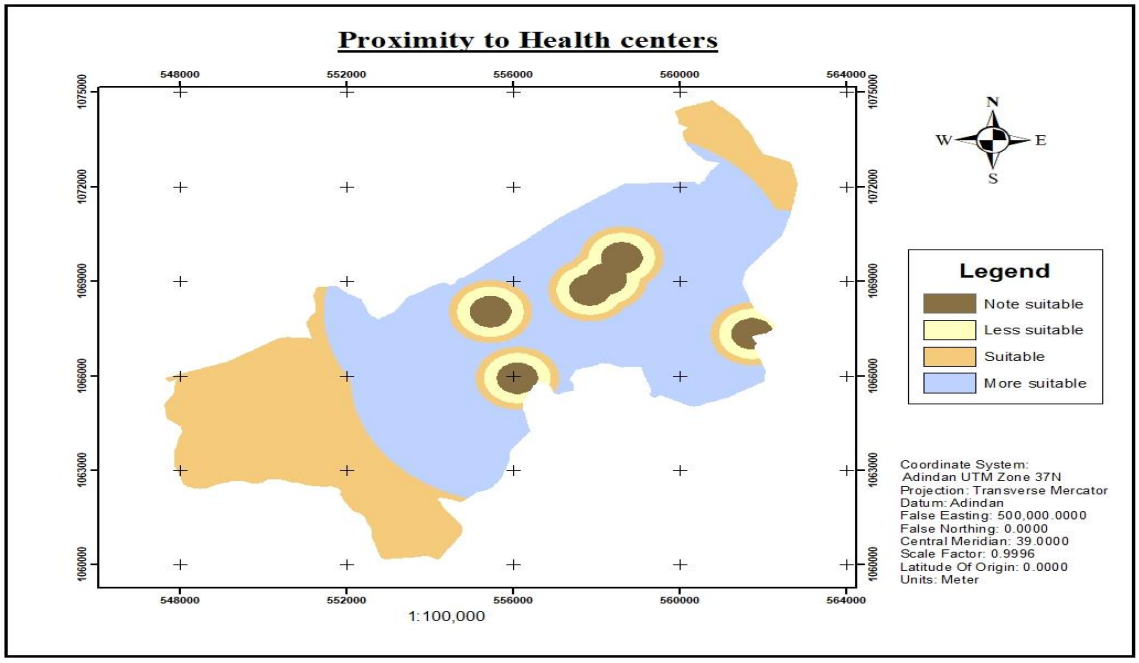


Figure 23: Health centers Suitability Map of Debre Birhan.

Slope suitability map

A good school site is on a fairly level piece of land so that kids may play comfortably, have easy access to schools, and the expense of construction is minimized.

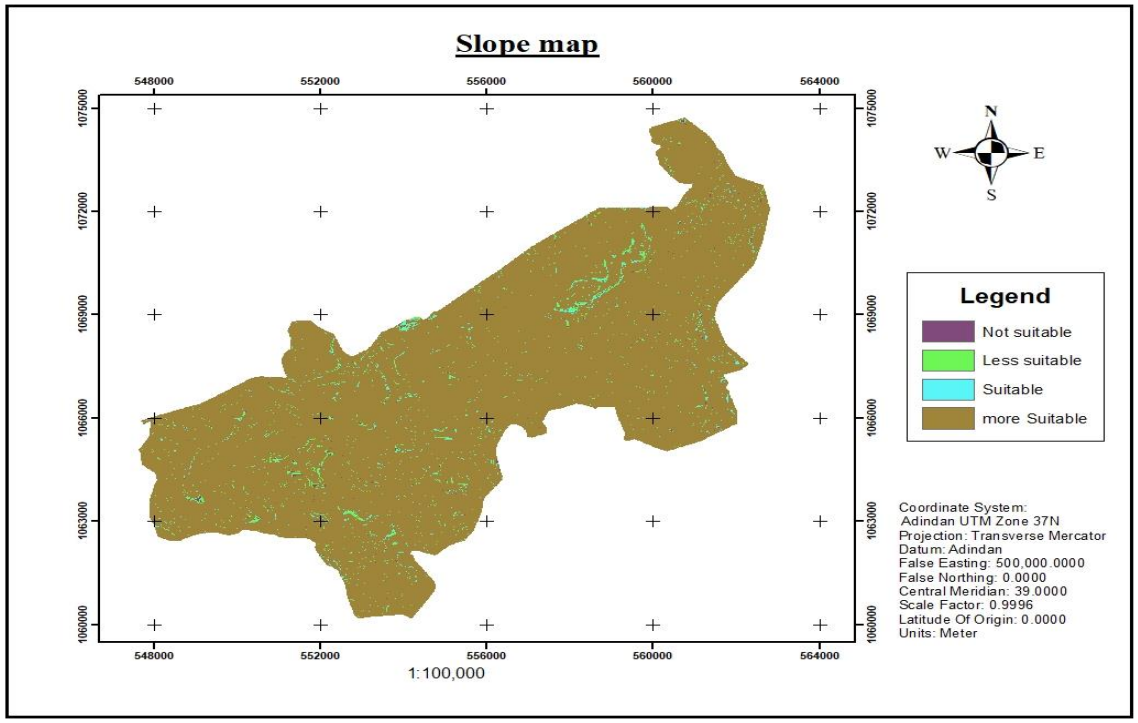


Figure 24: Slope Suitability Map of Debre Birhan.

Distance from Waste Disposal

Waste disposal in elementary schools can have a significant impact on both the environment and the health of students and staff. The distance of waste disposal sites from elementary schools is a key factor to consider when it comes to minimizing the risk of exposure to harmful pollutants and toxins. In general, it is recommended that waste disposal sites be at least a 3km away from schools to ensure the health and safety of students and staff members.

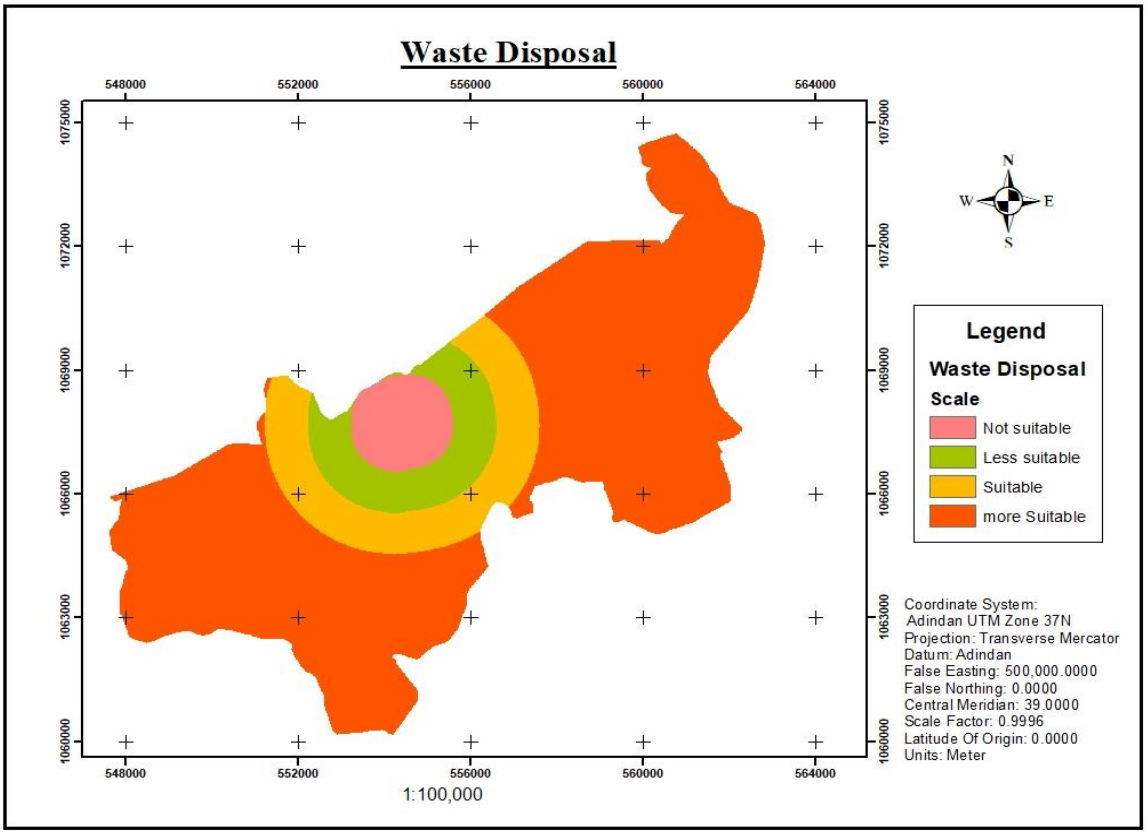


Figure 25: Waste disposal Suitability Map of Debre Birhan.

Distance from Commercial area

A commercial area or business area is a part of a city or town that is primarily occupied by businesses, such as offices, shops, restaurants, and service providers. It is typically characterized by high levels of commercial activity, infrastructure and facilities that provide to the needs of businesses and their customers, and a compact concentration of commercial buildings.

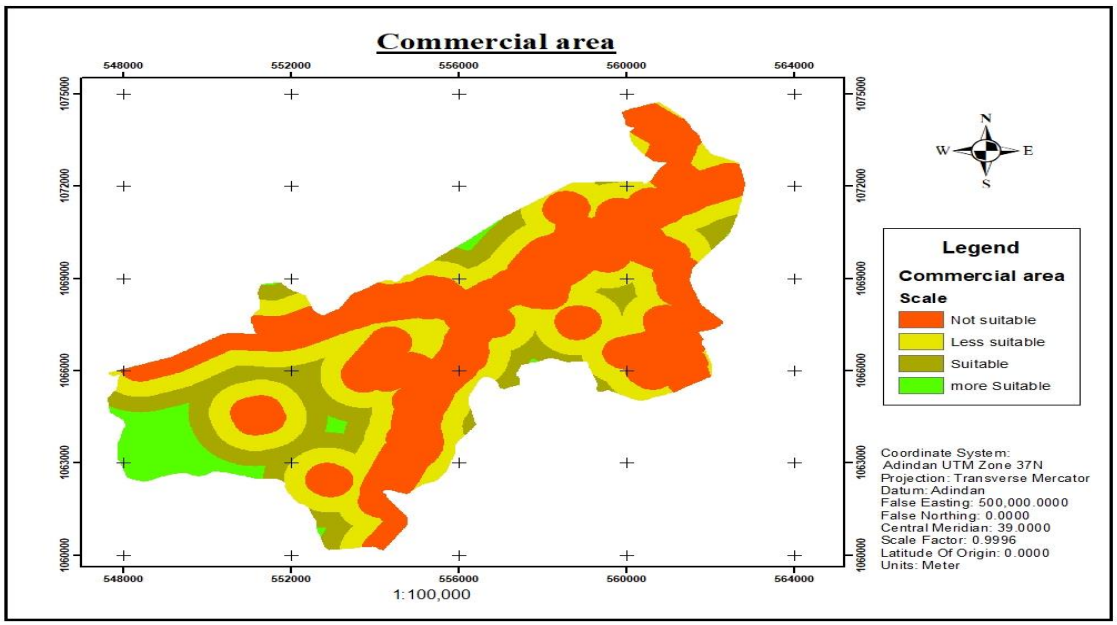


Figure 26: Commercial area Suitability Map of Debre Birhan.

Distance from river

An elementary school that is located far from a river would be a safe location for students. Some advantages of having a school situated away from a river is reduced risk of flooding and improved air quality. According the image output 0-50m is not suitable 50-150m is less suitable 150-250m suitable and also >250m is more suitable results.

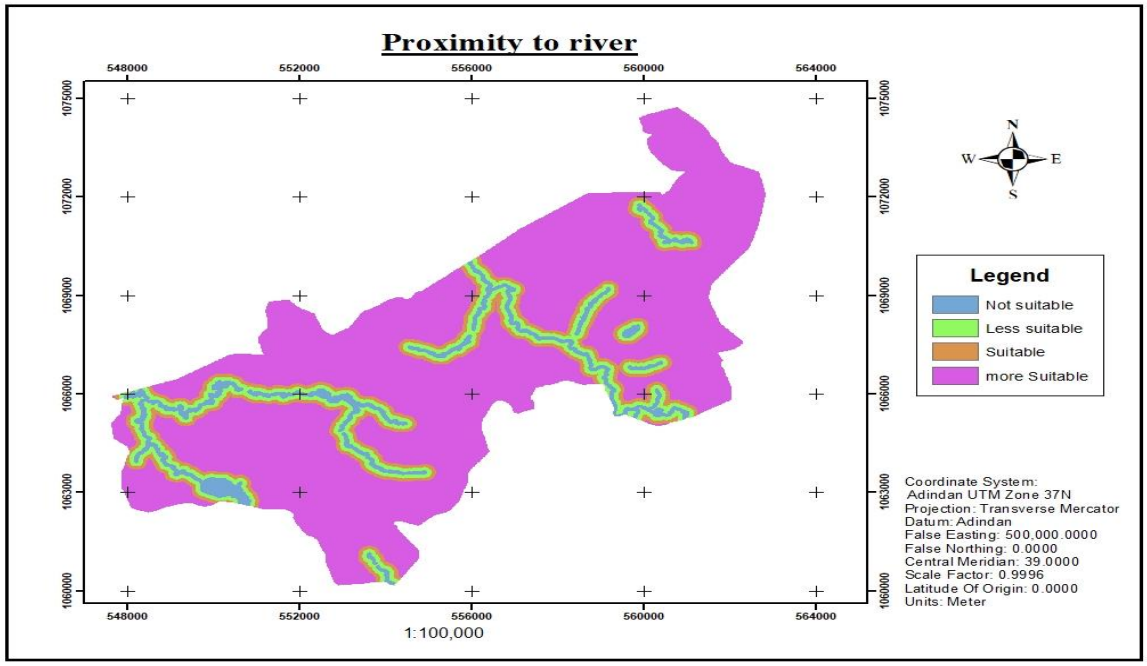


Figure 27: Proximity to river Suitability Map of Debre Birhan.

Existing sites of elementary schools

The existing site of elementary schools may far ones to others, it is recommended that elementary schools be located within easy walking or biking distance for the communities they serve. The distance of existing elementary schools ones to others is generally considered to be within a radius of 1000 meters is suitable and also above 1000m is more suitable, this distance is of schools dependent on the population density of the area.

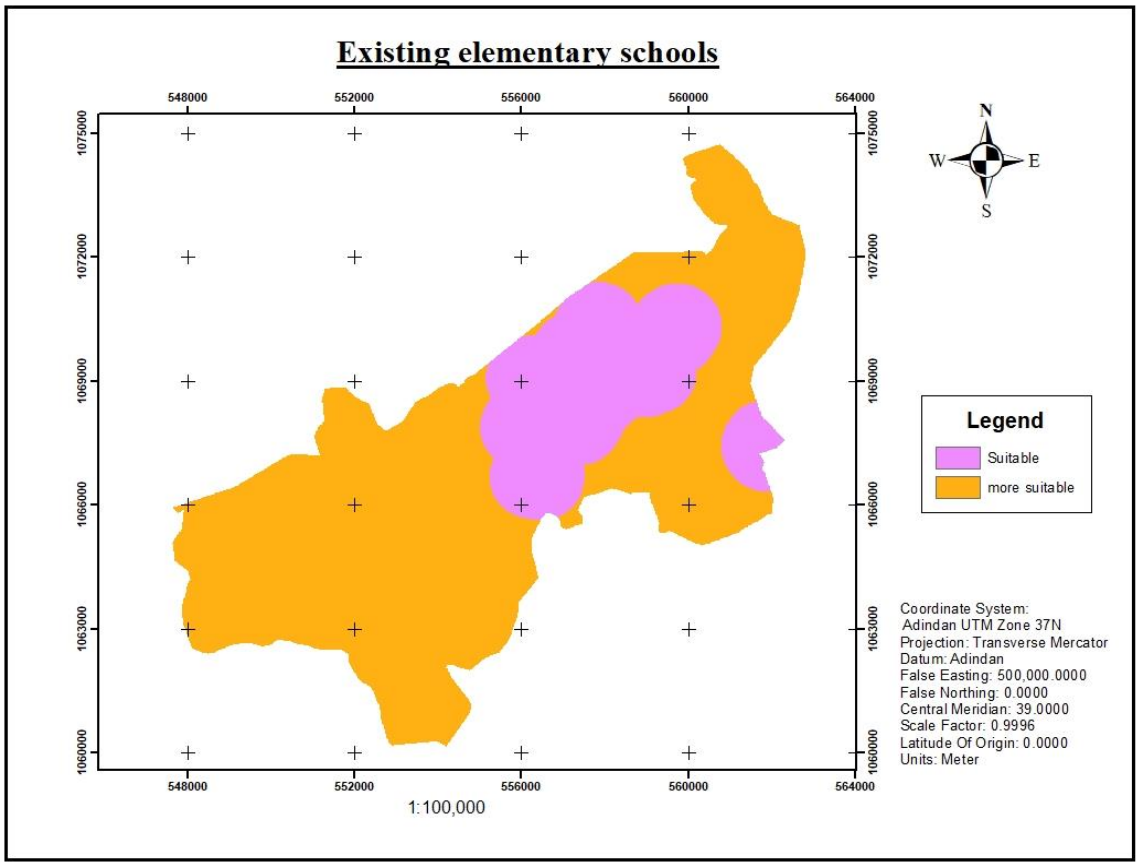


Figure 28: Existing elementary schools Suitability Map of Debre Birhan.

4.4. Safety factors model and map

4.4.1. Safety factor model

To create the final safety map, all four safety variables are layered according to their influence. The final map was created using Euclidian distance, reclassify, mask, extent, and overlay.

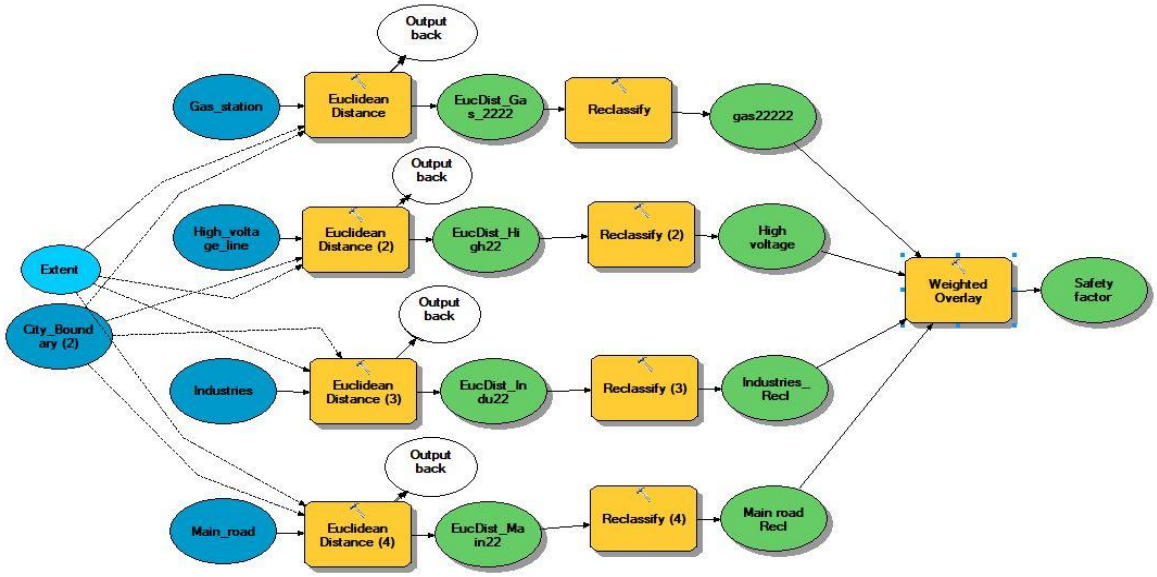


Figure 29: Safety factor model

4.4.2. Safety factor map

Safety factors is one of category this category have four criteria they are far industry, main road, gas station, high voltage line the weight of criteria is 47%,30%,14%,9% respectively. The weight is proposed from review and Geomatics experts and educational officer.

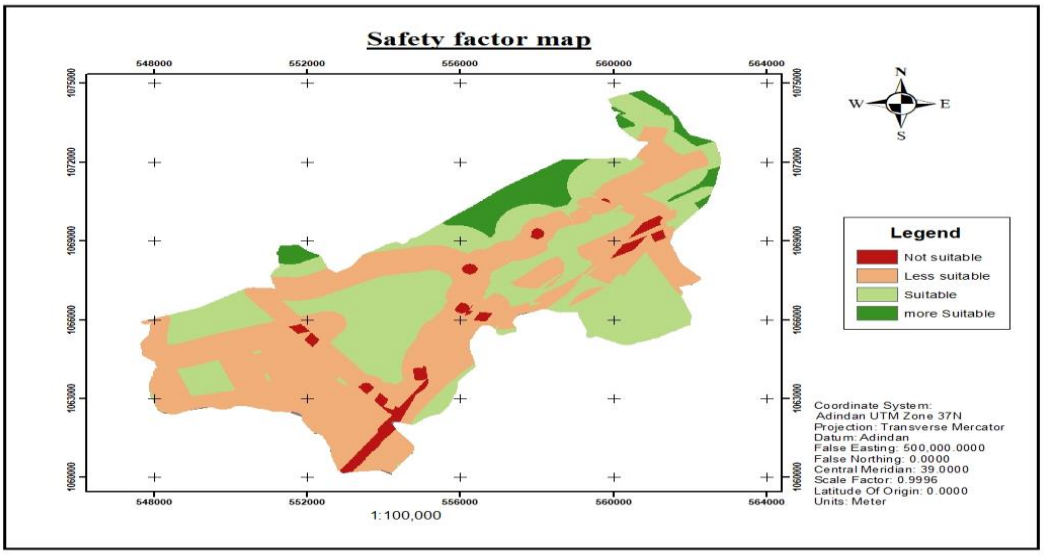


Figure 30: Safety factor map

4.5. Accessibility factors model and map

4.5.1. Accessibility model

Accessibility model is used to produce by overlaying access to roads, health facilities, and slopes. Access to a road (57), a health center (29), and a slope (14) have more of an impact in this model, respectively.

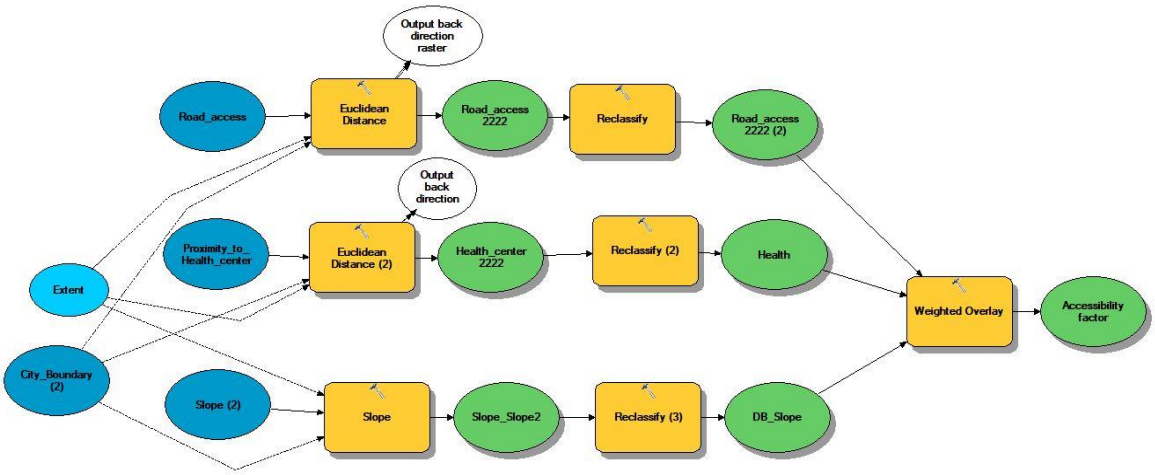


Figure 31: Accessibility model

4.5.2. Accessibility factor map

The model builder overlays the accessibility elements, such as road access, access to medical facilities, and slope, to create a single useful map.

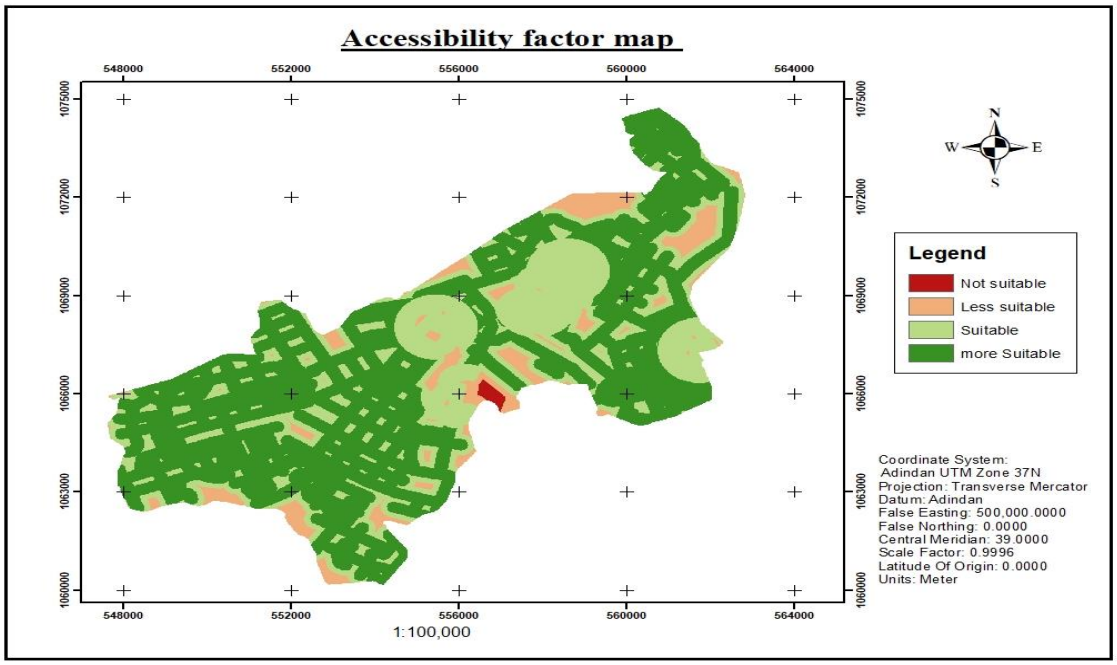


Figure 32: Accessibility factor map

4.6. Environmental factors model and map

4.6.1. Environmental factor model

All three Environmental variables are overlaid in accordance with their influence to produce the final Environmental map. Euclidian distance, reclassification, mask, extent, and overlay were used to generate the final map.

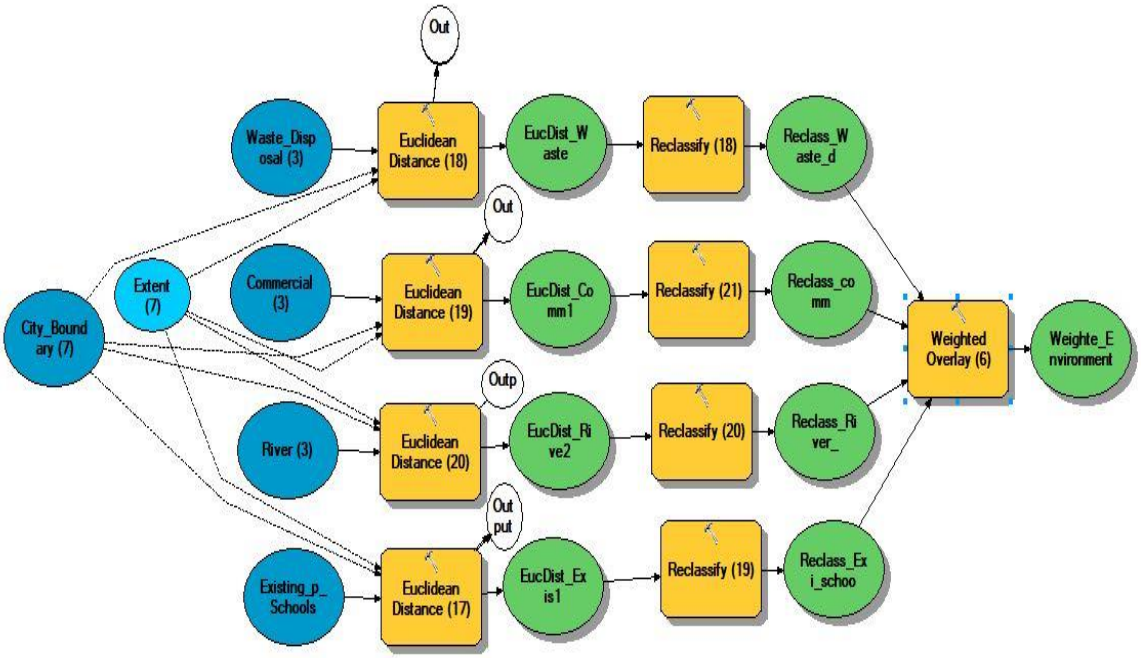


Figure 33: Environmental factor model

4.6.2. Environmental factor map

Waste disposal (44), commercial area (26), river (20) and distance from existing school (10) are four environmental factors that have produced maps that are combined according to their influence to produce one useful map. To create a map that is acceptable for the environment, the model builder's weighted overlay tool was employed.

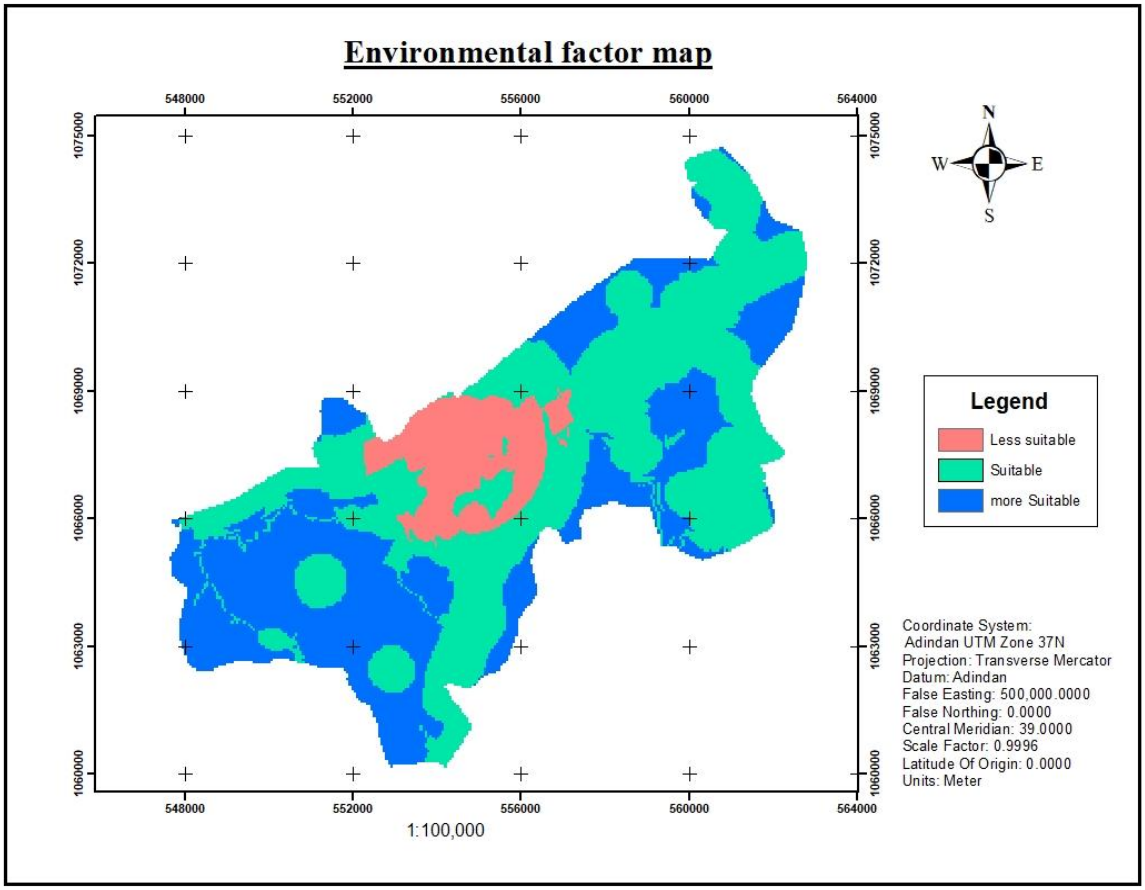


Figure 34: Environmental factor map

4.7. Final suitability map Result

4.7.1. Final suitable model

The model crated to create the final suitability map, this model combined the results from the three models for safety, accessibility, and environmental impact.

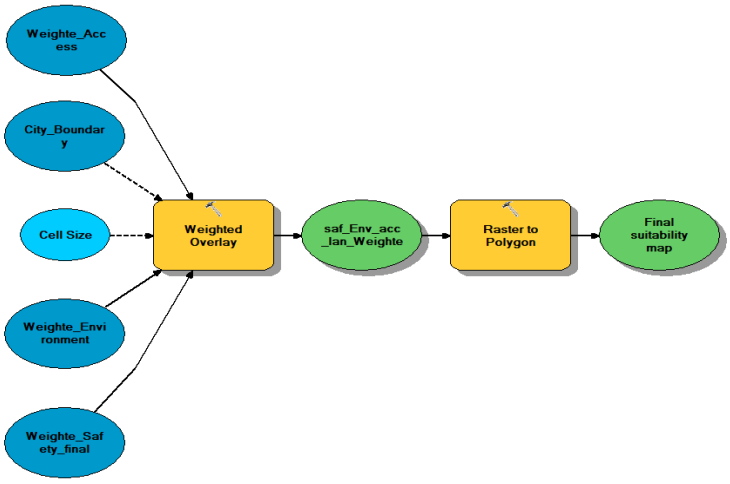


Figure 35: Final suitable model

4.7.2. Final suitability map

Using the weight overlay tool in modelbuilder, all three key suitability factor categories safety, accessibility, and environmental are superimposed in accordance with how much influence each has on the other to create a single final suitable map. The hypothesis section suggested that the most important determining factor for a school's suitability could be the safety factor, Accessibility factor and Environmental factor the influence is 68,18and 14.

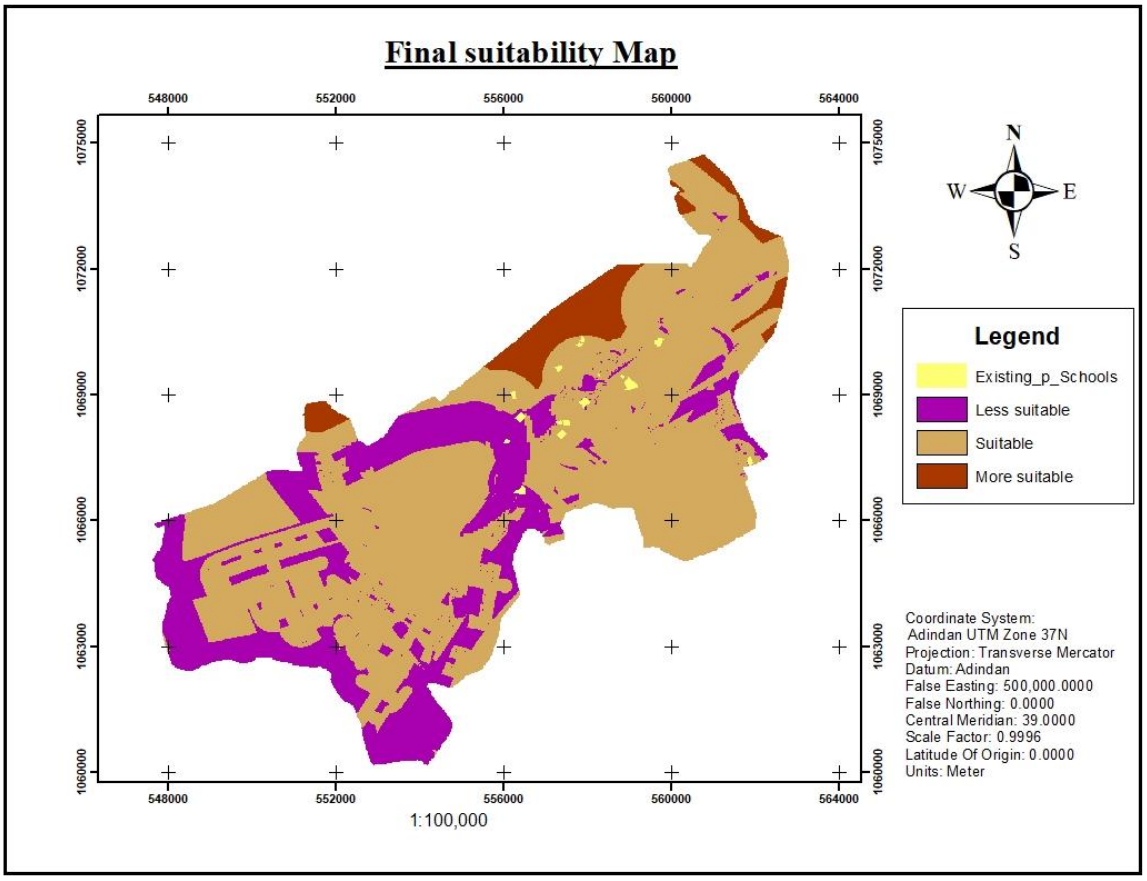


Figure 36: Final suitability map

4.7.3. Existing Schools suitability result

It is simple to determine the suitability status of existing schools after the school polygon has been overlaid on the final suitability map. Schools can be located by utilizing the pick by location feature. According to the final findings, there are not fail in more suitable and not suitable area of the schools are located in more suitable places, 72% are in suitable areas, and 28% are in less suitable areas.

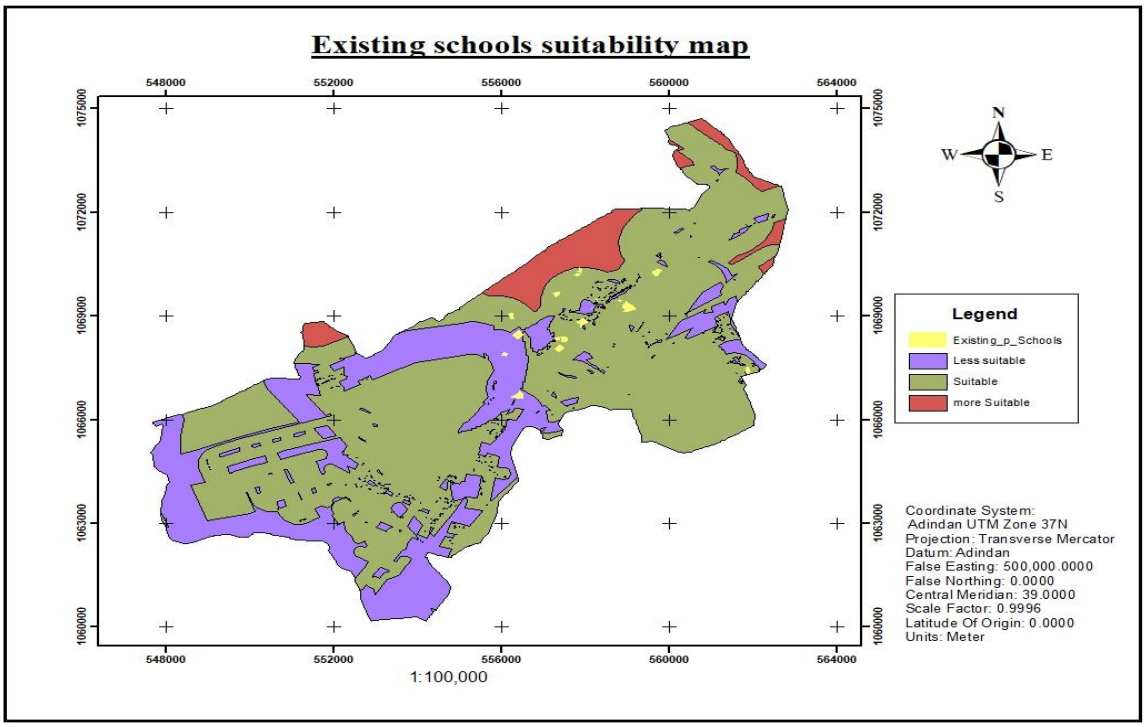


Figure 37: Existing Schools suitability map

Table 24: Existing Schools suitability result

No	Name	Student no	Status
1	Abune Gorgoriyos	1186	Less suitable
2	Abune Ephrem	411	suitable
3	Afewerk tefera	49	suitable
4	Andinet	1530	suitable
5	Atakelet	146	suitable
6	Ats Zerayekob	853	suitable
7	Berana youth	268	Less suitable
8	Biruh tesfa	1030	suitable
9	Devayen providens	748	suitable
10	Kaleyat Akadami	140	suitable
11	meliekit Acadamey	350	Less suitable
12	Milinium Acadamey	350	suitable
13	Model no 1	723	suitable
14	Model no 2	625	suitable
15	Selam chora	66	suitable
16	Sorisa	726	suitable
17	Tebassie Medhanialem	1478	Less suitable
18	Victryu	193	Less suitable

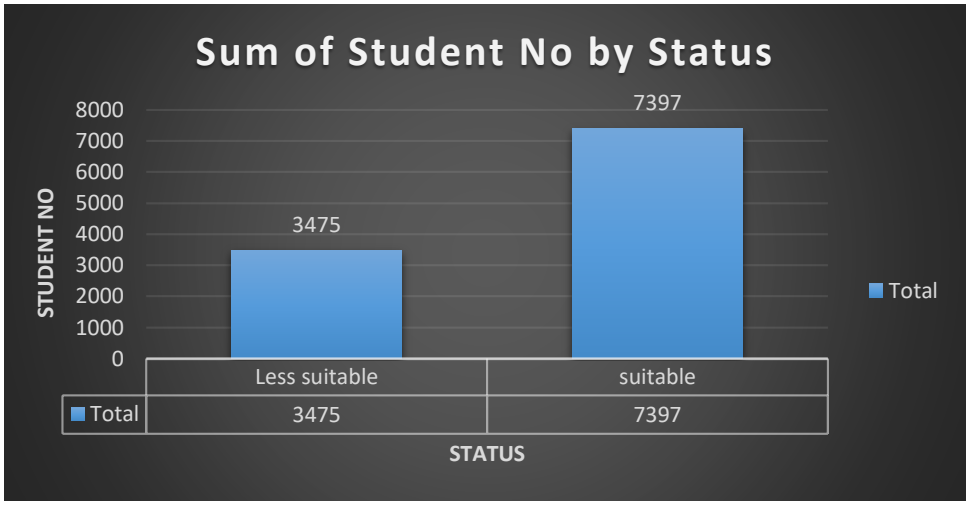


Figure 38: Student suitability states

4.8. New proposed school sites

4.8.1. New proposed site school model

Current and projected zoning and land use should be compatible with the use of the site for a school. If local regulations do not currently permit educational facilities, it could be a lengthy process to obtain a change in zoning or a conditional use permit. Evaluate this criterion according to the difficulty and associated risk. (State of Alaska, Site Selection Criteria and Evaluation Handbook, 2021)

The three suitable factors category and land use is the new proposed site school model

Concatenates in order to select the new suitable sites. Not suitable and less suitable from the three categories are restricted. From land use commercial area, industry area, landfill, forest and administration are restricted. More scale value is given to vacant area.

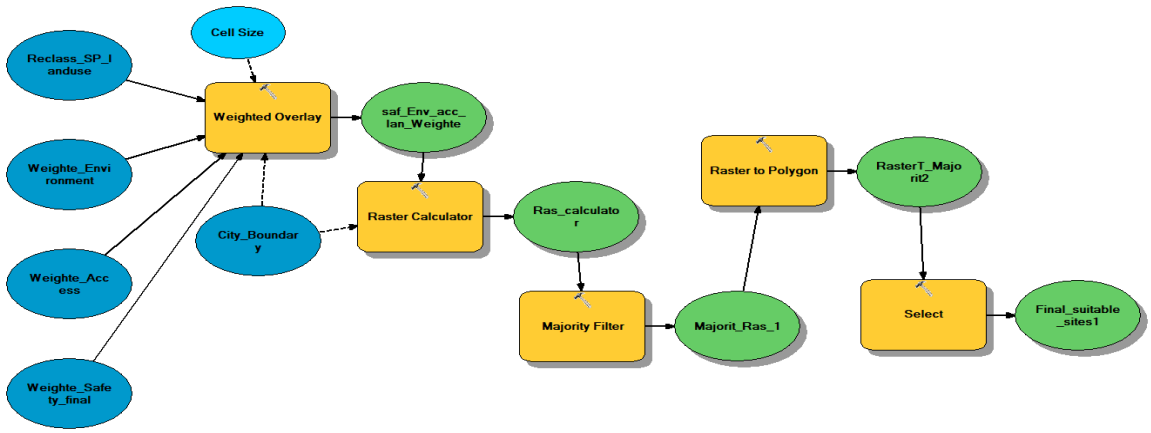


Figure 39: New proposed school sites model

4.8.2. New proposed suitable school sites

The next duty is to identify new suitable site schools based on the objective after examining the suitability of the existing schools. The new suitable area for elementary schools should fulfill all the requirement criteria's used to evaluate the existing schools. Area of the school site should be with in 15000m^2 up to 25000m^2 to be used for primary school. Additionally, it should be as far away from the existing school location. Although 95 sites were developed as a result of the model builder process, the best ones are highlighted in red circles.

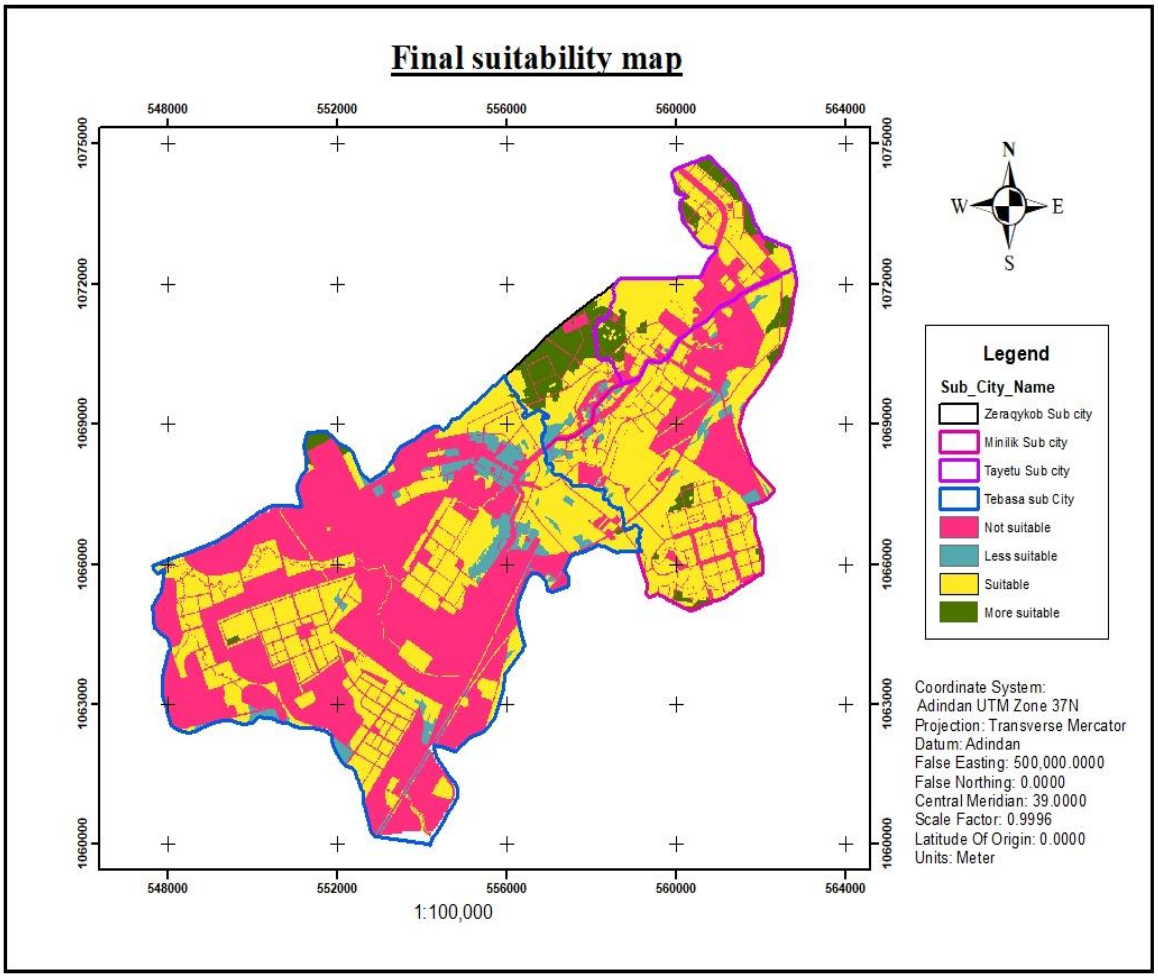


Figure 40: New proposed suitable school sites final Map

Additionally, it should be as far away from the existing school location. Although 95 sites were developed as a result of the modelbuilder process, the best ones are highlighted in red circles this all sites are on structure plan land use is residential but the selected area are not transfers.

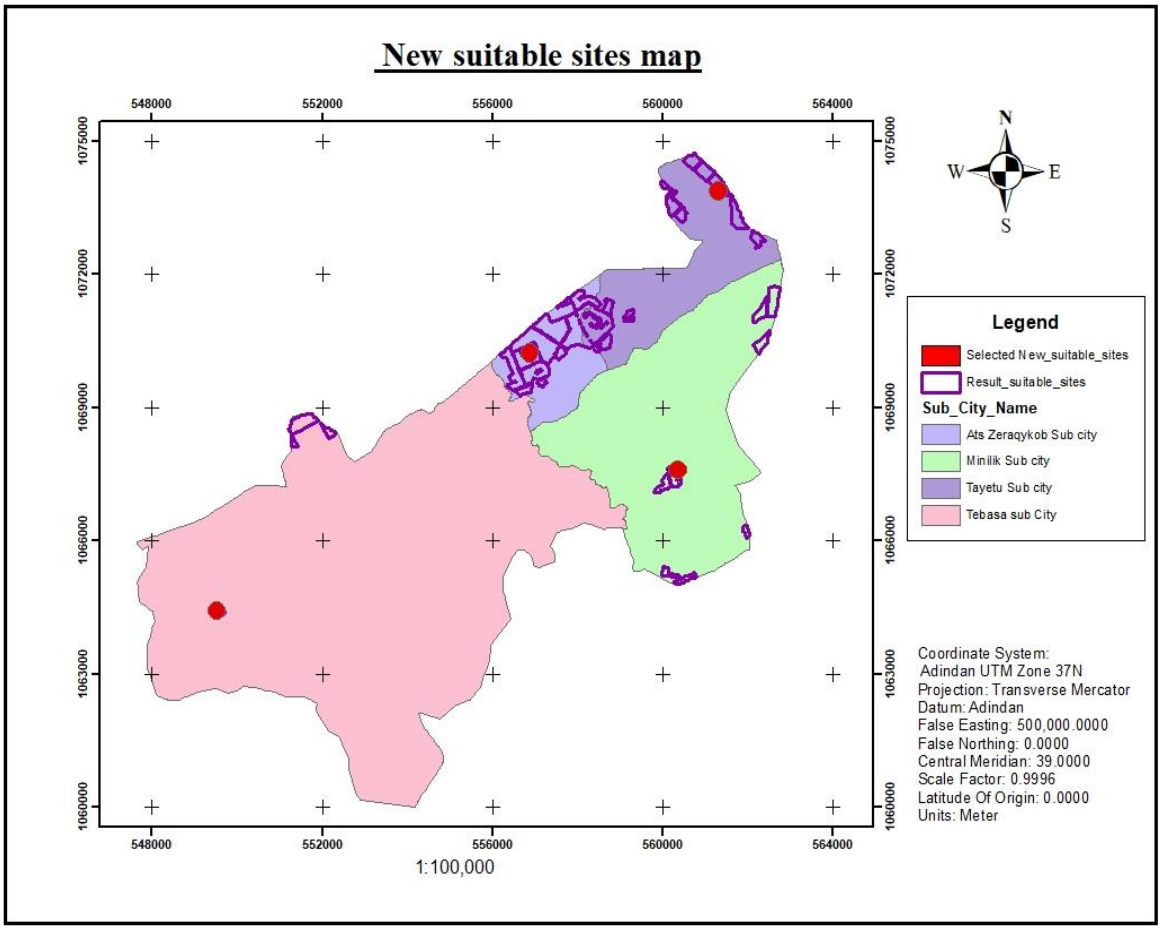


Figure 41: New Suitable sites Map

4.8.3. Evaluating the proposed sites

More than 15,000 m^2 of the newly proposed plots can be used for primary purposes cause the legal frame work recommend at list primary school area is 15000 m^2 to 25000 m^2. The new proposed site considered this article and proposed four sites the first two sites measured 18502 m^2, 17443m^2 and also other two is 25000 m^2. They are close to society and far from restricted areas like industry, high-voltage lines, and trash disposal. The newly recommended locations were converted to KML data and uploaded to Google Earth to be checked for site confirmation that they were on unclaimed land.

4.8.4. Field verification

Use a GPS device like the Garmin 72 Handheld to navigate the site. Few sites were erected on the built area as a result. Using the ArcGIS Measure tool, measurements were taken from the new location to the old schools. Some sites are fairly close to the current schools, while the sites that are digitized in blue are at least one kilometer away.

Site one

Site one is located in northern part of Debre birhan the site area is 25000m^2 the administration area is zeraykobe sub city is not constructed area on proposed area and near to residential place so more conform and reliable.

Figure 42: Field verification site one

Site Two

Site two is located in north east the site located in route of kuke yelesh the area is 25000m^2 the administration in Tayetu seb city that is on open space so this site for feature to elementary school is comfortable.

Figure 43: Field verification site two

Site three

Site three located in south direction the total area of proposed suitable site for elementary school is 18502 m^2 this site close to transferred to owner for residential area.

Figure 44: Field verification site three

Site four

Site four is situated in the western region of Debre Birhan; its proposed site size is 17443 m^2, and Tebasa Sub City serves as the site's area. While the proposed space for a school is undeveloped, this location part of debre birhan more transfer for manufacturing (industry) and the structural plan land use is for industry, the site is intended to feature built for primary schools.

Figure 45: Field verification site four

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The goal of this study is create a new approach, evaluate existing primary schools and to identify which locations is suitable for primary school in Debre Birhan. This study demonstrates the integration of AHP with integration of geospatial technology to evaluate the existing primary schools suitability and identify appropriate site for primary school sites. The difficult criteria for primary school can be resolved using this comprehensive strategy.

The main contribution of this study is the identification criteria and factors of primary school sites by applying the hierarchical structure of AHP in geospatial technology. AHP methodology supports to procedures of assessing alternatives and aggregating them to locate the most pertinent ones. The details of the criteria and class weights for the best locations for elementary schools were efficiently calculated using this methodology. The method contribute in the study to rank a set of alternatives or to choose the best option from a set of alternatives and also pairwise comparison supports to set the weight of each category criteria's. The study started by identify factors then calculate the weight and rating from the AHP analysis where the directors, education officer and Geospatial experts were asked to determine the relative importance of each criterion and factor. The determination of criteria and classification of factors for the identification of suitable sites for primary school were divided into three main categories safety, accessibility and environment sections. There were four criteria and eleven factors. Those are far of industry, main road, proximity to residence, gas station, and high voltage line, access to road (distance from road), distance from health center, topography (slope), waste disposal, commercial area, and river.

The overall weighted elementary schools suitability analysis of the area indicates that only 6.05 % of the area has more suitability condition. The remaining 63.4%, and 0.8% of the area are Suitable and Less suitable for elementary school. The criteria used to choose the best locations for schools, combined with additional structure plane land use data. To deciding where to locate a suitable primary school, the methodology used geospatial technology with AHP as an MCE tool. The findings showed contains 4.67 % includes only a small part of the central, north and eastern parts of Debre Birhan are more suitable area.

Four new proposed sites selected they are located at all sub city that's help to address all administration to use the area of proposed schools area minimum 15000 m^2 and 25000 m^2 maximum all sites are verified according to factors criteria and filed verification that are perfect for the addition of new schools. Since there were no established standards for school locations, the model was created based on the opinions of experts and information from a literature review. The model can reduce, incidences of congested, dangerous locations, underutilized schools and human bias will be eliminated.

5.2. Recommendations

On the basis of the study's findings, the author would like to suggest the following points

AHP analysis must be used since it accurately reflects the situation in the studied area.

There is a need for additional research on the location of educational facilities to put together the essential locational criteria in Ethiopia so that the location of new schools can be chosen systematically and scientifically.

To improve the teaching and learning environment in schools, regulations should be created criteria and implemented.

Some schools are entrance is in front of main road these schools are can to change the entry and exist entrance from other side of access road.

Moreover, the criteria used in this study, other researchers can considered also other criteria if available the data such as noise pollution data and the entire population data.

Integration of Geospatial technology is more suited to analysis the suitability location and support new abilities and advance help to the suitability process.

To process suitability by Euclidean distance analysis methodology according to the town/city behave researcher most be chose only main criteria because the criteria increasing according to Euclidean distance possibly inclusive the result to one class.

Reference

(n.d.). Retrieved from https://www.manage.gov.in/studymaterial/gis.pdf

DB Zone urban plane implimentaton office. (n.d.). *Major Points to be Considered when Evaluating Urban Plan Reports.* Debre Birhan.

Philip Kiprono Talam Moses Murimi Ngigi. (2015, may). Integration of GIS and Multicriteria Evaluation for School Site Selection A Case Study of Belgut Constituency.

(MOE), E. m. (2015). Education Sector Development Program V ESDP V. p. 13.

(MOE), E. m. (2020). Education Statistics Annual Abstract September 2019-March 2020 Ethiopia ministry of education . p. 15.

A. Hussaini, S. A. (2018). Integration of GIS and multi criteria evaluation for international school site selection. p. 41.

Ahmad, Z. B. (2010). SPATIAL MULTI-CRITERIA DECISION ANALYSIS FOR SAFE SCHOOL SITE SELECTION.

Ahmad, Z. B. (2012). Spatial multi-criteria decision analysis for safe school site selection. p. 11.

Aina, Y. A. (2012). Applications of Geospatial Technologies for Practitioners: An Emerging Perspective of Geospatial . p. 1.

Alaska, S. o. (2021). Site Selection criteria and Evaluation Handbook. p. 2.

Ali, K. A. (2018). Multi-Criteria Decision Analysis for Primary School Site Selection in Al-Mahaweel district Using GIS Technique.

AmirJamal, I. (2016). Multi-Criteria GIS Analysis for School Site Selection in Gorno-Badakhshan Autonomous Oblast, Tajikistan.

Anjar Dimara SaktiAnjar, M. A. (2022, DEC). School Location Analysis by Integrating the Accessibility,Natural and Biological Hazards to Support Equal Access to Education.

Baser, V. (2020). Effectiveness of School Site Decisions on Land Use Policy in the Planning Process. p. 2.

Bukhari, Z. (n.d.). SPATIAL MULTI-CRITERIA DECISION ANALYSIS FOR SAFE SCHOOL SITE SELECTION.

Dadfar, N. A. (2014, may). SUITABILITY ANALYSIS OF A NEW HIGH SCHOOL IN THE CITY OF CALABASAS.

Department of Education queensland government. (2022, September). New School Site Selection Guidelines.

Federal Urban Planning Coordinating Bureau. (2004, April). Manual for Demographic and Social Service Data Analysis.

Gelan, E. (2021). GIS-based multi-criteria analysis for sustainable urban green spaces planning in emerging towns of Ethiopia: the case of Sululta town . p. 3.

Geo-Information. (2021). School Location Analysis by Integrating the Accessibility Natural and Biological Hazards to Support Equal Access to Education.

Harun Din Haq, K. S. (2023, Januari). ANALISIS KESESUAIAN LAHAN UNTUK KAWASAN PENDIDIKAN DI KABUPATEN MAJALENGKA.

IrshadAmirJamal. (2016). Multi-Criteria GIS Analysis for School Site Selection in Gorno-Badakhshan Autonomous Oblast, Tajikistan.

J. U. Richard, D. C. (2016, January). Suitability Analysis of Secondary School Accessibility in Andoni L,G.A, Rivers State, Nigeria.

Jamal, I. A. (2016). Multi-Criteria GIS Analysis for School Site Selection in Gorno-Badakhshan Autonomous Oblast, Tajikistan . p. 5.

Marwah M. Al-khuzaie, H. J.-Y.-R. (2018). Suitability Analysis for the Locations of Schools Using Geographic Information System (GIS) and Remote Sensing for Al-Diwaniyah City, Iraq . p. 554.

Merga, M. D. (2014). An integrated application of AHP and GIS for environmental suitability analysis for villagization site selection: the case of Homosha Woreda, western Ethiopia . p. 12.

MOE, E. M. (2020). Education Statistics Annual Abstract September 2019-March 2020. p. 15.

Mukhopadhaya, S. (2016). GIS-based Site Suitability Analysis: Case Study for Professional College in Dehradun . p. 60.

Muleta, M. B. (2022). Integration of geospatial technologies with multi-criteria decision analysis for aquaculture land suitability evaluation: The case of Fincha'a River Sub-basin, Western Ethiopia. p. 3.

Mustafa, B. E. (2011). Site Suitability Analysis of Infrastructure Facilities for Giant Freshwater Prawn Farming . p. 2.

Ngigi, P. K. (2015). Integration of GIS and Multi criteria Evaluation for School Site Selection A Case Study of Belgut Constituency. p. 138.

Niels van Manen, H. J. (2009). *link.springer*. Retrieved from https://link.springer.com/content/pdf/bfm:978-90-481-2620-0/1?pdf=chapter%20toc

Ogba, J. U. (2016). Suitability Analysis of Secondary School Accessibility in Andoni L,G.A, Rivers State, Nigeria . p. 969.

Ogba, J. U. (2016, january). Suitability Analysis of Secondary School Accessibility in Andoni L,G.A, Rivers State, Nigeria.

Queensland goverment, D. o. (2022, September). New School Site Selection Guidelines. p. 7.

SayanMukhopadhaya. (2016, January). GIS-based Site Suitability Analysis: Case Study for Professional College in Dehradun.

State of Alaska. (2021). Site Selection Criteria and Evaluation Handbook.

State of Alaska. (2021). Site Selection Criteria and Evaluation Handbook.

Urban Planning Proclamation No. 574/2008. (2008). *Urban Planning Proclamation No. 574/2008.*

Waleed Lagrab, N. A. (2015, MARCH). Analysis Of Educational Services DistributionBased Geographic Information System (GIS). p. 113.

Waleed lagrab, n. a. (2017). A suitability analysis of elementary schools -based geographic information system (GIS) a case study of mukalla districts in Yemen. p. 731.

WALEED LAGRAB, N. A. (2017, August). A suitability analysis of elementary schools-based geographic information system (GIS) a case study of Mukalla districts in Yemen.

Worldbank. (2019, OCTOBER). *https://www.worldbank.org/en/topic/land/brief/geospatial-technology-and-information-for-development*.

www.manage.gov.in. (n.d.). *https://www.manage.gov.in/studymaterial/gis.pdf*.

Zubaidah Bukhari, A. R. (2010, January). Developing Policy for School Development Using Spatial Multi-Citeria. p. 3.

Zubaidah Bukhari, A. R. (2010). SPATIAL MULTI-CRITERIA DECISION ANALYSIS FOR SAFE SCHOOL SITE SELECTION. p. 2.

Zubaidah Bukhari, A. R. (n.d.). SPATIAL MULTI-CRITERIA DECISION ANALYSIS FOR SAFE SCHOOL SITE SELECTION.

Zubaidah_Bukhari. (2010, June). Spatial multi-criteria decision analysis for safe school site selection.

Appendices

Appendix A: Thesis questioner

Appendix A1: Questioner to be complete by geospatial experts and education officers

Purpose this questioner is to investigate the current status of school location in Debre Birhan and to be develop evaluation criteria to be used in evaluation of elementary school site using the integration of geospatial technologies analysis for my thesis work.

Thank you for good receipt first.

General question

Age: 18-20 ☐ 21-25 ☐ 26-30 ☐ 31-35 ☐ 36-40 ☐ 41-45 ☐ 46-50 ☐ more than 50 ☐

Sex: male ☐ female ☐

Educational level: Level ☐ Diploma ☐ first Degree ☐ Msc ☐ PhD ☐

Current position: _____

School Name: _____

1, how do you evaluate Generally Suitability of Debre Birhan school locations?

Unsuitable ◯ less suitable ◯ suitable ◯ more suitable ◯

2, Sites of school locations in Debre birhan are selected by developing criteria?

Strongly agree ☐ agree ☐ disagree ☐ strongly disagree ☐

3, Unsuitable school location can have negative impact on quality of education?

Strongly agree ◯ Agree ◯ disagree ◯ strongly disagree ◯

4, The following are determinant factors for suitability of school location. Please rate them by putting **x** in the box According to their importance you think.

no	Factors	Level									
		1st	2st	3st	4st	5st	6st	7st	8st	9st	10st
1	Proximity to residence										
2	Proximity to road access										
3	Far from commercial area										
4	Far from Waste Disposal										
5	Far from industry										
6	Far from river										
7	Far from Main road										
8	Far Gas stations										
9	high voltage										
10	Proximity to Health centers										

5, The above factors/constraints are grouped in to four main categories. Please rate them by giving **1**, **2** and **3** according their importance.

	Accessibility	Road access, near to
	Safety	Free of hazards, like high
	Environmental	West disposal, noise, & flood

Appendix A2: **Questioner to be filled by school directors and teachers**

Purpose this questioner is to investigate the current status of school location in Debre Birhan and to be develop evaluation criteria to be used in evaluation of elementary school site using the integration of geospatial technologies analysis for my thesis work.

Thank you for good receipt first.

General question

Do you want to evaluate your school site suitability? Yes ☐ No ☐

Age: 18-20 ☐ 21-25 ☐ 26-30 ☐ 31-35 ☐ 36-40 ☐ 41-45 ☐ 46-50 ☐ more than 50 ☐

Sex: male ☐ female ☐

Educational level: Level ☐ Diploma ☐ first Degree ☐ MSc ☐ PhD ☐

Current position: _____

School Name: _____

1. Indicate the sub City of your school location.

Tebasa ◯ Zeraykob ◯ Tayetu ◯ Minilik ◯

2. How do you evaluate Generally Suitability of Debre Birhan school locations?

Unsuitable ◯ less suitable ◯ suitable ◯ more suitable ◯

3. Sites of school locations in Debre birhan are selected by developing criteria?

Strongly agree ☐ agree ☐ disagree ☐ strongly disagree ☐

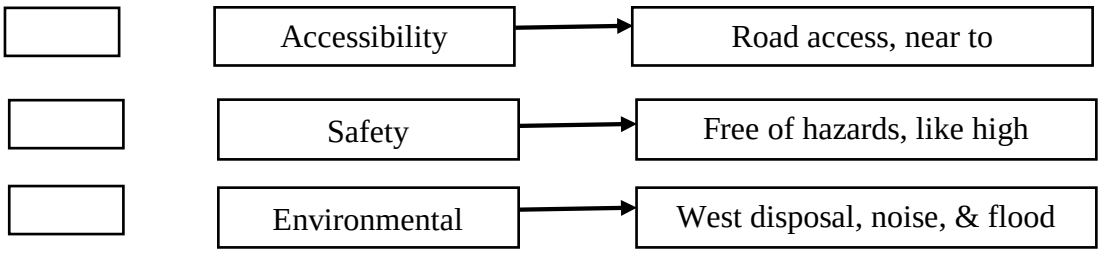
4. Unsuitable school location can have negative impact on quality of education?

Strongly agree ◯ Agree ◯ disagree ◯ strongly disagree ◯

5. The following are determinant factors for suitability of school location. Please rate them by putting **x** in the box According to their importance you think.

no	Factors	Level									
		1st	2st	3st	4st	5st	6st	7st	8st	9st	10st
1	Proximity to residence										
2	Proximity to road access										
3	Far from commercial area										
4	Far from Waste Disposal										
5	Far from industry										
6	Far from river										
7	Far from Main road										
8	Far Gas stations										
9	high voltage										
10	Proximity to Health centers										

6. The above factors/constraints are grouped in to four main categories. Please rate them by giving **1**, **2** and **3** according their importance.



ANNEX B: Correlation Results

Correlations

		Unsuitable school location can have negative impact on quality of education?	Please rate three main categories?	Sites of school locations in Debre birhan are selected by developing criteria?	How do you evaluate Generally Suitability of Debre Birhan school locations?
Unsuitable school location can have negative impact on quality of education?	Pearson Correlation	1	-.079	-.178*	-.087
	Sig. (2-tailed)		.331	.028	.284
	N	152	152	152	152
Please rate three main categories?	Pearson Correlation	-.079	1	.551**	.788**
	Sig. (2-tailed)	.331		.000	.000
	N	152	152	152	152
Sites of school locations in Debre birhan are selected by developing criteria?	Pearson Correlation	-.178*	.551**	1	.460**
	Sig. (2-tailed)	.028	.000		.000
	N	152	152	152	152
How do you evaluate Generally Suitability of Debre Birhan school locations?	Pearson Correlation	-.087	.788**	.460**	1
	Sig. (2-tailed)	.284	.000	.000	
	N	152	152	152	152

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

ANNEX B 1. The reliability result of Questioner data

Reliability Statistics

Cronbach's Alpha	N of Items
.703	4

ANNEX C

For final suitability map used weighed.