Geospatial Technology Based Suitable Solid Waste Disposal Site selection: a case study of Ejere Town, north Shewa, Oromia, Ethiopia

Mulu Asefa Damise

A Thesis submitted to

The Department of Geomatics Engineering

School of Civil Engineering and Architecture

Presented in partial fulfillment of the requirements for the degree of Master of Science in Geomatics Engineering (Specialization in Geoinformatics Engineering)

Office of Graduate Studies

Adama Science and Technology University

August, 2020

Adama, Ethiopia

Geospatial Technology Based Suitable Solid Waste Disposal Site selection: a case study of Ejere Town, north Shewa, Oromia, Ethiopia

Mulu Asefa Damise
Advisor: Getachew B/Maskel (Ph.D.)

A Thesis submitted to
The Department of Geomatics Engineering
School of Civil Engineering and Architecture
Presented in partial fulfillment of the requirements for the degree of Master of Science in Geomatics Engineering (Specialization in Geoinformatics Engineering)

Office of Graduate Studies
Adama Science and Technology University

August, 2020
Adama, Ethiopia

APPROVAL SHEET

I, the advisor of the thesis entitled "Geospatial Technology Based Suitable Solid Waste Disposal Site selection: a case study of Ejere Town, north Shewa, Oromia, Ethiopia" and developed by Mulu Asefa Damise, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Getachew B/ Meskel (PhD). ________ ______________ __________________

Major Advisor Signature Date

Andinet Kebede (PhD). ______________ ________________

Co-advisor Signature Date

We, the undersigned, members of the Board of Examiners of the thesis by Mulu Asefa Damise have read and evaluated the thesis entitled "Geospatial Technology Based Suitable Solid Waste Disposal Site selection: a case study of Ejere Town, north Shewa, Oromia, 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 Masters of Science in Geoinformatics Engineering.

________________________________ ______________ _________________

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 "Geospatial Technology Based Suitable Solid Waste Disposal Site selection: a case study of Ejere Town, north Shewa, Oromia, 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.

Mulu Asefa Damise	___________________	________________
Name of the student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled “Geospatial Technology Based Suitable Solid Waste Disposal Site selection: a case study of Ejere Town, north Shewa, Oromia, Ethiopia” prepared under my guidance by Mulu Asefa Damise submitted in partial fulfillment of the requirements for the degree of Masters of Science in Geo-Informatics Engineering. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Getachew B/ Meskel (PhD)________	____________	____________________
major Advisor	Signature	Date
Andinet (PhD)___________	______________	____________________
Co-advisor	Signature	date

ACKNOWLEDGEMENT

First and foremost, I would like to thanks almighty god for giving me bravery, strength, health and tolerance throughout the compilation of this thesis research work.

Secondly, my deepest thank goes to Ambo University for granting me this golden master's sponsored opportunity and for providing me the necessary financial support required for this thesis accomplishment.

Thirdly, I also want to extend my sincere gratitude to the department of Geomatics Engineering for let me to do on this thesis topic and for assigning an academic advisor for my thesis work.

Fourthly, I want extend my special thanks to Dabalo Diyana (PhD candidate) for his limitless comment, suggestion and help throughout this thesis writing.

This work would be impossible to complete Without their continuous and constructive Advice, hence, I am delighted to express my gratitude to my major advisor Dr. Getachew B/Meskel and Co-advisor Dr. Andinet Kebede.

I extend my thankfulness to Ejere Town Municipality Office, for providing me all the necessary data that were needed for this study.

Lastly not least; I want to say thanks to my lovely wife Asnaketch Terefe for she stands behind me by all round support and advise as I pass any challenge throughout the completion of this thesis work and to mother, brothers and sisters for their love, encouragement and support during my thesis study period.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LISTS OF ABBREVIATIONS AND ACRONYMS

AHP	Analytic Hierarchy Process
CSA	Central Statics Authority
DEM	Digital Elevation Model
ERDAS	Earth Resource Data Analysis System
GIS	Geographic Information System
GPS	Global Positioning System
LULC	Land Use Land Cover
MCDA	Multi Criteria Decision Analysis
MCE	Multi Criteria Evaluation
RS	Remote Sensing
WHO	World Health Organization
WLC	Weight Linear Combination

Abstract

Municipal solid waste management has become a great problem which need a serious consideration for many underdeveloped nations. Owing to the sensitivity of solid waste disposals as population increase and increasing volume of trash generates, solid waste disposal sites are a highly critical issue in the solid waste management system. In Ejere Town there was no suitable waste disposal site. Therefore, the main objective of this study was assessing suitability of solid waste disposal site using Geospatial Technology and Analytical hierarchy process of multicriteria decision making method. To achieve this objective the study conducted by geospatial technology integrate with analytical hierarchy process (AHP) of multicriteria decision making analysis methods. The finding of this study answers the question where is the potential suitable area for disposal. Different software was used to accomplish this study like ArcGIS, IDRISI selva, google earth and ERDAS imagine. The data used for this study were DEM to generate slope of the study area, structural plan of the Town, Landsat image 8 to prepare current land use land cover feature map, interview and field observation to have a confidence while assigning value for all parameters to calculate weight. In this thesis work eight parameters have been considered. These parameters were land use land cover, soil type, slope, proximity to (road, waste bodies, protected area, built-up). Suitability of all these parameters for solid waste disposal have been analysis using ArcGIS 10.8 version. Assigning value and making relative/pairwise compression among two parameters would generate weight for each of them using IDRISI software on and then overall spatial analysis was done in ArcGIS using weight overlay operation to determine suitable potential area for waste disposal in Ejere Town. As a result, four level of suitability were analyzed. Level of suitability analyzed were valued as 1,2,3 and 4 in which their degree of suitability was restricted, unsuitable, less suitable and more suitable respectively. More suitable area covers an area of 1ha and less suitable area cover 135ha. Generally, more suitable area was located at north east and north west direction and less suitable located border of the Town. The current dumping site must be stop to give the services for disposal purpose. Because it does not locate in proper location means dump site located gorge side in one side and adjacent to residential house on the other side.

Key word: Geospatial technology, Overlay, Suitability Analysis

CHAPTER I. INTRODUCTION

1.1. Background of study

Solid waste generation and management are difficulties that both emerging and developed countries face. Cities throughout the world now generate roughly 1.3 billion tons of solid trash per year. This volume is anticipated to expand to 2.2 billion tons by 2025 and to 3.40 billion tons by 2050 (World Bank 2018). Solid waste generation has become a growing environmental and public health issue around the world, particularly in emerging countries.

Even though industrialized countries began to manage their solid waste by developing leachate and gas pollution controllers to the system to limit contamination from the surrounding environment, developing countries began to manage their solid waste by employing sanitary landfill systems. However, in Africa most of the countries, solid waste management is still an open dump, despite the addition of leachate and gas pollution controllers to the system that keeps sensitive areas from pollution. This is exemplified by the fact that Africa's solid waste management system is still ineffective.

According to UNEP (2005), the lack of appropriate planning, lack of good sector governance, poor new technology supply and use, potential of existing legislation and regulation to improve the relative problems, and financial constraints to develop and promote projects are all factors contributing to Africa's poor solid waste management. Urban solid waste management is one of the most challenging environmental problems in developing countries. The problem is combined from different aspect like, as population growth, economic development and rapidly urbanization.

In most developing countries, for example, 30 to 50 percent of the population lives in cities. More than 60% of these people, mainly in African countries, do not have access to an appropriate and frequent disposal area (Biruk, 2017). In most urban centers in developing and least developed countries, solid waste is collected and disposed in illegal landfills randomly.
Because of poor infrastructure, lack organizational competence, financial constraints, and limited institutional capacity of municipalities to manage waste properly, increasing the production of municipal solid waste as a result of population growth and economic

development led to solid waste being disposed in indiscriminate areas such as drainage lines, open spaces, street sides, or is informally burned (Yenenesh et al, 2020). As a result, in many African countries, such as Ethiopia, solid waste management is becoming a serious public health and environmental concern. In Ethiopia, as in other developing countries, rising population, urbanization, economic development, and garbage generation need the implementation of a solid waste management system.

Furthermore, for long-term solid waste management, solid waste management policies and rules encompassing processes such as collection, transportation, storage, source reduction, recycling, and repeated use of a disposal site, among others, should be established (Biruk, 2017; (Gizachew, 2011). In Ethiopia, Ejere town, like other, Town is grappling with the problem of solid waste management, which is causing a slew of community health and environmental issues, including disease transmission, fire hazards, odor nuisance, air and water pollution, aesthetic annoyance, and economic losses (Ambaneh, 2016). This is owing to the town's unmanaged and inappropriate solid waste management, which pollutes the environment and has a negative impact on public health.

As a consequence, waste management (WM) has become a major public health and environmental issue in metropolitan areas as urbanization proceeds. Because, in every human being's daily activity, various solid wastes are generated from all over the place, not just at home (Biruk, 2017). Therefore, a better understanding of our environmental challenges motivates us to develop prevention technology, as well as demand regulations, policies, and strategies for how households handle and dispose of solid waste in order to reduce pollution and health issues.

Here, the role of the household played a significant role in the solid waste management system by storing solid waste in their private storage until they dispose of it to a secondary storage or public container outside of their compound, because waste storage is the responsibility of the waste producers in most African capital cities. Waste is stored in a variety of containers, such as plastic bags, various types of sacks, baskets, and boxes. Some people, on the other hand, throw rubbish without a storage facility and indiscriminately dump waste on open spaces, riverbanks, roadsides, and valleys (Aisa, 2011). There are significant techniques used in solid waste management system, like thermal treatment, composting, landfilling and recycling. Minimizing environmental pollution and human health problems caused by solid waste disposal sites is the most important issue in the solid waste management system. Therefore, in order to sustainably protect the environment and public health, solid waste must be disposed of in an environmentally sound and socially acceptable location.

Hence, environmental protection and public health considerations should be the principal concerns in site selection. Due to the nature of solid waste disposals as population increase and increasing volume of garbage generates, solid waste disposal sites are a highly critical issue in the solid waste management system (Kenate, 2017).

The approach of selecting a trash disposal site that takes into account the majority of waste management techniques. However, choosing an appropriate disposal site in today's community with limited resources is a difficult task (Zewudie, 2017). Because, the communities of small towns and villages in Ethiopia usually cannot afford disposal design, construction and operation standards equal to those applied in large cities, and in many cases, large cities cannot afford to apply standards equal to those of high-income countries. That is why selection of solid waste disposal site is to be difficulty because, many significance factors are considering as a criteria. Waste disposal site selection criteria will consider proximity from another physical characteristic of the area, like distance from settlements, surface water, road, restricted area (mosque, church, museums, park, etc.), land use/ land cover, slope, hydrology, soil type, Geology of the earth and socio-economic character of the town.

Therefore, due to involving many factors to analysis suitability of dumping site and selection of most suitable landfill site the process is so complicated (Aden, 2016). Nevertheless, geospatial technology is the best tool in selecting environmentally sound and socially acceptable disposal sites with accurate precision, cost and time effectively.

The development of GIS tied with availability of digital data from Remote Sensing technology and GPS data makes the process of landfill site selection very simple and easily manageable. GIS is used for landfill site selection processes because of its unique capabilities. Capability to perform an integrated analysis of spatial and attributes data from multisource datasets and automatically producing maps make the GIS different from the other technology (Shoba Balaguru, 2013). Additionally, GIS has a capability to perform identification of disposal site procedural of combined suitable candidate sites based on the given criteria. Suitability determinate criteria of the study area are determined by having consideration in mind how to minimize any potential health problems from direct or indirect contamination due to the proximity of a landfill site with respect to key geographic features.

Remote sensing technology is capable of providing timely spatial information used as the main source of input data for further assessing and management of the environment in GIS environment (Aden, 2016). For example, the following data extract from satellite image capture through remote sensing technology like, DEM of the study area, slope, the current land use/land cover information of the study area would be extracted and mapped from satellite images and used as an input data for the study. Because, multicriteria should be considered too decided the potential of solid waste disposal site. Although, there is multicriteria decision making (MCDM) tool is capable to overcome this limitation.

Generally, the main objective of this study was assessing the existing waste disposal site by evaluating with different parameters and selecting suitable potential site for waste disposal using geospatial spatial technology and Analytical hierarchy process of multicriteria decision making method for Ejere Town, Ethiopia. In this particular study, geospatial technology (GIS, GPS and remote sensing) was used to generate, manipulate and analyses spatial data used as landfill site selection criteria. Moreover, multicriteria decision analysis (MCDA) method integrated with geospatial technology to select potential solid waste landfill site that were effective and efficiently with low cost, less time and better accuracy for the study area.

1.2. Statement of the Problem

Ejere is one of the oldest towns in Ethiopia which faced a problem of solid waste management. Rapidly urban expansion of Ejere town has been taken places from time to time both formal and informal ways due to increments of population density. The factors of population growth in this town were immigration, employments and birth rate. Thus, as the town grows, so the generation of waste production does especially solid waste hazard (Zenebe, 2018). The town has public and private organization like, hospitals, health centers, school, banks, hotels, restaurants, factors, residential house, commercial and small micro-enterprise which generate solid waste. In most of developing countries municipality spends large proportion of its budget on collection, transport and disposal of wastes. Because, uncontrolled and improper solid waste management in the city is polluting the environment and affecting public health (Aden, 2016). In Ejere town there was one temporary dump site that municipality and land administration together located manually adjacent to Residential area of the community, local stadium and almost half of the site was overlap with gorge that directly linked to the river which was not scientifically and no technology applied to dump site selection. As many researches illustrate, residential area should be far from solid waste disposal site. Because, it has direct impact on public healthy and attitude (M. Vivek etal, 2018). Also, selecting suitable site using manual methods is tedious, time consuming and costly. This problem was solved using GIS and Remote sensing technology and its integration with multi-criteria approach to consider many of factors which have a capability to analysis multiply factor at a time through digital way (Zewdie, 2017)

Ejere Town Municipality do not have appropriate waste disposal site. As a result, this research was issued in identify suitable solid waste disposal site using Geospatial Technology and Analytical Hierarchy Process (AHP) of multicriteria decision making.

GIS play the main role in suitable solid waste disposal site selection. GIS was a comfortable recent Technology used for record, analysis, overlay, manage and display spatial and attribute data (Sunil, 2011). In Ethiopia many researches done on solid waste disposal site selection using GIS and Remote sensing. But no research has been done for this study area using geospatial technology for disposal site selection.

Generally, based on the problem describe above this thesis would assess the existed solid waste disposal site and selecting suitable potential site for waste disposal using Geospatial Technology and Analytical hierarchy process of multicriteria decision making method.

1.3. Objective of the study

1.3.1. General objective

The overall objective of this study was to select suitable solid waste disposal site using Geospatial Technology and Analytical hierarchy process of multicriteria decision making method.

1.3.2. Specific objectives

Up on the above general objective, the study was attained the following specific objectives

- To identify criteria used to determine suitability of solid waste disposal site in the study area
- To evaluate the present status of solid waste disposal site in Ejere Town within identified criteria
- To identify potential of the suitable disposal site in the study area

1.4. Research question

Therefore, to achieve the specific objectives listed above the following question were designed

- What are the parameters to use during solid waste disposal site selection in the study area?
- What is the current status of solid waste disposal site in the town?
- Where are the potentials of suitable solid waste disposal site in the study area?

1.5. Significance of study

The findings of the study were believed to have the following advantages:

- It may inform the administrative body of Ejere Town where is potential suitable waste disposal site of study area
- This study has policy implication in such that it will help policy makers and provide to better understanding about how to select suitable waste disposal site
- It may have a contribution for administrative and academic staff who benefit from the information and literature of this work by using it as an input.
- Additionally, the findings of this study will be an input for future researchers who interesting to conduct research in the area of focus, and above all the study is highly important for the partial fulfillment of the masters of degree program.

1.6. Scope of the study

Research was carried out at Ejere Town in Ethiopia's Oromia Regional State.

The purpose of this study was to assess the existing state of the dumping site and to identify suitable potential areas that was acceptable for disposal. The study take place by 2021 using eight parameters such as land use land cover, soil type, slope, built-up, proximity to (built up, protected are, water bodies, and road) and wind direction.

1.7. limitation of the study

There were some limitations while this thesis was done. For example, there was no standard criteria to reclassify the feature in national context rather using the international standard. Data used for disposal site suitability analysis was from economic, environmental and geology source. But, ground water table of environmental data was not used due to lack of data.

1.8. Organization of the study

This paper would been organized in to five chapters. The first chapter states about back ground of the study, statement of the problem, objectives, research questions, significance of the study, scope of the study and limitation of the research. The second chapter highlights a review of literature that consists of both conceptual review literature and research related review literature. The third chapter deals about background of study area and methodology of the research. The fourth chapter talks about discussion and result and at the state about conclusion and recommendation.

CHAPTER II. LITERATURE REVIEW

2.1. General concept of waste

2.1.1. Definition

American Resource Conservation Recover Act states that "solid waste means any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities".

United Nations, (1997) state solid waste is unusable things with low liquid content. Solid wastes include municipal garbage, industrial and commercial waste, sewage sludge, wastes resulting from human and animals' activities. ''Solid wastes are the organic and inorganic waste materials such as product packaging, grass clippings, furniture, clothing, bottles, kitchen refuse, paper, appliances, paint cans, batteries, etc., produced in a society, which do not generally carry any value to the first user (s). Solid wastes, thus, encompass both a heterogeneous mass wastes from the urban community as well as a more homogeneous accumulation of agricultural, industrial and mineral wastes'' (Ramachandra, 2006).

The Federal Democratic Republic of Ethiopia Solid Waste Management (FDRE SWM) Proclamation No. 513 (2007) defines Solid Waste and Solid Waste Management (SWM) as follows: 'Solid Waste' implies anything that is neither liquid nor gas and is discarded as unwanted. 'Solid waste management' means the collection, transportation, storage, recycling or disposal of solid waste, or the subsequent use of a disposal site that is no longer operational.

2.1.2. Types of urban solid waste

In most developing countries like, Ethiopia urban solid waste is considered as one among the other as immediate and serious environmental problems. As the name indicate solid waste is any discharged material which is unwanted to use. Types of the solid waste can be classified as from where the waste is produced or source. Therefore, urban solid waste is classified as like, Domestic waste, industrial waste, residential, commercial, institutional, agricultural, demolition of building or construction material and waste of utility material. Solid waste can also categories as hazardous and non-hazardous waste based on building element of the substance.

Hazardous waste generates from industrial, health center, household. This type of solid waste is a very dangerous waste to health of human, animals and environment due to its release toxic substance. Because, such waste is non- degradable in nature.

A small amount of hazardous waste generates from the residential area like, wood preservatives, paint thinners, oil-based paints, pesticides, insecticides, household cleaners. Non-hazardous waste is any waste that do not harm the people or the environment, and all waste that do not categories under hazardous waste are says to be non-hazardous. It can be produced from almost all source of solid waste (Hosam et al, 2016). All solid waste contains degradable and nondegradable component. Therefore, if it is not properly managed it cause directly or in-directly contamination of the environment.

2.2. Solid waste management system

Solid waste management is becoming one of the most serious problems in the whole over the world especially in developing countries particularly in Ethiopia urban area which led dangerous pollution to animate health (A.Royal and S.Kumar, 2016). As the living standard of the urban community increase solid waste management get more and more complicated since, solid waste generation has direct relationship with wealth of the people. As, WHO (1996) cited by (Kebede, 2020) inappropriate handling and disposing of solid waste led environmental pollution which forwarding health problem in the whole over the world special in developing country. As Tadesse et al (2008) cited in (Zenebe, 2018) properly management of solid waste determined by factor like, access and distance from communal container, finance, transparency to the community and absence or presence of dump site, which effect the culture of household have toward waste handling and disposing. Solid waste management is a process of monitoring, collection, transfer and finally, transportation in to land fill of solid waste. Therefore, it is good and proper way of solid waste management if location of dumping sites for solid waste disposal is far standardize distance from, residential areas, water bodies, road and settlements (Ahmed and K.V Suryabhagayan, 2019). Today Solid waste management can perform using different techniques like, landfilling, thermal treatment, biological treatment, and recycling differently in different countries as they can. Using one from the above techniques depends on capability of the country or city to perform those methods. Therefore, solid waste management is different from country to country as per level of their performance. This study focuses on the landfilling techniques of solid waste management.

2.2.1. Global solid waste management system

Solid waste management is a series problem throughout the world due to increasing quantity of solid waste from time to time. The primary aim of solid waste management is improving community health problem, control beauty of the environment and develop suitability situation for sustainable solid waste management (Zewdie, 2017). Properly manage solid waste is a very cost issue but it is an interesting and unique project to protect human health and environmental management to promote sustainable living condition for community. Solid waste management is not simple task due to it worth socially, environmentally, economically and politically in most countries over the world (Aden, 2016). Because, solid waste management deal about how to control solid waste generation, storage, collection, transfer and transport, processing and disposal of solid wastes. Solid waste management is implementing through different activities likes, waste reduction, recycle, transformation and land filling technology (sener, 2004). In most of developed countries like, USA America, Europe, chain, Nigeria etc., solid waste management is performing in modern techniques like source redaction, reuse and recycle. They developed and state to implement waste minimization strategies to improve the problem of open dumping system (Nwosu and chukwueloka , 2020). There are many advantages that can be derived from the use of these methods. These advantages are concern about economic, social and environment. To clear idea they reduce or prevent greenhouse gas emissions, reduce the release of pollutants, conserve resources, save energy and reduce the demand for waste treatment technology. At the end landfill space after reuse or property recovery there is residual solid waste that must be need to transported to landfill site. The landfill site used in developed countries is sanitary landfill that developed with fulfilling leachate and gas controller to detected contamination from sensitive area.

2.2.2. Solid waste management system in developing countries

Open dumping site is the most dominant solid waste management system in Africa countries especially, Ethiopia. Leachate and gas controller is not developed for this disposal site and it is not covered by soil after it fill. Therefore, leachate and gas from the waste polluted the surrounding and the reason for health problems to the community and environmental degradation (Ambaneh, 2016). This shown solid waste management system in Ethiopia is very poor. Solid waste management is weak due to absence of appropriate planning, lack of good governance, poor use of new technology, budget constraint, lack of rule and regulation guideline push to improve the problems. Poor solid waste management involve indiscriminately dispose the solid waste simple at illegally place like, river side, road side, and in canal which facing the problem of solid waste management that forwarding various community health and environmental problems likes, Disease's transmission, fire hazards, odor nuisance, atmospheric and water pollution, beautiful irritation and economic losses (Abate, 2017).This due to uncontrolled and improper solid waste management in the town is polluting the environment and affecting public health. The growing population and economic activities of the town resulted in generation of high quantity of solid wastes. So, as urbanization continues, managements of waste (WM) become a major complex and difficult to control in urban areas.

There are different solid waste management techniques which is safe and unsafe has been practices in our country Ethiopia particularly in Ejere Town. Those are burning, burying, open dumping from unsafe way of solid waste management was takes place in the Ejere Town as similar as most Town of the Ethiopia. A head for municipalities in the developing countries urban waste management has been challenged, due to poor infrastructure, bureaucratic competence and limited institutional capacity of the municipalities (Brihanu Y and Berisa G, 2015). There is also sanitary landfilling, recycle, reuse from modern technology has been used recently at a limited place like Addis Ababa. modern way of solid waste management is not performed well through over the country because, of many constraints like, budget, new developed technology used for the purpose, lack of trained person. But moreover, the objective of this research work is focus on landfilling site selection.

2.2.3. Solid waste disposal site

Solid waste dumpsite is a place designated for disposal of solid or semisolid materials, resulting from day-to-day human and animal activities that are considered useless, unwanted or hazardous. Additionally, it is a basic element of waste management system (Ahemad, 2018). There are two main type of disposal site, sanitary landfill or control dumpsite and open dumpsite. Open dumpsite is a place where solid waste is disposed. The environmental conditions expected from this site is bad especially in terms of the contamination to the environment and lives. Because, leachate and gas emission from this site is not controlled. Leachate is known as the liquid deposited at the bottom of the landfill. The other is sanitary landfilling, is also a place where waste is thrown or dispose. Sanitary landfill refers to an engineered facility for the municipal solid waste designed and operated to minimize public health and environmental impacts (sener, 2004).

The environmental condition expected from sanitary landfill site is more safe than open dumping because the technology of proper sanitary landfill practice is totally implemented. That mean leachate and gas emission are controlled through the system. The waste disposal process is the way in which hazardous waste isolate from people and environment. Solid waste disposal site is a very important issue in solid waste management system due to nature of solid waste disposals as population growths and increasing volume of waste generates (Lamessa kenate 2017). Solid waste disposal site is also known as dumping site which includes monitoring of the incoming waste stream, placement and the compaction of waste and installation of solid waste disposal environmental monitoring and control facilities.

Landfills are the final depository stage of a waste run out after all other waste management options takes place for providing long-term confinement of waste materials. But solid waste management is not end by waste dispose to the landfilling site. Furthermore, it needed controlling the waste properly at disposal site. Landfills can be categorized as open dumps,and controlled dumps or sanitary landfills. To be the location of land fill is preferably comparison parameter such as access to land, climate, disaster history, extent of available land, final use of land, geology, hydrogeology, topography, proximity to land use and local and national legislation will be considered (R. chandrappa and D.B, 2012).

2.2.4 Method of disposal site

There are main common classified types of disposal site to manage municipal solid waste in an appropriate manner (R. Chandrappa and D. B. Das, 2012).

a. Trench method: This method is ideally suited in areas where soil has a depth to cover solid waste material well and water table is far from surface of proposed disposal site. These landfills are constructed below the naturally occurring groundwater table. Special treatment should be made to control groundwater from entering the landfill and to control the movement of leachate and gases from completed cells. The excavated soil in the disposal site is used for daily/final cover.

b. Area method: is used where there is no favorable condition for excavation of the cell due to topography of the earth surface. leachate and cover material must far from animals, human and other places as distance provided to manage them from risk hazard. In area type landfills the great focus given to groundwater conditions assessment. While developing landfill Site installation of a lining and leachate control system (sener, 2004).
c. Depression method: In this method compressed solid waste is placed in canyon/depression. An appropriate area of land is identified, frequently solid waste can accumulate with multiply lift in valley or natural depression in the ground gradual. If a canyon floor is practically flat, the initial landfilling may be carried out using the excavated cell/trench method. The very important things here, is the availability of adequate material to cover the individual lifts and to provide a final cover over the entire of landfill. Before constructing the liner, system Cover material must be prepared (sener, 2004).

2.3. Solid waste disposal site selection

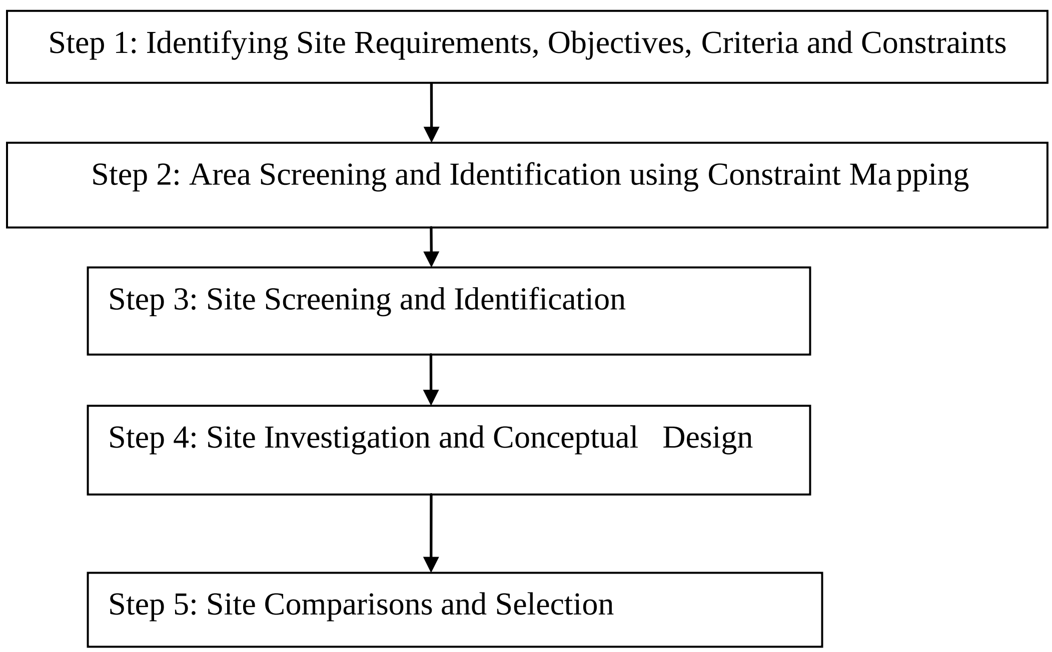
To decided selection criteria for choosing a site for landfill of a certain study area, relative literature and decision makers' opinion should mostly be required. To minimize effect of environmental sound for solid waste management, Selection of an appropriate site must ideal (yenenesh etal.,2019). Solid waste disposal site selection is a critical issue in urban area since it brings a great impact on the economy and the environmental health of the region and many sitting factors and criteria should be carefully organized and analyzed. One of the complicated steps in fixing solid waste disposal sites have precise steps involve site selecting and preparation of waste solid waste disposal site (kenate 2017). Solid waste disposal site selection should have the following tasks:

a) A systematic and impartial mode of evaluation and assessment of sites that can be practically considered available for landfill
b) An instrument for the comparison of candidate potential sites based on their suitability and then ranking them based on suitable and unsuitable,
c) A technique that will going to be practicable shall be achievable, cost effective, easy to implement, computerize and easily understand by all stakeholders (sener, 2004).

But, (as Seiied (2015), cited in kenate (2017) final disposal site selection is a difficult task to accomplish, due to need a consideration of many factors like, regulation, water supply source, land use, sensitive sites and road network. It is also the results of detailed site survey, engineering design and cost studies. This data often processing using GIS software tools to generate substantial amount of spatial information for land use suitability analysis. Solid waste disposal site analysis made using techniques combine multiple criteria decision analysis (MCDA) and GIS in order to make an initial ranking of the most suitable area. Then after, integration of GIS and Analytical Hierarchy Process (AHP), then AHP is used for ranking of waste disposal site beside multiply parameter to solve site selection problem. After that, weight linear combination (WLC) used for combination of weight of different parameter for overlay analysis.

2.3.1. Steps in Waste Disposal Site Fixing

The following flow chart display the task that should be performed in process waste disposal site sitting step by steps.



Source (Tsegaye, 2006) as cited by (Ambaneh, 2016) thesis project

Step 1: Identify Site Requirements, Objectives, Criteria and constraints

The first step in the process is to identify landfill site and size, which are requirements and determine the objectives, limitations and standards to be used in the process. Objectives like to minimize the risk of environmental pollution and health problems. Once the criteria and constraints are established, the data requirements can be determined and there may additional criteria used in this thesis project.

Step 2: Area Screening and Identification Using Constraint Mapping

Constraint mapping is a common method that includes creating a series of maps to show the areas identified as unsuitable for land filling based on each of the constraints. When the maps are overlaid, the potential candidate sites can be simply identified. landfill sitting process is evaluating the basic suitability of all available land for land filling to aid in the selection of potential sites for more detailed evaluations. The resources and constraints of the government agencies involved in the process should be taken into consideration.

Step 3: Site Screening and Identification

An identified areas that restricted will be evaluated and compared in order to identify potential sites suitable for disposal site. The objective of this step is to reduce the number of sites to for comparison in the next step. Reduction of the number of sites for comparison to select the most protentional suitable disposal site is required for saving time and cost. The data used to compare and evaluate the sites in this step is usually based on published data from concerned offices and area verification.

Step 4: Site Investigation and Conceptual Design

The detail data collected for each potential candidate site and makes a design. Site surveys should be designed to confirm published data, and collect data required measuring how well each site meets the criteria. To fully understand how each site may affect water resources, subsurface exploration and topographic surveys are carried out at the candidate sites. Designs are then completed to the point where approximate cost estimates can be made for comparative purposes.

Step 5: Site Comparisons and Selection

Step contain a detailed evaluation and comparison of the potential candidate sites. This requires comparing data collected from site investigations and published sources, and conceptual designs. The objective of this step is to identify the most location land for the required purpose by meeting the selected criteria. Moreover, this is success by weighting and rating criteria. The weight of each parameter is determined according to its relative importance them as standard and personal judgement. The method used for rating does not necessarily need to be the same for all criteria. Numerical ranking such as a scale of 1 to 9, or a qualitative ranking such as high, medium or low can be used.

2.4. Solid Waste Transfer station

The strategy of solid waste transfer involving replacing and reallocating the solid waste collection bins for minimizing collection time, distance travelled and man-effort, and consequently financial and environmental costs. Replacing and reallocation of waste collection bin has been takes place via GIS based route optimization (Sunil kumar,2011). Waste collection methods are communal systems where containers located in public places, block collection and door to door collection. Once collected, domestic solid waste is transported to transfer bin. This transfer storage made from different material and size. There are many transfer storages such as plastic bin liners, rubber steel bin, Mobile refuse bins, Mobile refuse containers, Bulk containers, Open bulk containers and closed bulk containers.

2.5. Factors Governing Solid Waste Disposal Site Selection

International practices always account for environmental, economic, social, and technical factors in selection and construction of solid waste disposals site. The key objectives of the disposal site selection are to ensure that access of disposal service is located at the best location as much as possible with a minimum negative impact to the community weather socially, economically and environmentally. There are several parameters that should be considering while test suitability of solid waste disposal site for Town or country through over world. In the process of landfill siting, a considerable evaluation is required to identify the best available disposal location which meets the requirements of government regulations, costly effective, environmental, health, and social costs by considering several factor or parameters. Solid waste disposal designers are initially concerned with the viability of a site (sener, 2004). To be Say disposal site is viable, a solid waste disposal site must be constructed in accordance with specific rules, regulations, factors and constraints which is different from place to place or from country to country. In generally, by considering all of the above context and the other local condition I would have review the parameters used by different countries to select solid waste disposal site.

2.5. Worldwide solid waste disposal site selection principle

Solid waste disposal site is a very important issue in solid waste management system due to nature of solid waste disposals as population growths and increasing volume of waste generates

(Lamessa kenate 2017). Now, world cities produce about 1.3 billion tons of solid waste per year. This volume is expected to increase to 2.2 billion tones by 2025 (Yenenesh Hailu et al, 2020) and by 2050 to rise 3.40 billion tons annually (World Bank 2018). The most famous solid waste disposal method in the whole over the world is landfill. Primarily concern of disposal site designers is checking viability of that site. International practices of solid waste dumping site selection always account for environmental, economic, social, and technical factors while constructed.

2.5.1. Factor Governing Disposal Site Selection in India

Several countries among the other India, Australia, Malaysia, Niger, North Dakota, Philippines, Uganda, and United States have put their rules and regulations guideline to refer when selecting suitable sites for sanitary design. These guidelines are used to protect primary community health and environmental beauty.

The following are the factors that several researchers have been used to determine the suitability of a site to be used for waste disposal. These factors have been chosen according to the standard and regulations for landfills sitting in India and from published literature considering the case study situations (Md Mainul Sk, Sk Ajim Ali and Ateeque Ahmad and Ali Ahemad, 2020): -

a) Elevations: is topographic feature of the land which has up and down surface. Elevation largely affects the construction and operation of the landfill sites and must be taken into account. According to their research suitability value categorizes into five class for the disposal site. The elevation ranges from 56-124 m and the suitability rank range from 1-5. Rank 1 indicate the land elevation is highly suitable and rank 5 indicate less suitable (Ali and Ahmad, 2020).

b) Slope: Land geomorphology of any area is measured by slope gradation that describe by in percent or degree units. The higher degree slope is technically unsuitable for disposal site construction. Because steep slope reasonably for leachate movement and contaminate water and soil surrounding. The slope value ranges from 0-17; 18-35; 3653; 54-71 and 72-89^{o}. The most suitable areas were considered to be the plane areas which is rank of 1. as the area with less than 17° slope is thought to be extremely suitable for disposal landfill site and the areas with more than 17° slope are considered as unsuitable (Ali and Ahmad, 2020).

c) Soil: Soil classification is based on the report by the National Bureau of Land and Soil Survey (NBLSR), India. The soil type ranges from clay loam to clay; clayey skeletal and sandy clay loam to clay were used for the study. However, only Clay loam to clay is considered as best suitable site and received the highest rank for low porosity and impermeability (Şener et al. 2011).

d) Geological structure: - Here in the study area three comprised formations of geology including panchet, laterite and alluvium. As these study panchet gate the highest mark which is 1 and it is most suitable for disposal site selection and construction (Şener et al. 2011).

e) Land use land cover: - In India, as study shown as many researchers use the LULC map covers the areas of built-up, settlement, industrial zone, swampland, sparse vegetation, vacant land with vegetation, green space with vegetation and barren land. Barren land was assigned as highly suitable areas for candidate landfill site construction in the study area and ranked as 1 and built-up and settlement areas were considered as not-suitable because populated area is affected due to odor, dust, and noise from landfill site (Ali and Ahmad, 2020).

f) Surface water bodies: - Related literature decided as distance from surface water to disposal site 100 to 300 m varied for landfill site selection. A landfill site should be located standard distance away from any surface streams, lakes, rivers, wells or wetlands, because landfills generate contamination to the water bodies by release leachate and toxic gases that affect the users. India country enacted rules and regulation the follow in MSWM, while siting landfilling, the area of water bodies far less than 200-m distance was rejected and the area highly suitable areas for municipal landfill sites with > 800 m buffer zone (Ali and Ahmad, 2020).

g) Distance to Tube Wells and Wells: disposal site must not very close proximity tube well water. Five different buffer zones with 100 m intervals were constructed and > 400 m areas were considered highly suitable for landfill siting and ranked 1 and on the other side rank 5 is given for buffer zone of <100m which is restricted (Ali and Ahmad, 2020).

h) Distance to road: landfill site is sitting by considering economic context. That means cost for developing new road project to give access to these services and transportation. In case area with less than 100 m were received highly suitable and ranked as 1. Area > 400 m distance were considered as least suitable for landfill site construction and ranked as 5 (Ali and Ahmad, 2020).

i) Distance to Industrial Belt: The area adjacent to industrial zone is buffered with an interval of 500 m were prepared in GIS environment and the areas with less than 500 m were rejected for giving service for disposal site as per the rules and regulation of Municipal Solid Waste Management, India. But, the area with distance more than 2000 m considered as highly acceptable for landfill establishment and ranked of 1 pasatari.et al (2019).

j) Distance to Sensitive Places: The area adjacent to protected area is buffered with an interval of 500 m were prepared in GIS environment and the areas with less than 500 m were rejected for giving service for disposal site as per the rules and regulation of Municipal Solid Waste Management, Act 2016, India. The areas with more than 2000 m distance from landfills were received as highly acceptable for landfill establishment (Ali and Ahmad, 2020).

The factors governing disposal site selection described above would been summarize as the following in the table form.

Table 2. 1 Factors governing disposal site selection in India country

No	Proposed criteria	Distance(m)
1	Distance from historical sites, ancient areas and international museums	>250
2	Distance to Industrial Belt	>500
3	Slope	<17%
4	Geological structure	Planchet
5	Land use land cover	Bare land,
6	Distance from well water or water supply	>100
7	Distance from roads	<100
8	Distance from water bodies	>200
9	Soil	Clay loam to clay
10	Elevation	<124

2.5.2. Factor Governing Disposal site selection in Australia

The Environment Protection Authority (EPA, 2016) based on (NSW Department of Urban Affairs and Planning, 1996) has set out restrictive criteria for landfill siting including the following:

a) Protected area: 250 m as buffer zones from landfill sites to "national parks, historic and heritage areas. conservation areas, wilderness areas, wetlands, littoral rainforests, critical habitats, scenic areas, scientific areas and cultural areas".

b) Water bodies: 40 m as suitable buffer zones from landfill sites to "a permanent or intermittent water body or in an area overlying an aquifer that contains drinking water quality groundwater that is vulnerable to pollution".

c) Residentials: 250 m as proper buffer zones from landfill sites to “a residential zone or dwelling, school or hospital not associated with the facility".

d) 1000 m as buffer zones from landfill sites to residential zones, schools and hospitals.

e) Landfill sites should not locate within "a karst region or with substrata that are prone to land slip or subsidence".

f) Landfill sites should not be located within "specially reserved drinking water catchments".

Table 2. 2 Factors governing disposal site selection in Australia

No	Proposed criteria	Distance(m)
1	Distance from historical sites, ancient areas and international museums	>250
2	Distance from well water or water supply	>40
3	Distance from residential having social service	>1000
5	Distance from urban residential areas having social services	250
6	a karst region	Not located

2.6. Factors Governing solid Waste disposal site selection in Ethiopia

Most of the time, solid wastes are dumped in drainage lines, open space, near to the street and informally burned in Ethiopia. Unsafe disposing system is practices, such as open dumping, burning and burying (Kebede, 2020). As different studies shown us there are different criteria used by different scholar to determine whether the proposed site is suitable or not based on their interest of study, availability of data, condition, government policy and others many factors in Ethiopia. Tirusew, 2013 as cited in kenate (2017) distance from protected areas, settlement, river and lake, distance from main roads, distance from airport, land use/land cover, slope, soil type, site capacity/ area of site to solid waste disposal site are the major important factors to be considered to locate the best suitable location for solid waste disposal site. There are several researches have been done in Ethiopia on the same issue, but I would take as an example one research to show factor considered for suitability of disposal site. The research has been done by Morka Kebede (2020) in Asossa town, Ethiopia.

I. Soil: It is recommendable that the soil of the selected site has good natural impermeability in order to reduce the possibility of aquifer contamination. The soil of the selected site should be clayey (MUDC, 2012). Soil is one of the criteria to select landfill site. The site is dominantly constituted by residual soils comprising: Silt clay soil, highly rounded gravel to boulder size materials, highly fractured volcanic (basalt rock the first aquifer), slightly massive basalt, massive basalt, slightly massive basement rock and highly massive granite.

II. Distance from Road Network: landfills shall not be located within 400 m of any major highways and city streets and also should not be placed too far from existing road networks, to avoid the expensive cost of constructing connecting roads (Issa, 2012 and MUDC, 2012). But, Morka (2020) state for his study area buffer zone is done by interval of 200m and the area with 300m is unsuitable for solid waste site selection. But area with >700m is highly suitable.

III. Surface Water (Rivers, Streams): To maintain the environmental health of water sources at least 500m buffered distance should be ringed through straight line calculation (MUDC, 2012). But, Morka (2020) in his project considers local context and buffer the surface water with 200m. Area with 200m is rejected from suitability analysis and area with distance > 300m received as highly suitable.

IV. Distance to Well/Reservoir: Areas further from 300m distance at equal interval are considered as suitable. A place with 300m distance is take as constraint and area with >400m is consider as highly suitable.

V. Land use /Land Cover: From the existing land use/cover built up and settlement area are constraints for disposal site location. The other land use was categorized as range from least suitable to highly suitable.

VI. Slope: An area whose steepness results in low average cost and easy for construction and maintenance is highly recommended for the location of waste disposal site. The land with a slope less than 10% is highly suitable for solid waste dumping (MUDC, 2012 and Tirusew et al., 2013). As morka (2020) claim as suitability of the area for disposal site is start from 1-12 %.

VII. Distance to Social Services: the landfill should not be located within 1000m distance of sensitive areas like churches, mosques, parks, schools and memorial sites (MUDC, 2012). 300m buffer distance from a landfill is taken as an appropriate distance to identify areas that are rejected in the analysis part of this thesis. 300m buffer zone is consider as fall from suitability analysis and buffer is made by 50m interval and area distance > 350m take as highly suitable (Morka, 2020).

VIII. Distance to built-up area: Built up area includes commercial areas, governmental and private institutions, schools, health-centers, religious institutions, educational institutions, residential area and other social services area. The greater the distance from residential areas the more suitable for landfill site selection. Distance to the built-up area is buffer with 500m was a restricted area and the other was classified as per their suitability. Distance > 1000m was highly suitable for site.

IX. Distance to Airport: the minimum buffer distance was 1000 which is unsuitable and area with distance > 3000m were highly suitable.

Table 2. 3 Factor governing solid waste disposal site selection in Asossa.

No.	Criteria	Distance
1	Distance to built-up area	>0.3km
2	Distance from Airports	>3km
3	Distance from memorial sites, churches and schools	>0.3k
4	Distance from surface water	>0.2km
5	Distance to Well/Reservoir	>0.3km
7	Distance from Road Network	0.3km
8	Soil type	< loam
9	Slope	1-12 %
10	Land use /Land Cover	Open space

In this study except criteria on number 2, I would be used all of the factors for determine the suitable disposal site for the study area.

The reason why the I do not consider the criteria number 2 was that the study area did not have airport.

2.7. Multi Criteria Decision making (MCDM)

In integration of multi-criteria decision-making method within GIS technology-based location analysis encompasses information such as, geographical data, the decision maker's preferences and the combination of the two. MCDM is a developed mathematical tools and methods of compering different option by considering various criteria to choose one of them accordingly. AHP and WLC are the most known method of it through which suitability of geo-environment is analyzing for disposal site (Imtaiz etal., 2012) that will be used for this study

2.7.1. Analytical Hierarchy Process (AHP)

From multicriteria decision methods Analytic Hierarchy Process (AHP) is the one that introduced by (Saaty, 2008). For site selection AHP apply systematic way of decision-making weather the site is suitable or not by determine an eigenvalue of each factor through the pairwise comparisons approach (Imtaiz etal., 2012). The main function of AHP is to support decision makers to select the most appropriate choose from the variate of alternatives. It also assigns the weight for each evaluation criteria internally as well as externally then, decision makers decide the result of evaluation through pair wise comparison of the criteria.

2.7.2. Weight Linear Combination Method (WLC)

under this study the weight linear combination technique of multicriteria analysis approach is used for combine all the factors and prepare map after weight is assign to each criteria's internally and externally (Zewdie, 2017). It gives relative decision suitability analysis by making overlay analysis.

2.8. Role of GIS and RS in solid waste disposal site selection

GIS play the main role in solid waste management in case of disposal site selection in this study. GIS is a comfortable recent Technology used to record, analysis, overlay, manage and display spatial and attribute data (Sunil kumar,2011). The application of GIS and Remote Sensing techniques is a very recent technology in assessment of land suitability. GIS provides a common framework for integrating and analyzing multiple datasets based on geographic location. The main goal of GIS in this study is to take raw data and transform it, via overlay and other analytical operations, into new information, that can support decision-making processes. Gideon Ufoegbune et al., (2012) say that GIS is a final method which is capable of stores, retrieves, analyses and displays spatial or location determination information like, latitude, longitude and altitude as well as non-spatial information for site selection as user defined specification. GIS is not only instrument used to select the landfill site within low cost, time and effort of human power but, also it used to provide digital database for the future controlling of the solid waste dumping site.

Remote sensing is the science, technology or art of taking measurement on an object without in contact with it to derive information for further processing, analyzing and displaying that information (Dr. Roba Gemechu, 2018). The main role of Remote sensing in solid waste disposal site selection is to extract many site selection criteria for disposal like, map of; land use land cover, and drainage. It also generates *digital* data as it used for GIS as input for further analysis.

2.9. Conceptual Framework of the Study

How all the literature reviewed in this chapter is combined with this research to develop a framework for selecting waste disposal areas and summarize the conceptual framework. Choosing the ideal waste disposal site is a complex process that requires data on economic, environmental and social diversity. As pointed out in the literature review section, important research has been conducted on the choice of on-site solid waste disposal sites and the most commonly used independent variables that affect the suitability of disposal sites. Scholars are the terrain slope, elevation, Land Cove (LULC) land use, road network and geological factors used as independent factors. Therefore, according to the literature, suitability type and study area, main roads, elevation slope, built-up area, LULC, water body, wind direction and soil type, the independent variables of the current study are determined to improve suitability. Establish a solid waste disposal site by coordinating these factors based on geospatial technology. Geospatial technologies, mainly geographic information systems (GIS), global positioning systems (GPS), Google earth pro and remote sensing, play a considerable role in the selection of waste disposal sites because it manages the large amounts of data and integrates data from different sources. The correct selection of waste disposal sites not only depends on thematic map standards, but also supported by the use of different geospatial analysis tools, including spatial analysis, classification, buffering, digitization, extraction, weighted overlap and proximity analysis. The correct site selection for waste disposal sites is sensitive to the influence of the weights assigned to the factors. Mistakes and doubts are common features of decision makers in suitability analysis, and influence factors that affect the final decision weight. Therefore, in order to avoid ambiguities in the decision-making process, it is critical and necessary to establish weights based on the multi-standard analytical hierarchy process (AHP). According to literature review, there is no common standard distance for buffering standards, and different researchers have adopted different distances. Therefore, in order to overcome this limitation, this study considered local conditions and average distance that some researchers used. Finally, the weighting factors are integrated to produce the expected result of this study, which is the suitability map of the waste disposal site.

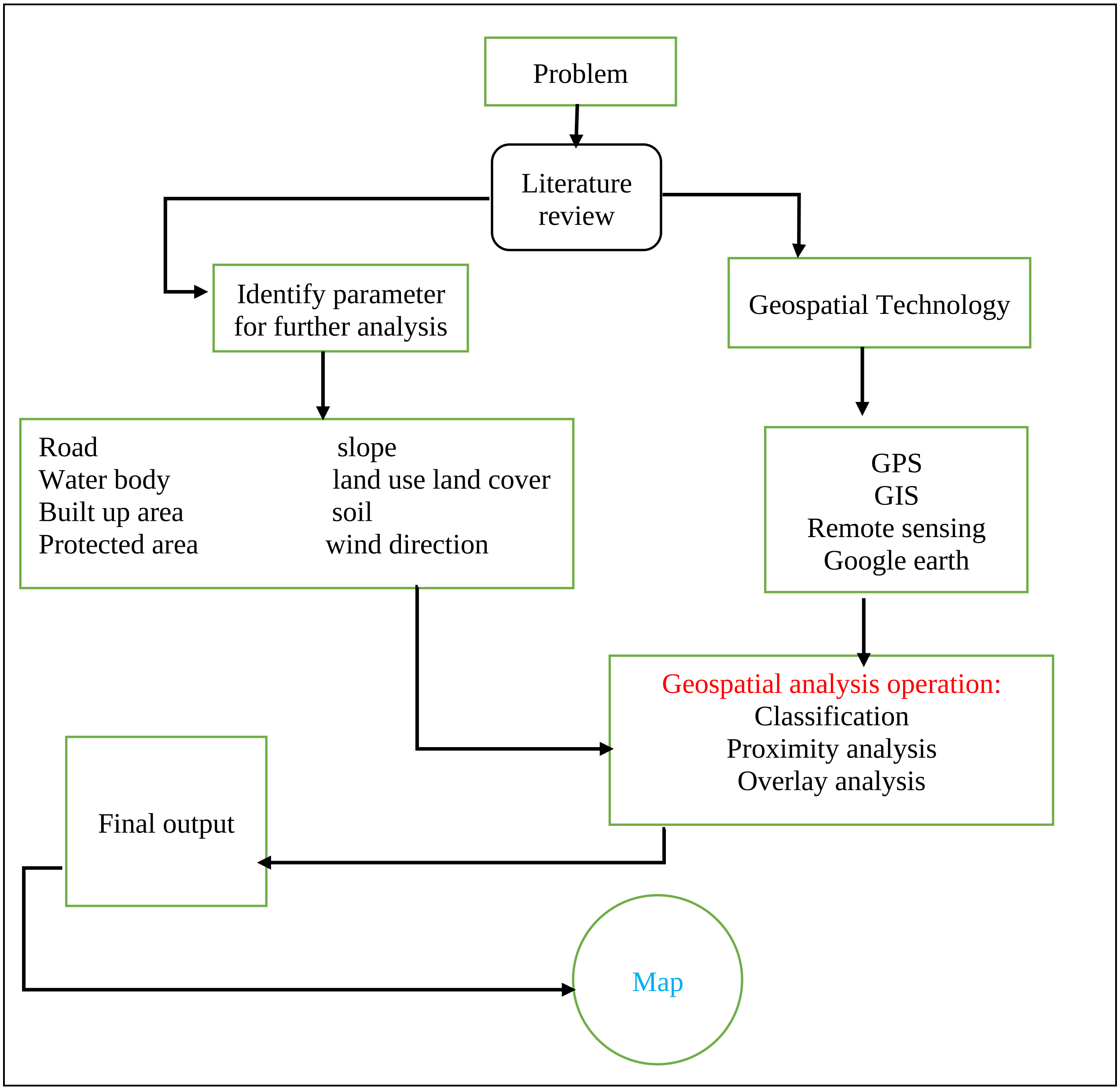


Figure 2. 1 Flow chart of framework

CHAPTER III. MATERIAL AND METHODS

3.1. Description of Study Area

3.1.1. Location

Hidebu Abote is one of Oromia woreda which locate in the northern part of the region. It is known for its agricultural products specially, teff. Ejere is the capital Town of Hidebu Abote woreda which is fast growth from time to time. The town cover the area of 422.9 hectares which hold population density of the total 23682. Among the total population female 12542 and male 11440. The geographical location of Ejere Town is between $9^0$55’30’’ N-$9^0$55’26’’ N latitude and between $38^0$31’07’’E-$38^0$31’28’’E longitude and an average elevation of 2381 meters (Ejere Town municipality office, 2020).

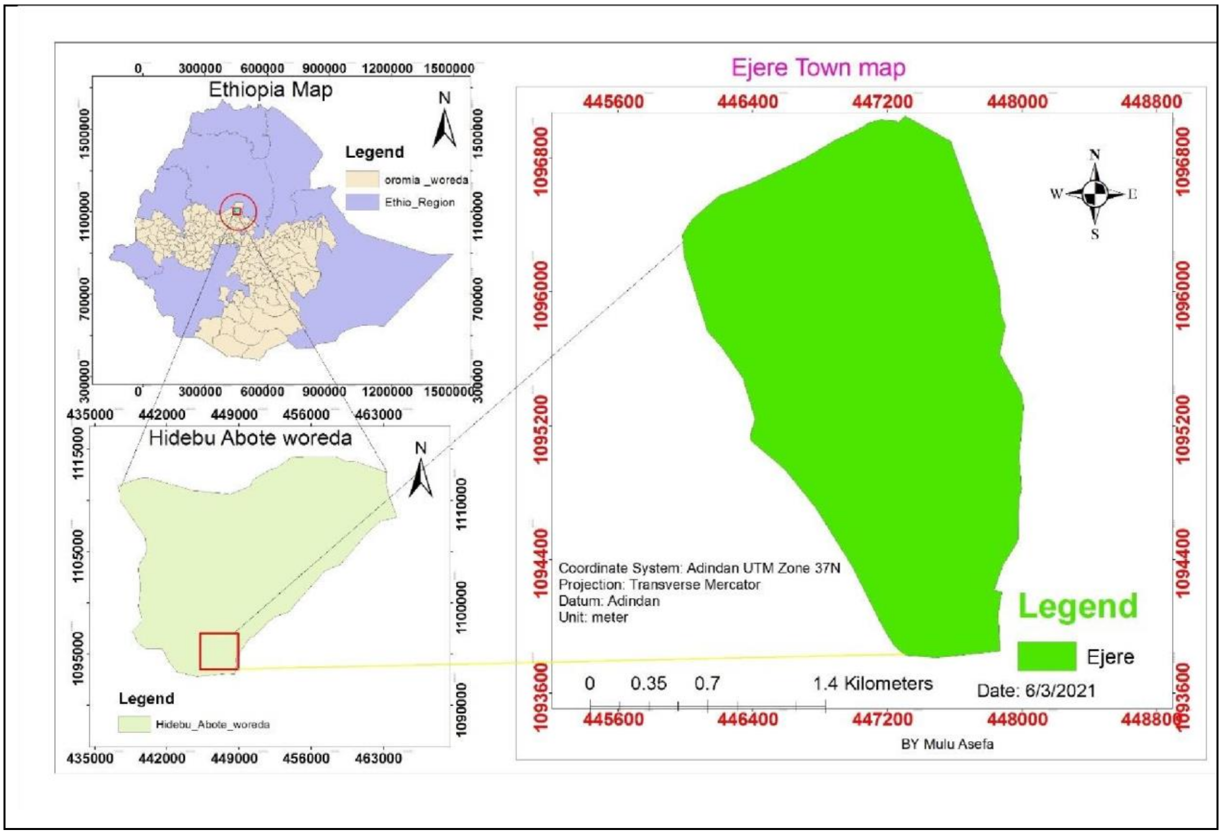


Figure 3. 1 Map of study area

3.1.3. Landscape

Ejere town is characterized by plain surface of topography with an elevation ranging from 2312 m to 2450m. The town has an elongated shape that extends from North to south east. Elevation is the criteria that show topography of the area. The elevation of the study is higher at the north and south east of the town and getting lower at the center of the town (DEM study area and field observation, 2021)

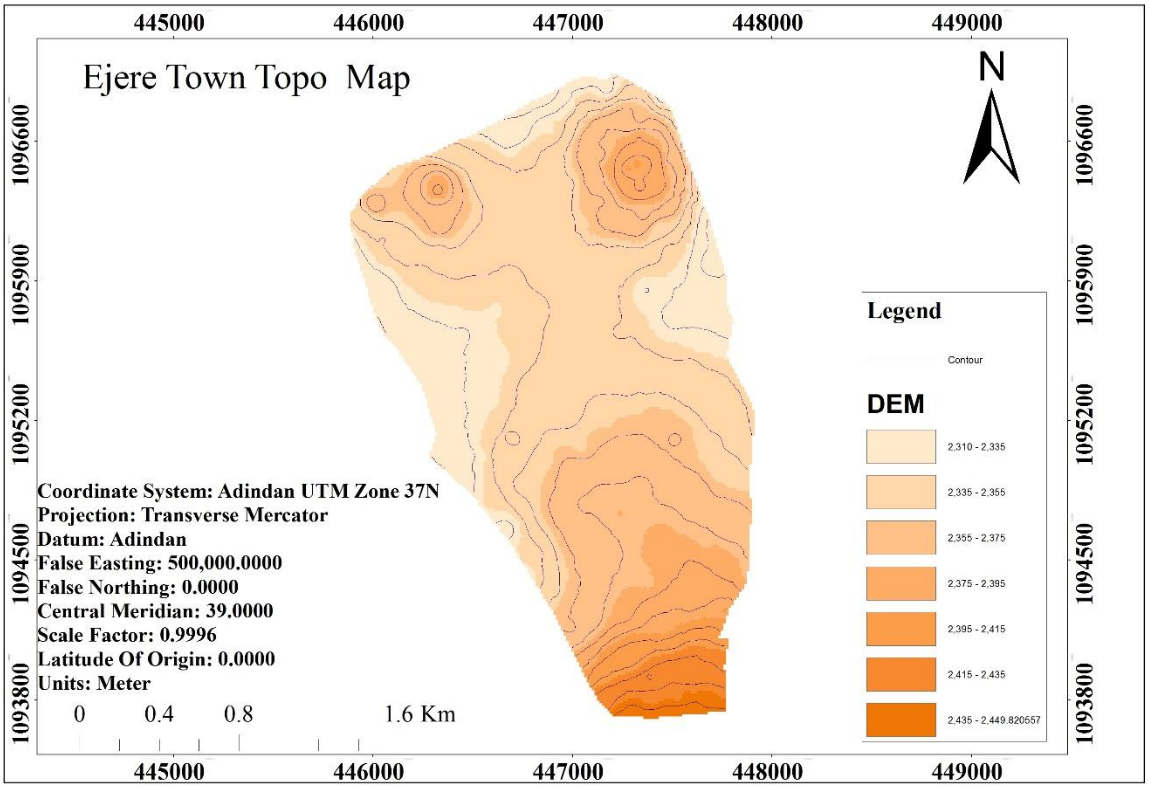


Figure 3. 2 Topographic Map of study area

3.1.4. Population

Over the past few years, the human population of Ejere town has been growing rapidly. According to CSA, 1994, the total population of the town was 1,992 with the growth rate of 3.07%. As CSA 2005, the total population the town was 3,556 with the growth rate of 3.96%. furthermore, as per CSA of 2007 the total population of the town was 6,395 with the growth rate of 7.71%. The current population of the town will be projected to 23682 by 2021 (office, 2021)

3.1.5. Rainfall of Study Area

The study area is mainly arid and semi-arid with hot temperature for most of the year. The climate of Ejere town is characterized by four distinct seasons. The main wet season is called summer extends from June to August, short rainy season called autumn locally known as tsedey extends from September to November, Dry season called winter locally known as bega extends from December to February and a little rainy season called spring locally known as belg extends from March to May. Generally, according to the traditional climate zone classification Ejere town is categorize as Woina dega climatic zone. The average annual rain falls of the study area from 2015-2019 was display as the followed in a graph form. This graph shows the maximum and minimum amount of rain falls in Ejere town.

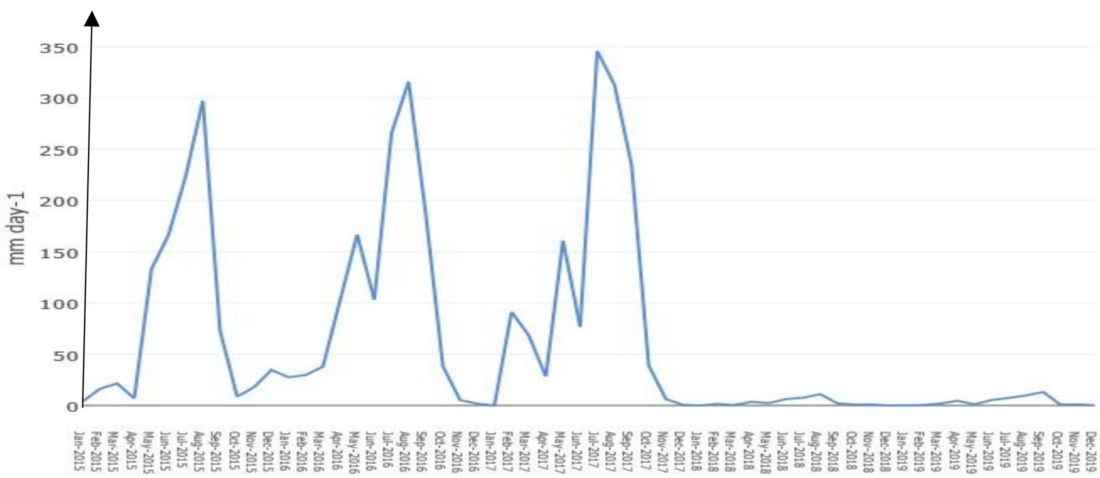


Figure 3. 3 Graph shown amount of rainfall

The information display above would have summarized as the followed in a table form.

Table 3. 1Average Rainfall of study Area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Av-RF	49.45	81.8	82.36	86.42	163.84	135.66	253.91	277.1	168.04	60.9	46.44	48.2

Table 3. 2 Average Rainfall of study Area

Source National Meteorological Agency

3.1.6. Temperatures

North Shewa zone experiences mean annual temperature ranging between 10 and 25°C. Accordingly, the maximum and minimum temperature of the study area was display as the following by the graph below.

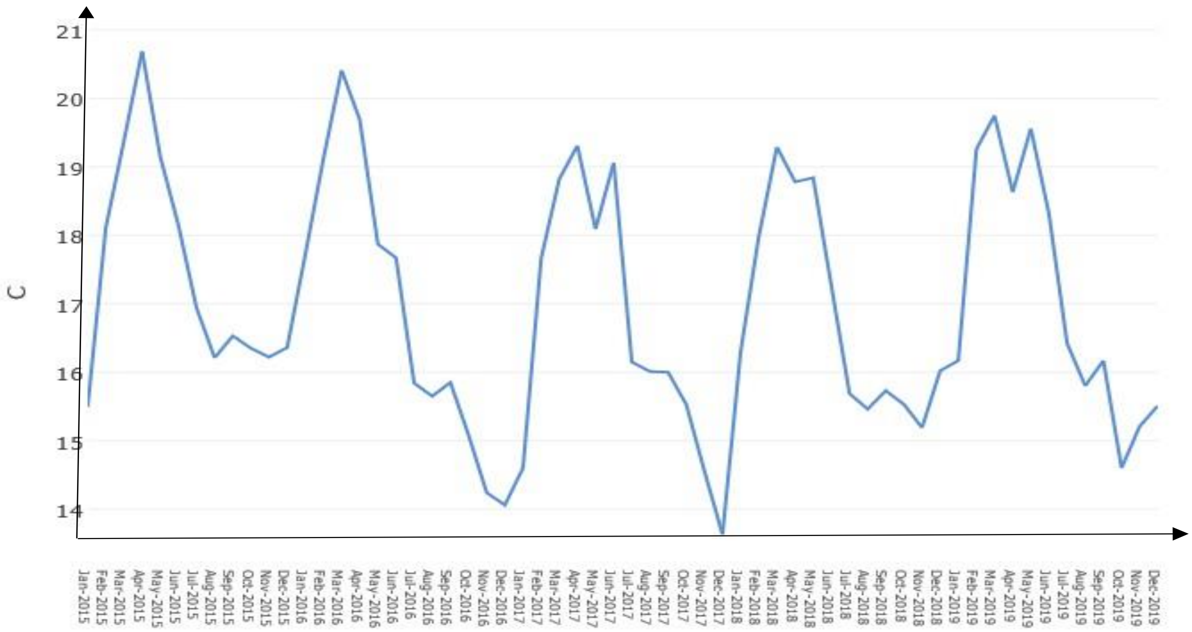


Figure 3. 4 Graph shown average temperature

The average temperature the study area could be summarized as followed in the table below

Table 3. 3 Average temperature of the study area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AvTem(C^0)	16.63	18.82	19.93	19.98	19.19	18.52	16.59	16.16	16.27	15.62	15.44	15.64

Source: national meteorology agency

3.2. Data source and collection techniques

In this study both primary and secondary data would have been used. Primary data were like, photo of current dump site, illegal dump on which people simple throw waste to open space, location of current disposal site by Global satellite positing (GPS). Also, the primary data would have been collected by observation and field survey. Secondary data were also used for this study specially for literature review. Secondary data involve master plan of the Town, satellite images, geological, Road network and social services documents.

Table 3. 4 Secondary data type and source require for the study

Data types	Description	Data source
Structural plan of Ejere town 2012	To digitize Town boundary, water bodies, built-up area	Ejere municipality
Landsat 8 OLI imagery 2020, pixel 30mx30m Resolution	Current land use land cover	USGS open-source website
ASTER DEM Model version 002 Resolution 30mx30m	To generate the Slope and Topography	USGS
Road network	Digitize	Google Earth of 2019
GPS data	Collect by Germain72 for Navigation	Field observation

3.3. Material and software

To be accomplished this study the followed material would been used.

Those are: Arc GIS software, ERDAS software, IDRIS Software, GPS Instrument and personal computer.

Table 3. 5 Materia and software I had have used in these study

No	Material and software	Purpose
1	Arc GIS 10.8 version	Digitizing, Buffering, Overlaying, Extract, Data conversion spatial analysis, proximity analysis, Reclassify and preparation of thematic map
2	ERDAS imagine 2014 software	For generate current land use
3	IDRISI Software	Value assign and weight computation
3	GPS Germain 72	Data collection for location verification
4	Microsoft-word 2016	For writing and editing final study
5	Micro-soft excel	Used For calculating accuracy assessments of land use land cover classification.

3.4. Method of Data analysis and presentation

Integrated Geospatial Technology with Analytical Hierarch process (AHP) was a method used to analysis spatial and non- spatial data for this study. AHP method was selected to be used in this study because it has a capability to analysis multiple variables at once and also highly qualified techniques since it could be analysis quantitative and qualitative data. The analysis should be made by using different software but, it was generalized in ArcGIS environment. There are different ArcGIS operational tools used in this study for determine location of suitable site for solid waste disposal in the study area. Those GIS operational tools are; Georeferencing, Digitizing, buffering, Conversion tools, weight overlay, spatial analyst and AHP are super tools used in this study for appropriate site selection for Ejere town.

3.4.1. Georeferencing

Georeferencing a process of determining the accurate coordinate for map or raster image to refer the location of image area on the surface. It is the process of making announcement between internal digital map and ground coordinate system. It also assigns the real coordinate to the raster image to determine the location of an area on the surface. The spatial data from different environment could be georeferencing using the coordinate on the structural plan of the study area. Georeferenced data were projected for additional analysis.

3.4.2. Digitizing

Digitizing is one of the GIS operations which used to convert the base map of study area to digital data for further analysis. It is also the process of convert analogue information to digital format to having a soft copy of data on the computer for further analysis. This operation can take place through on screen digitizing different feature from structural plan of the study area and Google Earth. Feature digitize from the structural plan of study area were boundary of the town, built area and land use type and data digitize from Google Earth were DEM and road network that used for further analysis.

3.4.3. Buffering

Buffering is a process of making a zone for strategic point, line and polygon of an area with specified width. It is one of the geoprocessing tools used for proximity analysis for specified criteria like, built area, road network, stream or gullies and protected area to test suitability of site for dumping solid waste. For this project I have used multiple ring buffer to make buffer zone.

3.4.4. Overlay

Suitable site selection involves multiply parameters as a criterion. Multi criteria decision making method is used for analyzing a problem by considering multi factors. Overlay is a process of create a relationship between variate of factor map consider as criteria used to select the location of dump site. all the weighted factor maps were overlaid using weighted overlay extension of spatial analyst tool (Zewdie, 2017). In this study overlay analysis performed using weight overlay extension from analyst tools to identify the suitable place for disposal site by making compression among factor map based on their value of weight assigned to each of them. Since, the higher the value implies the high suitability for located disposal site. The layers of parameters buffered before were overlaid using ArcGIS environment and a map clearly display all areas suitable for locating the dumpsite lying outside of the buffered zones. The final map showed the potential areas suitable for siting a landfill in Ejere town.

3.4.5. Conversion Tools

Conversion tools is a geoprocessing tools that used to converting raster data types to different data format like, cad, shapefile, layer and table

3.4.6. Conveying Weight for Criteria

From multi criteria decision making, Analytical Hierarch process (AHP) widely used for assigning weight for each and every parameter. Since, AHP is to support selection of the best alternative from various possible choice for decision makers to decide the location of suitable dump site. The weight assign to each parameter will analysis through overlay analysis using weight linear combination technique (Imtiaz, 2012). Generally, in this study, an integration of GIS and MCDM method will be used for selecting disposal site of Ejere town. The following figure shown as the general work flow

3.5. Research Design

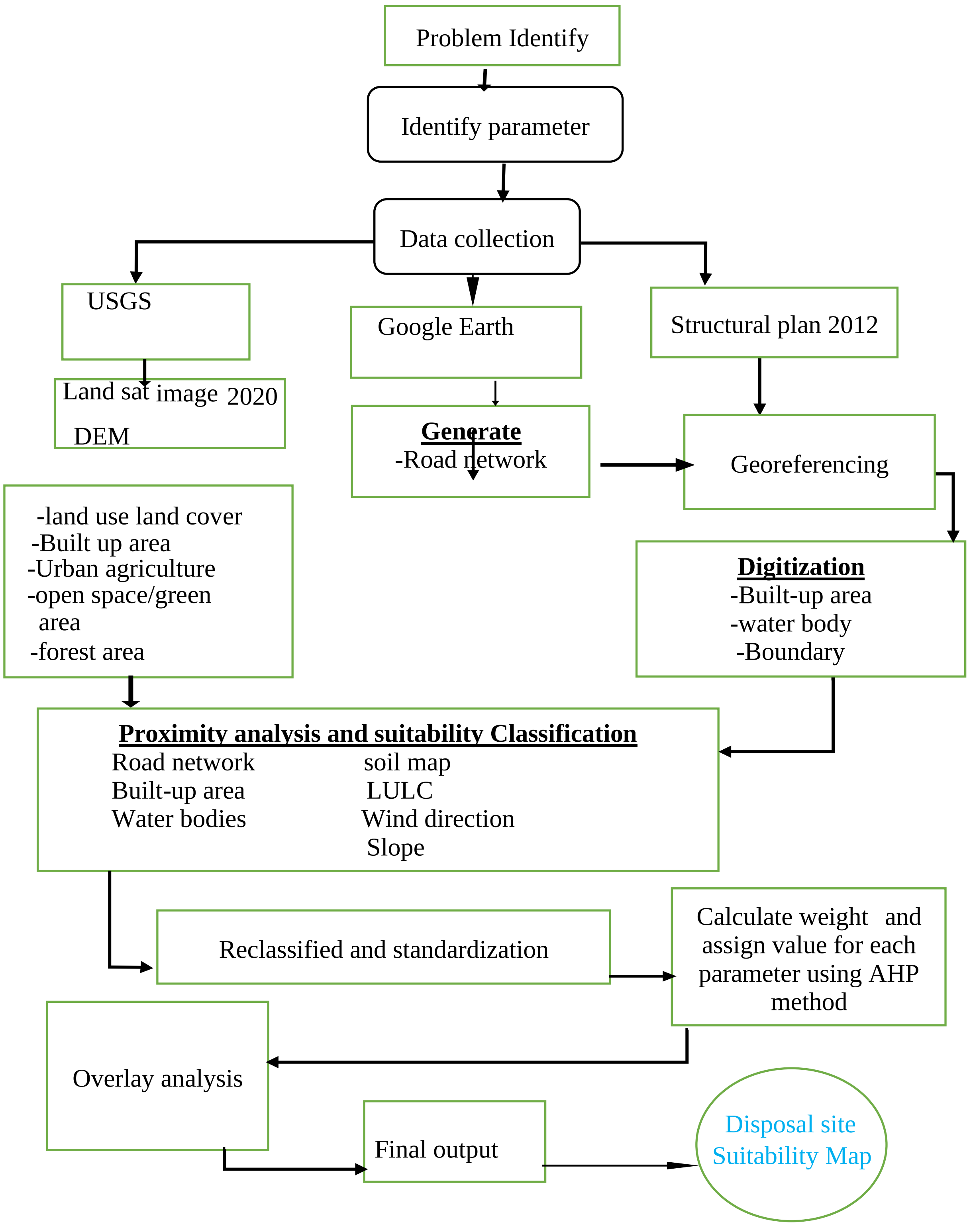


Figure 3. 5 work flow chart

CHAPTER IV. DATA ANALYSIS, RESULT AND DISCUSSION

Under this chapter different data sets that were used to select suitable solid waste disposal sites have been evaluated, the results were discussed and presented at the end. For this work, suitable sites were determined by using the GIS capability and weighting product of AHP method. Waste disposal site must be situated and designed so as to meet the essential conditions for avoiding environmental pollution and surface water contamination. Likewise, site should be kept as far away as possible from population density, for reducing impact on public health. Additionally, the site should be located not much far from existing roads for saving road development, collection costs and transportation. Also, waste disposal site does no positioned at steep terrains which difficult to constructed and also bring high runoff. So steep terrains are not suitable for construction of waste disposal site. In this thesis work land suitability could be reclassified on the base of FAO (1993) land suitability classification guideline. FAO classify land suitability in to five categories in which land suitability classes reflect degrees of suitability. The classes are given Arabic numbers. The designations are: Class S1, Highly Suitable; Class S2, Moderately Suitable; Class S3, Marginally Suitable; Class N1, Marginally Not Suitable; and Class N2, Permanently Not Suitable. Furthermore, FAO explain degree of suitability for class number it represents as the followed. **Class S1** land has no significant limitations to sustained application of a given use. It may include minor limitations that will not reduce productivity, benefits or costs below the lower boundary set for the class.

Class S2 land has limitations which in aggregate are moderately severe for sustained application of a given use. The limitations happen reduce the value, benefits or costs compared with S1 land to a lower limit set for the class.

Class S3 land has limitations which in aggregate are severe for sustained application of a given use and will so reduce physical value as compare with S2.

Class N1 indicates that the land is marginally not suitable and has limitations that may be manageable in time but which cannot be corrected with the existing knowledge or under present social conditions to give acceptable physical value.

Class N2 indicates that the land is permanently not suitable for the given use usually because of physical limitations. N2 land should be delineated early in the study to avoid unnecessary studies on land which will never be developed for the given use. BY considering this and other guideline from relative literature review I have had classified land suitability for solid waste disposal site in to five categories such as Highly Suitable, Moderately Suitable; Marginally Suitable;

Marginally Not Suitable; and Permanently Not Suitable

Maps were created for each suitability criterion and the final composite map was finally produced by simple overlaying of the individual maps. The buffering zones used, ranks and weights were summarized using tables**.** In generally the objective of this research would be achieved through field verification and non-structured interviews with resident and municipal land administration experts in addition to spatial data analysis.

4.1. Parameters Used to Determine Suitability of Solid Waste Disposal Site in Ejere Town

Parameters used as a criteria to decide suitability of waste disposal stie were selected based on information from relative literature after reviewed it and taken into consideration the local condition of the study area. For this study eight (8) suitability criteria includes: distance from settlement, protected areas, roads network, stream/river, soil type, urban land use type, wind direction, and slope were used. This was based on the relevant literatures, local condition, standards of Ethiopian Ministry of Urban Development and Construction, in addition to international practices. All the parameters were reclassified unsuitable, less suitable, moderate suitable and highly suitable. Maps are created for each suitability criteria and the final composite map is finally produced by simple overlaying of the individual maps.

4.3. Present status of solid waste disposal site and selection criteria

One the objective of this study was to assess the present waste disposal site of the study area by comparing it with selected criteria and parameters. The objective was achieved through field observation and interview land administration experts and residents of the town. The result shows that the municipal of the town together with the land administration office selected and prepared the existing open dumping site without any criteria. According to the observation and interview, the existing solid waste disposal site is not suitable, because the existing site does not consider major environmental and health factors, like distance from drainage, and built-up area.

Mean that existed open dump located with almost 8m from residential area on one side and adjacent to gorge in another side as shown in the figure 8(a).

Figure 4. 1 Existing Disposal Site
Source: Google earth pro

4.2. Parameters for Disposal Site Selection and Criteria's

As stated in chapter two, the first step landfill sitting process is identifying site requirements or criteria. Since the main objective of this study was selecting suitable landfill site, criteria used should minimize surrounding environmental, economic and social impacts. The following criteria were used to meet the above objectives.

Table 4. 1 Parameters for Disposal site selection

No	Parameter	Layer Name	Criteria
1	Surface water	Stream	1000 meter away
2	Road Network	Road	between 1000- 2000 meter
3	Slope	Slope	less than 10 %
4	LULC Type	LULC	barren land and area covered by grass lands
5	Built up Area	Settlement	1000 meter away
6	Soil type	Soil	Clayey soil
7	Protected areas	Protected Areas	1000 meter away
8	Wind direction	Wind direction	

Source: Ministry of Urban Development and Construction, (2012)

4.2.1. Landscape Factors

Landscape shows the shapes of land features of the area. Slope is one the landscape factors characterizing the suitability of land for waste disposal site.

Slope**:** Slope is one of the criteria to sitting waste disposal site. Also, slope is an important factor in suitable site selection operation, because slope determines the amount of runoff in the site. Not only this but also slope is a critical for building of waste disposal sites, because land feature having higher slope require higher costs of construction of disposal site. This is due to huge number of materials, technology and human power needs high budgets (Kenate, 2017) and (Kebede, 2020). In this thesis work, slope of the study area was generated from DEM using Arc-GIS spatial analyst extension of surface tool. The slope generate from DEM of the study area have been classified in to five class based on FOA classification. Suitability of slope of the study area for waste disposal site selection would be determined after reviewed related literature. Different researchers decided suitability of slope for waste disposal site selection differently. For example, Aden Ali (2016) decided as an area with slope 10-20% as highly suitable, area of slope < 10% is moderately suitable and area of slope > 20% as unsuitable for waste disposal site selection. Inversely (Kenate, 2017) state area with slope of 0-3% is unsuitable, area with slope > 20% as less suitable and area slope with 3-15% as suitable for waste disposal site selection. Zewdie (2017) and (Ambaneh, 2016) claim the idea of (Kenate, 2017) as the area of slope < 10% is highly suitable and area of slope > 16% as restricted or unsuitable for waste disposal site selection. Kebede (2020) state that a place of slope >1% is restricted and a place of slope 3-12% is highly suitable for sitting disposal site. The slope suitability to siting solid waste disposal site for the study area in to five class, reclassified and standardizes based on the above relative literature and local condition. The gentle slope area should be considered as highest suitable than the steepest slope of an area. As the slopes get to steeper there is a possibility of high risk of pollution and potentially that place is not a good site for disposal. It covers slope class of 0-3% which is very flat in the study area. The five class of slope for the study area could be classified as 0-3% less suitable, 3-9% highly suitable, 9-15% moderately suitable, 15-20% temporary unsuitable and > 20% permanently unsuitable for disposal purpose.

Table 4. 2 Slope classification and its Suitability for Disposal site

No	Slope class (%)	Degree of suitability	Rank	Area (ha) coverage	Area (%) coverage
1	0-3%	S3	3	171	44.18
2	3-9%	S1	1	178	45.99
3	9-15%	S2	2	36	9.31
4	15-20%	N1	4	2	0.52
5	>20%	N2	5	0	0
6	Total			387	100

Source attribute Table of ArcGIS

In the above table degree of slope suitability represents by S1, S2, S3 this means highly suitable, moderately suitable, less suitable and N1, N2 means temporary suitable, permanently suitable respectively. It's ranks also represent as 1, 2, 3, 4 and 5 respectively. The place of highly suitable for waste disposal site cover an area of 178 hectare (ha) which is 45.99% out of total area. Moderately suitable area covers a size of 36 hectare (ha) which is 9.31% of the total area coverage. Area coverage of 171 ha is less suitable for waste disposal site siting. 2 hectare of the total area which is 0.52% it represents temporary unsuitable for the purpose of solid waste disposal site. There are no area categories as permanently unsuitable for disposal siting in the study area.

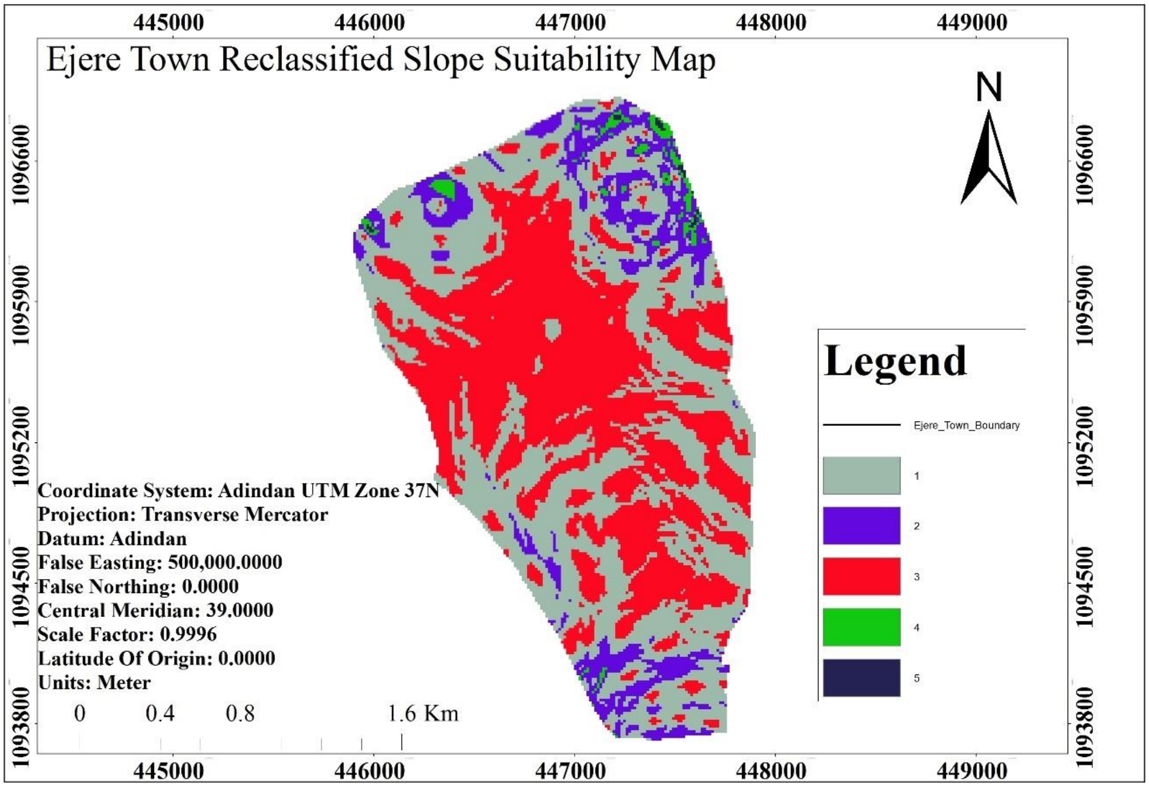


Figure 4. 2 Reclassified slope Suitability Map

4.2.2. Road Network Factor

Road is one of the Determinate factor or parameters that should be considered in suitability analysis. In Economic and social point of views road network is one of the important parameters for solid waste disposal site selection processes. For example, consideration of road economy for waste disposal site selection involves farness and closeness of distance it has from the road access. Since, the waste disposal site was very far from the road access it affected economy of the concerned body, because it required new road that would been constructed. New construction of road needed additional budget for material, skilled person and equipment's. However, if disposal site was very close to the road especially to the main road it encounters environmental pollution and healthy problems to the peoples. That means waste disposal sites should not be very close to roads, because as landfills close to roads may result public health problem. Therefore, while locating waste disposal site consideration of distance from the road paly a great role for sustainable solid waste management. As the general concept, the landfills shall not be located within 400 meters of any major highways, city streets, or other transportation routes (Ambaneh, 2016). Different researchers assigned different value for distance between road side and disposal site boundary to make a buffer zone to confirmed suitability of an area for waste disposal site selection. Distance of disposal site from the road for this thesis research could be determined after reviewing different related literature. I reviewing many different related literatures to decide the optimum distance between road access and disposal site. Among the related literature research done by sener (2004) and Berisa and Birhanu (2015) argue 100m was the minimum distance that disposal site does not locate. While, (Ambaneh, 2016), (Zewdie, 2017), and MUDC (2012) reclaim the first argument by using a buffer of 0-400m as the minimum distance for disposal site selection. According, to (Aden, 2016) state 500m as the minimum distance with which solid waste disposal site do not locate. Kebede (2020) decide as it was enough for suitability analysis if the minimum distance from road to waste disposal site had been 300m. That means the area with distance of 0-300m was restricted for solid waste disposal siting. In this study the existing road network was generated from google earth and analysis in GIS environment. After summarized the above related literature and consider the local condition I was choose the minimum distance of 300m for this thesis work. Buffer zone of the study area were reclassified in to five as permanently unsuitable, temporary unsuitable, less suitable, moderately suitable and highly suitable. Therefore, Multiple Ring Buffer tools were used to create buffer classes around the roads with 0-100m, 100m-200m, 200m-300m, 300m-500m and 500m-700m range as a buffer class for minor roads and 0-200m, 200-300m, 300-500m, 500-700m, and 700-1200m for major road buffer distance. Buffer suitability classification for this thesis work had been summarized in the table and figure below.

Table 4. 3 Road buffered Distance and its suitability

No	Buffer class for		Degree of suitability	Rank	Area (ha) for		Area by % for	
	minor road (m)	Major road (m)			minor road	Major road	minor road	Major road
1	0-100	0-200	N2	1	229.21	139.59	54.3	33.04
2	100-200	200-300	N1	2	91.72	62.29	21.73	14.74
3	200-300	300-500	S3	3	56.73	105.93	13.44	25.08
4	300-500	500-700	S2	4	38.5	75.45	9.12	17.9
5	500-700	700-1200	S1	5	6.03	39.05	1.43	9.24
Total					422.19	422.31	100	100

Source Arc map layer and attribute table

In the above table degree of slope suitability represents by S1, S2, S3 this means highly suitable, moderately suitable, less suitable and N1, N2 means temporary suitable and permanently suitable respectively for major road. On the other hand, S1, S2 and S3 were represents as highly suitable, more suitable and suitable for minor road respectively. It's ranks also represent as 1, 2, 3, 4 and 5 respectively for both minor and major road buffered distance. The area coverage for both minor and major road buffered distance were different for particular degree of suitability. That means highly suitable degree of suitability cover an area of 6.03ha and 39.05ha for minor and major road respectively which were 1.43% and 9.24% of their total area. Area coverage 38.5ha, 56.73ha, 91.72ha, 229.21ha represents as more suitable, suitable, temporary unsuitable and permanently unsuitable for minor road respectively. Likewise, area coverage of 75.45ha, 105.93ha, 62.29ha, 139.59ha represents moderately suitable, less suitable, temporary unsuitable and permanently unsuitable respectively for major road. As shown on the above table the 200m and 700m were minimum and maximum distance for minor road that used to buffer the zone to located disposal site. Since, minor road was the internal road and extend to give access to disposal site for the community it is enough if the disposal site far 200m from the minor roads. Here the maximum distance I used for minor road was 700m because, it covers buffer zone in the study. Further, information was gone from the following figure 4.3 below

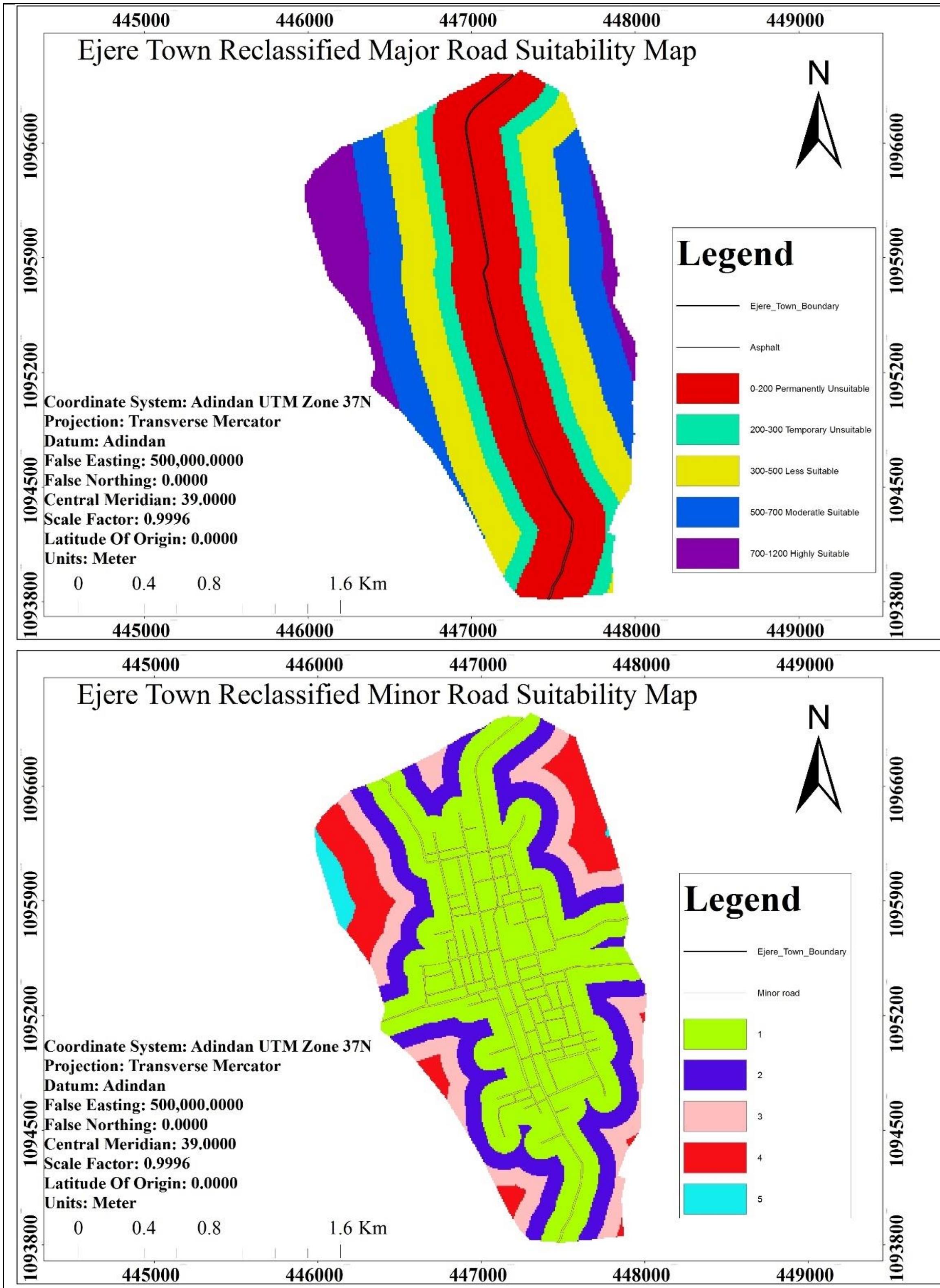


Figure 4. 3 Road buffer reclassified and its Suitability

4.2.3. Surface Water

There is no river or lake pass through or located in Ejere town. But there is the river basin in the north and south of the study area from close distance to the town. Most of the surface waters in the study area are Gorge. So, at the rain season water flow from the center of the town toward these two basins. The landfill site must not be close to surface water bodies. Because, as the distance between the landfill and water bodies close to each other, there was high probability of polluting the water. The pollution in water resources causes series problems in environment and public health.

In this study the Gorge were generated from structural plan of the town. Then it was buffered after reviewing different relative literature and compare and contrast them with local context and using the standards of MUDC, 2012, to locate suitable sites for landfills. Suitability classification for this thesis was performed after reviewing so many different related literatures. Different scholar used different value for surface water buffer zone to determine its suitability class. For example, (Zewdie, 2017) used 500m distance as the minimum for placing disposal site. (Brihanu Y and Berisa G, 2015) and (Aden, 2016) claim that 200m, as a minimum distance for a landfill should be located away from water bodies. Likewise, (Kebede, 2020) state the minimum distance required to locate waste disposal site away from water bodies was 200m which is marginally suitable and an area of distance >300m were consider as highly suitable in his thesis. In this thesis work the above literature concept and environmental condition could be taken into consideration to reclassify buffer distance of surface water suitability for disposal site. Degree of suitability for surface water in this study area was classified in to five class as shown in the table 4.4 below. The minimum limited distance used in this project work was 300m. The area with 0-300m was constraint or restricted to locate waste disposal site. But, area of site covers the distance >300m from water body were considered as suitable for solid waste disposal site siting.

Table 4. 4 Waterbody buffer distance classification

No	Class	Degree of suitability	Rank	Area(ha)	Area in %
1	0-200	Permanently unsuitable	5	72	17.03
2	200-300	Temporary unsuitable	4	64	15.13
3	300-500	Less suitable	3	110	26.00
4	500-700	Moderately suitable	2	67	15.84
5	>700	Highly suitable	1	110	26.00
6	Total			423	100

Source: Arc Map and attribute table of the layer

As shown in the table 4.4 above the area which were highly suitable was cover 110 hectares. This indicate 26% of the total area could be highly suitable for waste disposal site sitting. If disposal site would be constructed in this site contamination of water body was minimized since distance from water to disposal site far away mean that > 700m. Moderately suitable area cover 15.84 ha which was 67% of the total area that far away 500-700m from disposal site. Nonetheless area cover the distance of < 300m would be unsuitable for solid waste disposal site construction in the study area.

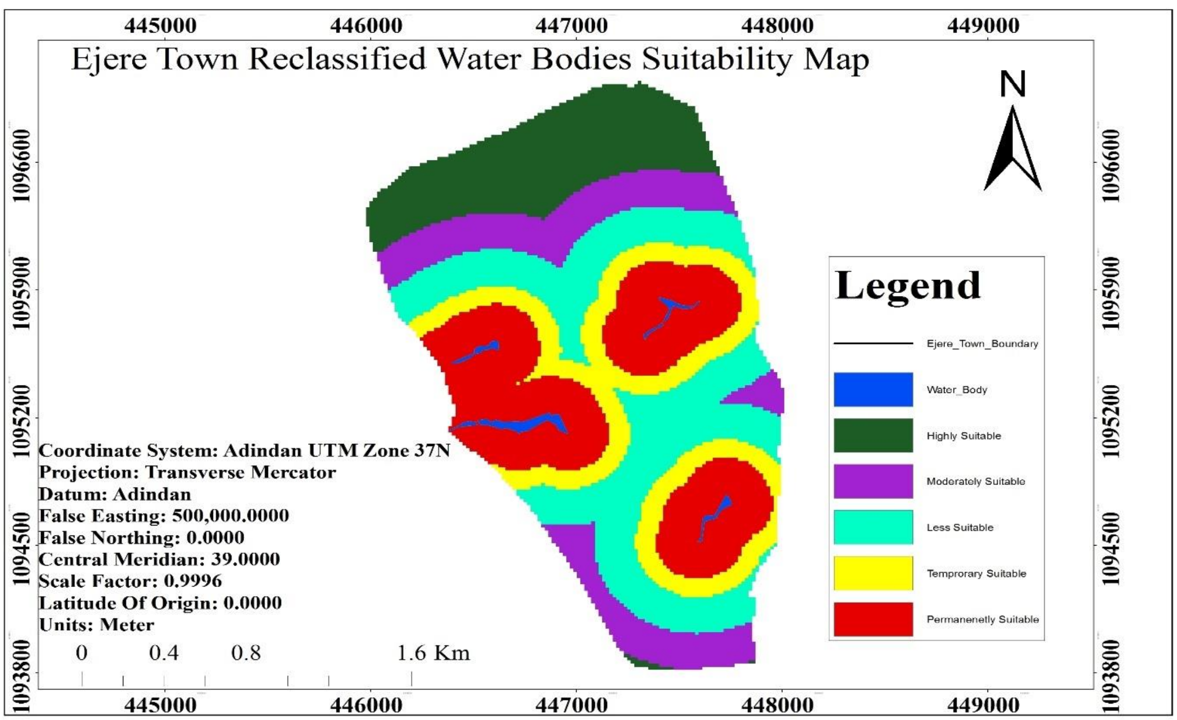


Figure 4. 4 Reclassified water bodies Suitability map

4.2.4. Protected Areas

Protected area is a place where human being performed their day-to-day activity. So, it is a densely populated, social service and historical area. Therefore, the distance of protected area from the boundary of landfill is very interesting issue to fixed disposal site. Due to the need to avoid possible interventions and risks to human health, landfills should generally be placed more than 300 m away from the built buffer zone, especially the distance from social service agencies (Brihanu Y and Berisa G, 2015). The protected areas in this study include churches, public libraries, museums, schools, and health centers. The waste disposal site should not be in close proximity to the above-mentioned sensitive areas, and the surrounding buffer zone should not exceed 300 meters. As the distance from the area increases, the suitability of the land for garbage dumps also increases. The X, Y coordinates of protected area at the study area was collected using Germain GPS instrument for verification and buffered using the standards of MUDC, 2012, to locate suitable sites for disposal area. Therefore, four different areas have been designated, among them, the buffer zone away from the protected area is more suitable, while the closest one was less suitable for waste disposal. This research believes that the reclassification distance starts from 0 to 300 meters was unsuitable, from 300 to 400 meters is less suitable, from 400 to 500 meters was moderately suitable, more than 500 meters is highly suitable

Table 4. 5 Protected area degree of Suitability Classification for waste disposal site

No	Suitability Class	Degree of suitable	Rank	Area (ha)	Area by %
1	0-200	Permanently unsuitable	5	49	11.61
2	200-300	Temporary unsuitable	4	56	13.27
3	300-400	Less suitable	3	79	18.72
4	400-500	More suitable	2	95	22.51
5	>500	Highly suitable	1	143	33.89
6	Total			422	100

Source: Arc map layer of protected area feature and it`s attribute table

As shown in the table 4.5 above 105 ha area coverage was unsuitable and 143 ha of area coverage was highly suitable for locating waste disposal site in the study area. Whereas, the other suitability class were in between of the two class.

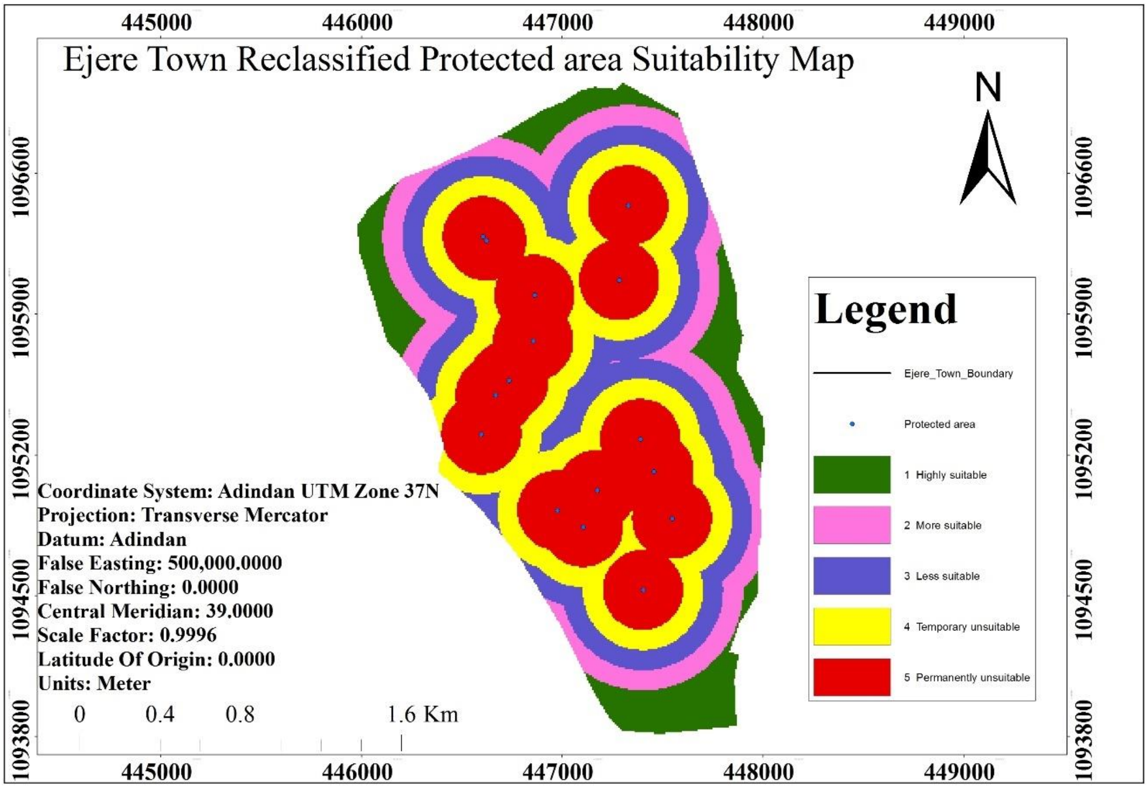


Figure 4. 5 protected area reclassified suitability map

4.2.5. Built up Area

As Kenate (2017) state EMUDC, 2012 pointed out that solid waste disposal should not be less than 1 km away from urban residential areas, historical sites, including international museums, and other social activities of public concern, such as aesthetics, smell, noise, and property value decline. However, (Kenate, 2017) and (Zenebe, 2018) claim this idea as 300m distance of built-up area from waste disposal site was enough for disposal site selection. The distance from the solid waste disposal site to the building is an important environmental parameter for choosing a solid waste disposal site. Built-up areas include settlement areas, commercial areas, government and private institutions, schools, health centers, religious institutions, educational institutions, and other social service areas. The buffer zone of these built-up areas should be as far away as possible from any waste disposal because it is the determinant of contamination. For the work of this study, after consulting different studies and related documents, the distance from the garbage disposal site to the built-up area was determined. Therefore, this study classifies the distance of the construction area as follows.

Table 4. 6 shown the Built- up area suitability classification in detail.

No.	Buffer class by meter (m)	Degree of suitability	Rank/value	Area (ha)	Area by percent (%)
1	0-200	Permanently Unsuitable	5	374	88.62
2	200-300	Temporary unsuitable	4	27	6.4
3	300-500	Less suitable	3	20	4.74
4	500-700	More suitable	2	1	0.24
5	Total			422	100

Source attribute table and ArcGIS layer map of the feature

From the table 4.6 above the value 5 was higher in number but assign for permanently unsuitable degree of suitability and the inverse was true for value 2 which is more suitable. In the study area high area coverage is hold by unsuitable site which was 401 hectare and suitable site for waste disposal was 21 hectares only. The detail was described in the following figure 4.6 below

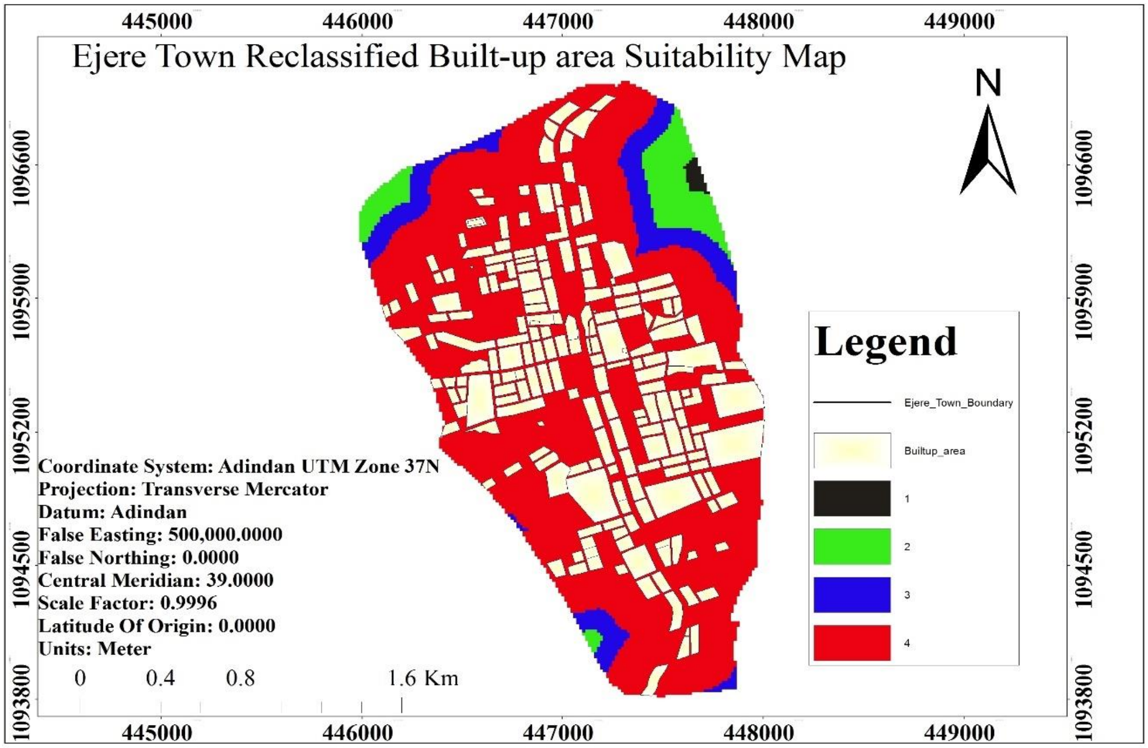


Figure 4. 6 Reclassified Built-up area suitability classification

4.2.6. Soil Nature

According to the FOA soil classification, Ejere Town has three soil types. Leptosols, nitisols and vertosol from the soil group. Vertosols are the main soil group in the study area. The nature of the soil varies in depth and content from region to region. The permeability of each soil depends on the composition of its texture. Detailed soil characteristics in the study area are described below.

1. Leptosols

The reference soil group Leptosols is suitable for very shallow soils on hard rocks or materials with high calcium content, but also for very gravel and / or deep stony soils. This soil was found in the southern part of the study area. Judging by its characteristics, this type of soil is not suitable for landfills due to its shallow depth, being made up of hard rocks and underdeveloped soil (Gizachew, 2011). Leptosols are formed from less than 10% of the parent material of different rocks and have a depth of 25 cm. The area covered by this group of soils is very sensitive to erosion. Because of this and their depth from the soil surface, leptosols are not suitable for locating solid waste disposal sites.

2. Nitisols

On the basis of the world reference soil group, Nitisols is suitable for deep, well-drained red tropical soils with fuzzy layer boundaries and underground layers with a clay content of more than 30%. Nitisols is a heavily eroded soil, but it is much more productive than most other red soils. It is formed by rock matrix materials with good physical properties for planning purposes, with fine texture, deepness and stability (FAO, 1993). Due to their good texture and depth, nitisols are more suitable than leptosols for siting waste disposal site. This type of soil exists in the northern part of the study area.

3. Vertosols

They are important agricultural soils. They have a high clay content and therefore have a high moisture storage capacity. These soils have high yield potential but require proper fertility management. Vertosols is a naturally fertile soil, but due to the limited availability of nutrients, it has poor drainage and is difficult to process. The most important feature of Vertosols is their high-water retention capacity, which is the result of deep profile and high clay content (Zewdie, 2017). Due to its inherently low porosity, characterized by fine-textured soil with clay content> 60% vertosols was highly suitable for locating waste disposal site in the study area. Suitability of soil in the study area for sitting waste disposal would display in the following table and figure 4.7 below.

Table 4. 7 Soil Suitability classification

No	Class	Degree of suitability	Rank	Area(ha)	Area (%)
1	Vertosols	Highly Suitable	1	299	70.85
2	Nitisols	Less Suitable	2	87	20.62
3	Leptosols	Unsuitable	3	36	8.53
4	Total			422	100

Source: attribute table and Arc map layer

As shown in the table above and chart below vertosol was highly suitable soil type followed by nitisols which was less suitable to sitting waste disposal site. vertosols cover 299 hector and nitisols cover an area of Ejere Town which was 70.85 and 20.62 percent respectively and 8.53 percent covered by leptosols which was unsuitable for waste disposal site.

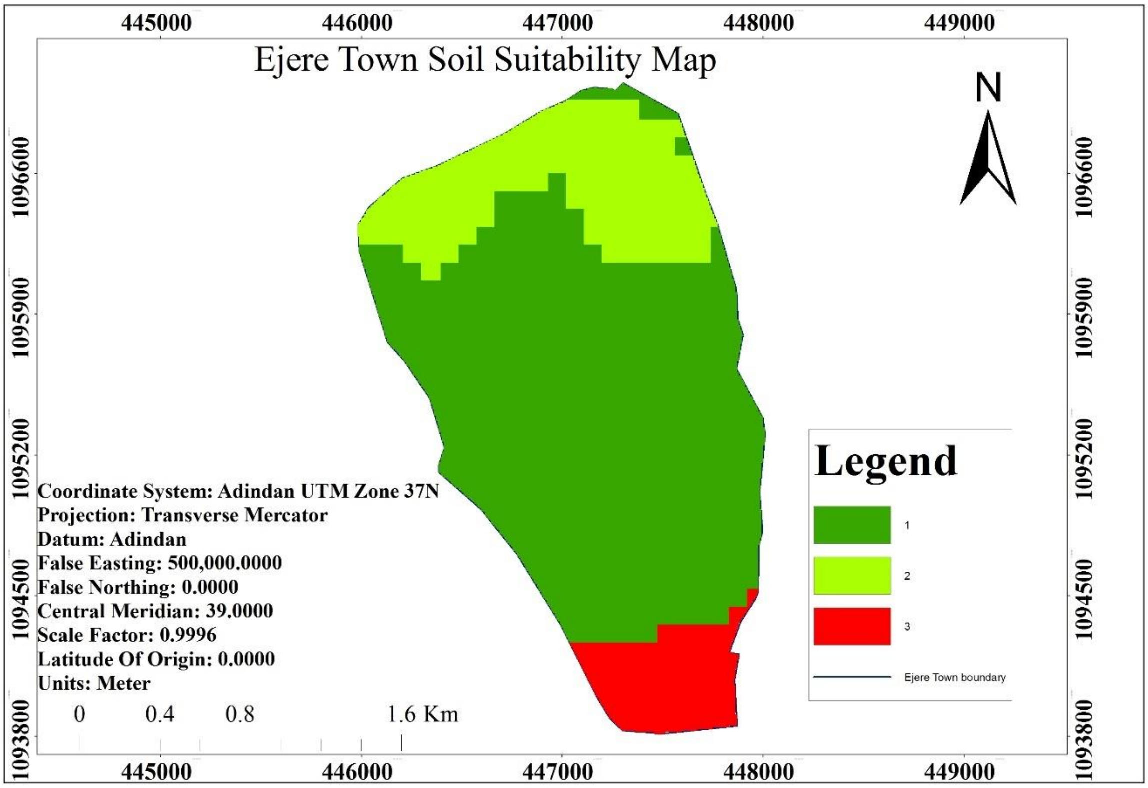


Figure 4. 7 Reclassified soil Suitability Map

4.2.7. Land Use Land Cover Types

The type of land coverage of the Town was analyzed from Landsat 8 Oli acquired by 2020. Ejere Town Master plans were used as auxiliary information during image classification. The images were made under the classification monitored. The classified pixels were grouped into four common categories as follows: Therefore, the type of land use was classified according to the importance of evaluating the appropriate site to find the landfill. Forest area and urban / green space is suitable for waste disposal whereas built-up area was not suitable (Zewdie, 2017). For this study forest area was highly suitable and built-up area was unsuitable for waste disposal and the other class were in between of the two class. Here as Zewdie (2017) open space is more favorable for siting waste disposal but in this thesis open space/green area were consider as less suitable than that of forest area. Because, town municipality use open space as green area means recreational area. Not only this but also it is small in area coverage as we seen from the figure 4.8. Therefore, the master plan of the survey area was used as a guide to identify a typical class of land coverage. This was used to solve the problem of identifying similar reflectivity features, such as green areas with open terrains, and farmland. Finally, supervised classification was carried out by ERDAS Imagine Software. Suitability of land use land cover (LULC) for waste disposal siting were analyzed as shown in the figure and table 4.8 below.

Table 4. 8 Land use land Cover (LULC) Suitability Classification

No	Class	Degree of suitability	Rank	Area(ha)	Area (%)
1	Built-up	Unsuitable	4	140	33.2
2	Open space/green area	Less suitable	3	4	0.94
3	Urban agriculture	More suitable	2	231	54.73
4	Forest area	Highly suitably	1	47	11.13
5	Total			422	100

Source attribute table and arc map layer

Large parts of the study area were covered by Urban agriculture and built-up area and least area cover open space/green area Land use/land cover of the study area is shown below. As shown in the figure 4.7 below forest area represented by dark green color, urban agriculture by TIN color, open space/green area green, built-up area by read color which their value was 1, 2, 3 and 4 respectively.

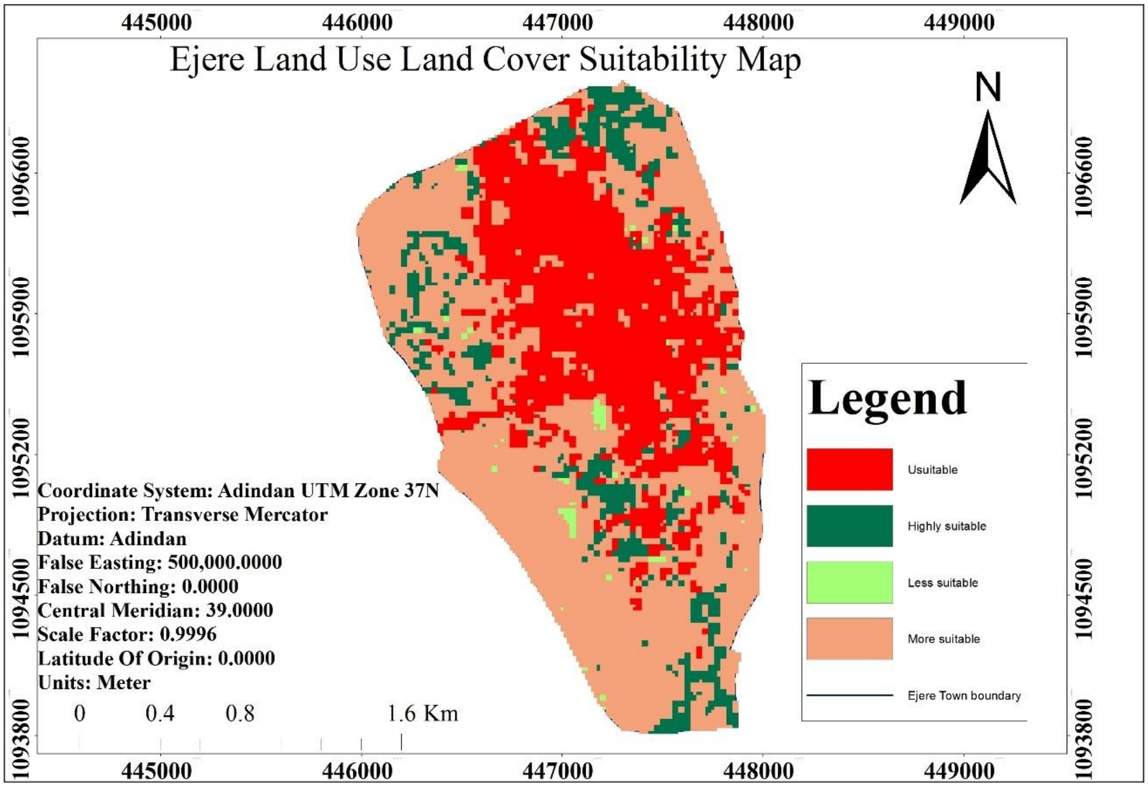


Figure 4. 8 Reclassified LULC Suitability Map

Table 4. 9 Accuracy assessment

	Built-up area	Open space/green area	Urban agriculture	forest	Total user
Built-up area	10	0	0	0	10
Open space/green area	0	2	0	0	2
Urban agriculture	0	0	12	0	12
Forest	1	0	0	2	3
Total producer	11	2	12	2	30

Accuracy assessment formula

$$\text{User's Accuracy} = \frac{\text{Number correctly classified pixels in each category}}{\text{Total number of reference pixels in that category (Total Row)}} *100$$

Built-up area =10/10 *100 = 100%

Open space/green area =2/2*100 = 100%
Urban agriculture = 10/12*100 = 83.33%

Forest = 2/3*100 = 66.66%

$$\text{Producer's Accuracy} = \frac{\text{Number correctly classified pixels in each category}}{\text{Total number of reference pixels in that category (Total Column)}} *100$$

Built-up area =10/11 *100 = 90.9%

Open space/green area =2/2*100 = 100%

Urban agriculture = 10/12*100 = 83.33%

Forest = 2/2*100 = 100%

$$\text{Overall Accuracy} = \frac{\text{Number correctly classified pixels in each category (diagonal)}}{\text{Total Number of Reference pixel}} *100$$

= 26/30*100 = 86.66%

$$\text{Kappa coefficient (T)} = \frac{(TS*TCS-\sum(\text{Row Total*Column Total}))}{TS^2-\sum(\text{Column Total- Row Total})}$$

TS= Total Samples, TCS= Total Corrected sample

$$= \frac{(30*26-\sum(11*10)+(2*2)+(12*12)+(2*3)*27)}{30^2-\sum(11*10)+(2*2)+(12*12)+(2*3)*27} *100$$

780-44/900-44 =736/856 *100 = 85.98%

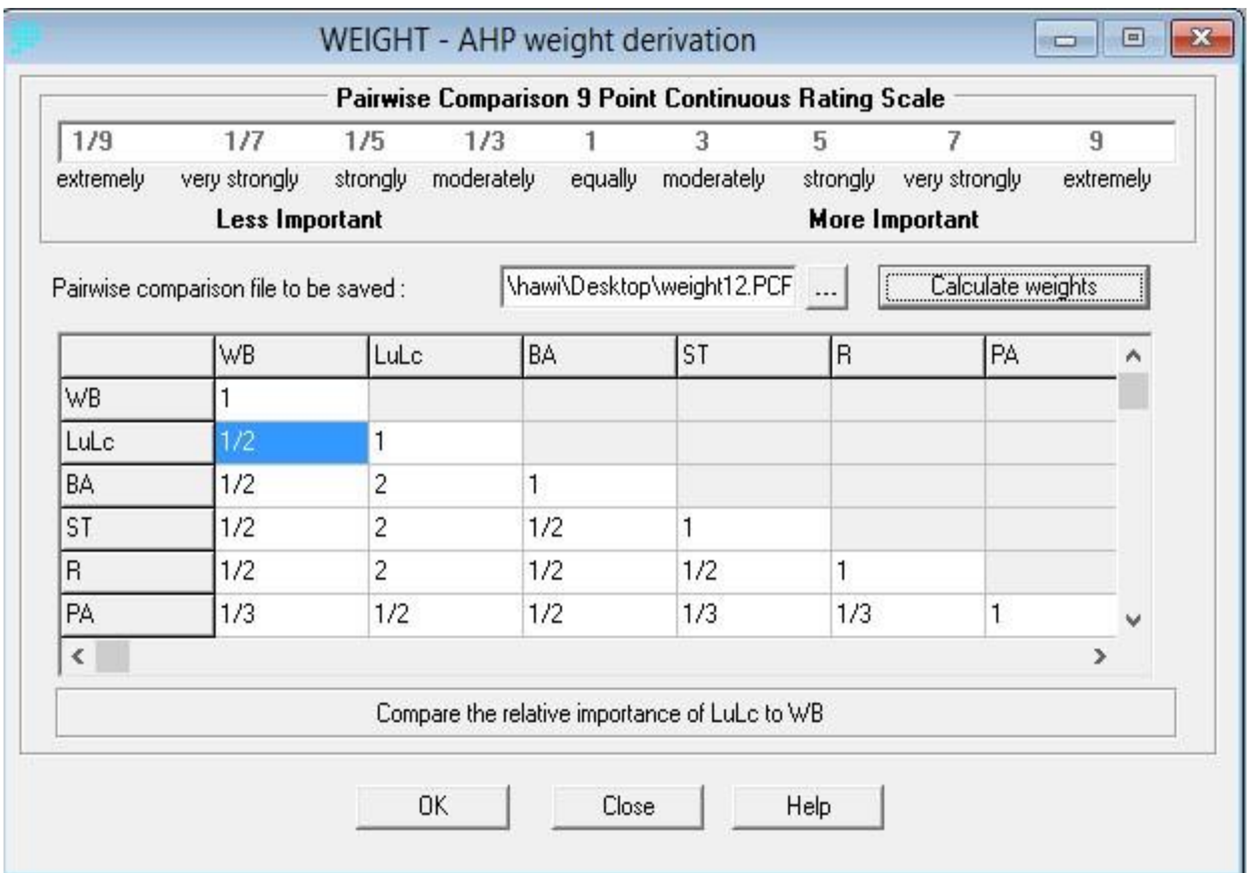
4.2.8. Wind direction

The wind is the horizontal movement of the air characterized by its direction and speed. The direction of the wind is the direction in which the wind blows at a rate determined at a constant speed. In Ejere Town, the dominant wind direction was the wind blows from north to southeast part of the Town. Therefore, the direction of the wind is an important planned contribution to propose the use of the land that affects close contamination. A remarkable wind direction can affect the downstream population of the installation.

4.3. Assigned and Calculating Weight for Each Parameters

Site selection for solid waste landfills involves comparing different options based on environmental, social, and economic impacts. Therefore, based on experience and possible effects on the surrounding environment, different weights are assigned to all parameters. When assigning value to each criterion, it needs to give careful attention. Because the higher the weight value, the more important the criteria would been in overall utility (Aden, 2016). The development of weights provides a pairwise comparison of the relative importance of a number of parameters with the applicability of pixels to the activity being evaluated. The procedure of generate weights follows the logic developed by Saaty (1980) under the Analytical Hierarchy Process (AHP). The main use of Analytical Hierarchy Process (AHP) in this thesis was to give the sequential order of the parameters per influential power it has on the surrounding community. Weight percent is given based on the 8-point continuous scale pairwise comparison (Table 4.8). Then, analyze these pairwise comparisons to produce weights that add up to 1. These parameters and the resulting weights are used as input to the Multiple Criteria Assessment (MCE) module for the weighted linear overlap analysis combination.

Table 4. 10 AHP weight derivation method for all parameters



	WB	LuLc	BA	ST	R	PA
WB	1					
LuLc	1/2	1				
BA	1/2	2	1			
ST	1/2	2	1/2	1		
R	1/2	2	1/2	1/2	1	
PA	1/3	1/2	1/2	1/3	1/3	1

Consistency Ratio = 0.07<0.1 is acceptable

The eigenvector of weights is:

WB: 0.2429

LULC: 0.1156

BA: 0.1978
ST: 0.1656
R: 0.1432
PA: 0.0780
S: 0.0569

Table 4. 11 Value assigned and Weight Derivations

	WB	LuLc	BA	ST	R	PA	S	Wd	Weight	Weight (%)
WB	1								0.2429	24
LuLc	2	1							0.1156	12
BA	1/2	2	1						0.1978	19
ST	1/3	½	½	1					0.1656	17
R	1/2	½	½	1/2	1				0.1432	14
PA	1/3	½	½	1/3	1/3	1			0.0780	8
S	1/2	¼	1/3	1/2	1/3	2	1		0.0569	6
Total									1	100

Source calculated by IDRISI selva
(Key. WB = water bodies, LuLc = land use land cover, BA = built up area, ST = soil types, R = road network, PA= protected area, S = slope,).

This relative compression was taken place among two parameters to determine which parameter relatively importance than the others for suitable waste disposal site selection. Therefore, in order to determine the applicability, all possible combinations of the two factors are compared according to expert judgment to prepare a pairwise comparison matrix, from which the module calculates a set of weights and consistency ratios. As a result, the sum of the weight of all parameters was 1 as shown in Table 4.9 and consistency ration would have been 0.07 which was < 0.1. since, the consistency ration is acceptable. But if the consistency ration is greater than 0.1 the compression must be revised. This relationship is very important because it shows any inconsistencies that may occur during the pairwise comparison process shown in Table 4.8, and reveals the AHP weight derivation interface to derive the weight and its consistency relationship for the selection of solid waste disposal field.

4.4. Potential Solid Waste Disposal Site Suitability Analysis Result

4.4.1. Overlay analysis

To prepare the final result of this study the overlay analysis for all parameters should be done. Therefore, overlay analysis would have been performed as in the following Table 4.10

Table 4. 12 Weight overlay analysis for solid waste disposal site selection parameters

No	Parameters	Class	Degree of suitability	Rank	Influence (%)
1	Proximity to Surface/Water bodies	0-200 200-300 300-500 500-700 >700	Permanently unsuitable Temporary unsuitable Less suitable Moderately suitable Highly suitable	5 4 3 2 1	24
2	LULC	Built-up Open space/ green area Urban agriculture Forest area	Unsuitable Less suitable More suitable Highly suitably	4 3 2 1	12
3	Proximity to built-up area	0-200 200-300 300-500 500-700	Permanently Unsuitable Temporary unsuitable Less suitable More suitable	4 3 2 1	19
4	Soil type	Leptosols Nitisols Vertosols	Unsuitable Less suitable Highly Suitable	3 2 1	17
5	Proximity to road network	0-200 200-300 300-500 500-700 700-1200	Permanently Unsuitable Temporary unsuitable Less suitable More suitable Highly suitable	5 4 3 2 1	14

6	Proximity to protected area	0-200 200-300 300-400 400-500 >500	Permanently unsuitable Temporary unsuitable Less suitable More suitable Highly suitable	5 4 3 2 1	8
7	Slope	0-3% 3-9% 9-15% 15-20% >20%	Less suitable Highly suitable More suitable Temporary unsuitable Permanently unsuitable	3 1 2 4 5	6

4.4.2. Final Suitable Solid Waste Disposal Site Map

The result of the overlay analysis of all parameters would prepare the final result of this study. As a result, the (figure 4.9) was the final suitability map for solid waste disposal site of study area. By this study area which is highly suitable for solid waste disposal site was not discovered. As shown the map the value 1 represented by red was restricted area for siting waste disposal, value 2, 3, 4 was unsuitable, less suitable and more suitable for the required selection of solid waste disposal. In the final suitability map of solid waste disposal site more suitable area cover 1 hectare, less suitable cover an area of 135 ha, unsuitable and restricted/ permanently unsuitable were 239 and 2 hectares respectively.

Table 4. 13 Suitability Level and Area Coverage of Final Map

No	Class	Level of suitability	Area (ha)
1	Restricted	1	2
2	Unsuitable	2	239
3	Less suitable	3	135
4	More suitable	4	1
5	Total		377

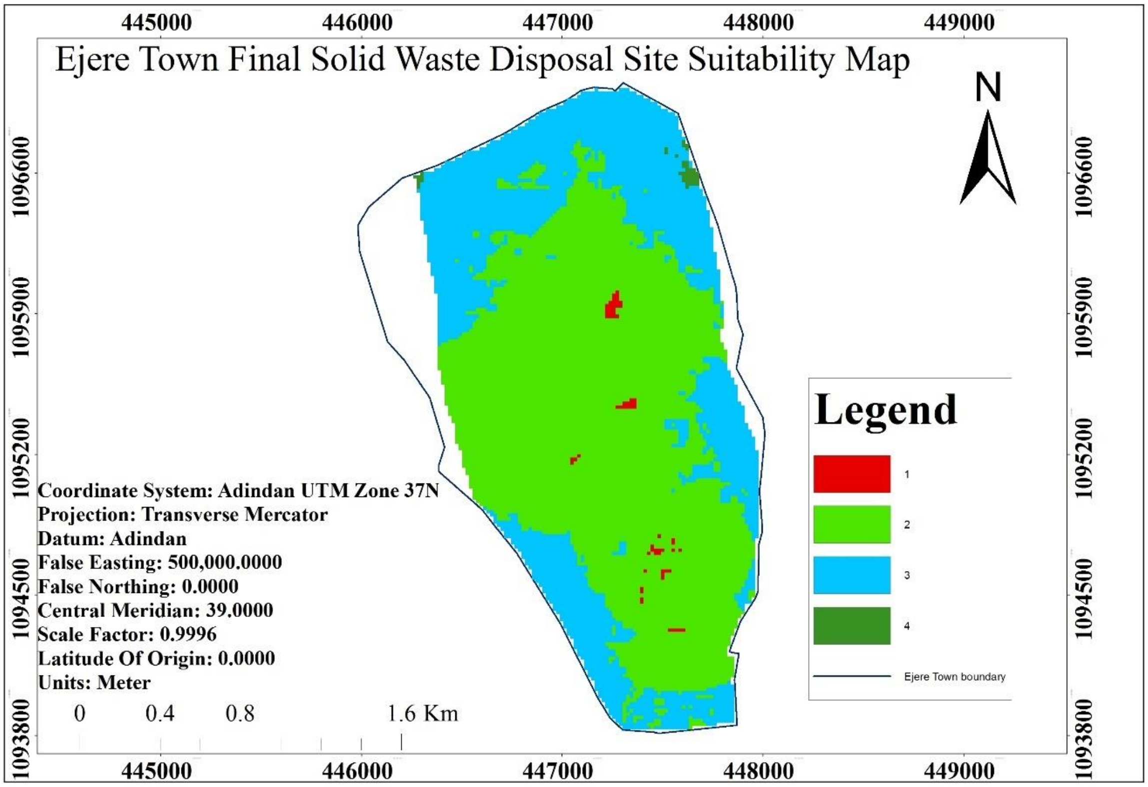


Figure 4. 9 Final Solid Waste Disposal suitability map of Ejere Town

Source ArcGIS overlay analysis

4.5. Discussion

The main objective of this study was assessing the suitability of solid waste disposal site in the study area. The finding of this study confirms that the existing solid waste disposal site was not suitable. It was affected by factors LULC, Soil types, Slope, Proximity to (Road, Built-up area, Protected area and Water bodies). The study found that among the identified major criteria, approximately proximity to water bodies has the most weighing influence (24%), followed by proximity to built-up area (19%), Proximity to road (14%), soil types factor (17%), LULC factors (12%), protected area (8%) and slope (6%). The result of this study shows the weight given for proximity to water bodies through pairwise comparison was the highest relatively which accounts around 24% for the analysis this emphasizes that water bodies spatial factor was the most determinant factor in solid waste site selection. Affording to the solid waste disposal site suitability map result of the current study, Ejere Town is in only restricted, unsuitable, less suitable, more suitable zone for disposal site development. In addition to this, the result validates that an unexpectedly highly suitable class was not observed in the final suitability map.

The distance between the solid waste disposal site and the river is one of the factors that determines the appropriate solid waste disposal site. According to established standards, the further the solid waste treatment site is from the body of water, the more suitable the site will be. The existed disposal site in the study area was 3-5 meter from water body. Therefore, it was not suitable. From the finding, the area which were highly suitable was cover 110 hectares. Moderately suitable area covers 15.84 ha.

The distance from the built-up area is also the other important criteria. Since built-up area and other social service users pose fewer odors and health problems, it is best to dispose of solid waste away from built-up areas. The result validates that in the study area high area coverage is hold by unsuitable site which was 401 hectare and suitable site for waste disposal was 21 hectares only.

Additionally, wind direction is the other criteria used suitability analysis of solid waste disposal site. From the analysis of this thesis more suitable site was identified in the north east and north west direction of Ejere Town. But, the direction of wind in the study area was from north to south. Since, the more suitable area located at north west is more preferable than the one located in the north east. Because the odor from disposal site harm the community health and environmental condition in the Town.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

In this thesis work eight parameters were used to assess suitability of solid waste disposal site for Ejere Town. These parameters were proximity to (water bodies, road, protected area, built-up area), soil type, slope and wind direction. Preparation of feature map for each parameter followed by rasterization in order to reclassify the level of suitability using ArcGIS.

Furthermore, weight was assigned for all parameters using analytical hierarchy process (AHP) method in IDRISI selva software by evaluating which parameter is influential than the others for further overlay analysis. Then overlay analysis were made to select the suitable potential area for solid waste disposal site. As a result, four level of suitability would be discovered by overlay analysis. There is no highly suitable area for waste disposal site in the study area. But, area that more suitable, less suitable, unsuitable and restricted was the output of this study which cover an area of 1, 135, 239 and 2 hectares respectively.

Generally, more suitable area was located at north east and north west direction and less suitable located border of the Town. However, the more and less suitable area in the north west direction is more suitable than the north east due to influence of wind direction.

5.2. Recommendation

Based on the finding of this study the following recommendation has been made

- The municipality of Ejere Town should be seen the problem that happened due to location of waste disposal site
- The municipality should have plan to construct disposal on the suitable site identified by this thesis work.
- While constructing solid waste disposal municipality shall considering size of disposal site to minimize cost for identify another suitable site and to construct it.
- The next researcher who wants to performed research on the same issue for this study area may bring more appropriate result if considering the other parameters like ground water table and geology data in addition to parameters involved by this study.

REFERENCES

Hosam et al. (2016). *managements of hazardous waste.* London: itech open.

A.Royal Edward williams and S.Kumar. (2016). *integrated waste management.* switzerland: spinger international publisher.

Abate, B. (2017). Waste management in case of Bahir Dar near lake Tana in Northwestern Ethiopia. *AJEST*, 11(8), 393-412.

Aden. (2016). *GIS and Remote sensing based suitable site selection for solid waste disposal.* Adis Abeba: Addis Ababa Universty.

Ahemad Kabir. (2018). *Application of Geographic information system in site selection for solid waste.* Kofar Kaura.

Ahmed and K.V Suryabhagayan. (2019). Solid waste dumping site selection using GIS- based multi-criteria spatial modeling a case study in logia Town, Afar, Ethiopia. INWASCON.

Ambaneh, M. (2016). *Solid waste disposal site selection using Geographic information and Remote sensing.* Adis Abeba: Adis Abeba University.

Aisa. (2011). The role of household in solid waste management in east Africa capital city Wageningen: ISBN.

Brihanu Y and Berisa G. (2015). *Assesement of solid waste management practices and the role of public parcipation.* Jigiga : International journal of Enviromental protection and policy.

FDRE. (2007). solid waste managment proclamation No.513.

Gizachew, K. (2011). *GISandRemote Sensing based solid waste landfill site selection.* Addis Ababa.

Imtiaz. et al. (2012). GIS-based analytic hierarch process as multicriteria analysis decision instument . *Arabian Journal of geoscience*.

Kebede, M. (2020, september 8). *suitable site selection for solid waste disposal by using Geographic Information System and remote sensing in Assosa.* Bahir Dar : Bahir Dar University. Retrieved from http://dspace.org: http://hdl.handle.net/123456789/11335

Kenate, L. (2017, 06). *Suitability Analysis of Solid Waste Disposal Site using GIS Techniques.* Adis Abeba: Addis Ababa University. Retrieved from http://etd.aau.edu.et/handle/123456789/5512: http://localhost/xmlui/handle/123456789/5512

M.Vivek, T.Vengatesan, S.Joseph raj ,S. Ashok kumar, S.Sathya narayanan,. (2018). Integrated solid waste management using GIS and remote sensing approch in a city area. *IRJET, 05*(05).

Md Mainul Sk, Sk Ajim Ali and Ateeque Ahmad and Ali Ahemad. (2020). *Journal of Cartography and Geographic Information*.

Nation, u. (1997). American Resource Conservation Recover Act.

Nwosu Agnes and chukwueloka Henry. (2020). Review of solid waste managment stratagies in Nigeria. *Journal of Enviromental and Earth sience* .

R. chandrappa and D.B. (2012). *solid waste management principle and practices.* New york: spring

Sener, B. (2004). *land fill site selection by using Geographic information System.*

Sunil, k. (2011). *Integrate solid waste management volume 1.* In Teach open.

Tirunew and Amare. (2013). Solid waste dumping site suitability Analysis using Geographic Information System and Remote sensing for Bahir Dar Town, North Western, Ethiopia. *AJEST*, (11), 976-989.

Z. H. (2018). *GIS and Remote Sensing application in Solid Waste Management and optimal site suitability assessement for landfill.* Shashemene.

Zewidie. (2017). Suitable Solid Waste Disposal Site Selection using Geographic Information System and Multi-criteria. Adama: Adama Science and Technology University.