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Assessment of Wereda Level Urban Solid Waste Transfer Sites in Addis Ababa: The case of Addis Ketema Sub-city

By:

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February, 2021

Addis Ababa, Ethiopia

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University, Ethiopian Institute of Architecture, Building Construction and City Development, in Partial Fulfillment of the Requirements for the Award of Master's of Science Degree in Urban Planning

Advisor:

Birhanu Girma (PhD)

February, 2021

Addis Ababa, Ethiopia

Declaration

I, the undersigned declare that this research work entitled "**Assessment of Wereda Level Urban Solid Waste Transfer Sites in Addis Ababa: The case of Addis Ketema Sub-city**" is the result of my own original work and has never been presented in any University/institution for any degree or other purposes. All materials used from other sources other than my own idea in this study are duly acknowledged & properly cited.

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Approval

As a member of the Examiners board of the Master's thesis open defense of Danat Workalemahu, we have read and evaluated the Thesis prepared by Danat Workalemahu entitled "**Assessment of Wereda Level Urban Solid Waste Transfer Sites in Addis Ababa: The case of Addis Ketema Sub-city"** and recommended to Ethiopian Institute of Architecture, Building Construction and City Development, Addis Ababa University to accept the Thesis as it meets the accepted standards with respect to originality and quality for the in Partial Fulfillment of Requirements for the award of Master's of Science Degree in Urban Planning.

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Abstract

One of the problems caused by population growth is the problem of solid waste management systems. This problem is particularly acute in developing countries such as Ethiopia. The traditional solid waste management system which is dumping solid waste on open platforms without applying any specific technology and without suitability study is polluting Addis Ababa which is the capital city of Ethiopia and, it overshadows the beauty of the city. Also, these small-scale solid waste transfer sites are creating a foul odor and affect the people's health that lives and use the area. Based on this, the objective of this study focuses on, Assessing the impact of solid waste transfer sites and locating sustainable sites by using GIS techniques in one selective sub-city in Addis Ababa which is Addis Ketema sub-city. The method that was applied for the study is more descriptive that to show clearly or to make it visible the existing situation of solid waste transfer sites. Based on the results, the researcher study different criteria (guiding principles) to proposed potential suitable sites for solid waste transfer stations. A transfer station is a building or processing site specially designed for the temporary deposition of solid waste. According to this, about five social and physical criteria were used to select the potential site and All maps were Geo-referenced and reclassified according to their suitability and based on the standards of solid waste transfer station site selection. As the result showed, from the total study area 3.6% was found as the most suitable location for solid waste transfer station, 8.7% suitable, 9.3% were moderately suitable and 78.4% was unsuitable for locating solid waste transfer station. This sustainable site was satisfied both the environmental and social norms and principles that used to locate solid waste transfer station potential locations in the study area. Based on this, all concerned governmental bodies should give proper attention to different guiding principles and norms for the best result on solid waste management process on solid waste transfer station locations in the city of Addis Ababa, on sub-city level.

Key Words: Addis Ketema Sub City, Solid Waste Management, Solid Waste Transfer Station, Site Suitability

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Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

AASBPDA	Addis Ababa Sanitation, Beautification and Park Development Authority
AAMP	Addis Ababa Master Plan
AASWMS	Addis Ababa city Solid Waste Management System
AAPDC	Addis Ababa Plan and Development Commission
AK	Addis Ketema
AKSWM	Addis Ketema sub city Solid Waste Management
EPA	Environmental Protection Agency's
ENDA	Environmental Developing Agency
FDRE	Federal Democratic Republic of Ethiopia
GPS	Global Processing System
GIS	Geographic Information System
HH	Household
HHW	Households Hazardous Waste
IPCC	Intergovernmental Panel on Climate Change
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGO	Non-Governmental Organization
SMM	Sustainable Materials Management
SWM	Solid Waste Management
SP	Structural Plan
USEPA	United States Environmental Protection Agency
UNDP	United Nation Development Program
WUP	World Urbanization Prospects

Chapter One: Introduction

1.1. Background of the Study

Through the period of 2025–2050 in globalized and urban world, it is suggested that around 60–75% of global population will live in urban areas. This line leads to several problems such as poor waste management approach (Gutberlet2018). Waste is anything that no longer has a use or function and needs to be recycled or disposed of, right (AVMA, 2020). Whereas, MSW referred to as a waste contains of standard substances like yard trimmings, product packaging, clothing, furniture, bottles, newspapers, food, and electronics. The most Bases of waste include suburban waste (waste from different households) and waste from insinuations, business locations, like hospitals, businesses and faculties. MSW didn't contain industrial, unsafe or construction and demolition waste (EPA, 2018)

SWM is outlined as the collection, treating, and eliminating (disposing) of solid material that's throwaway because it's served its purpose or is not any longer useful and separation of solid waste during a technique that harmonizes with the highest principles of community engineering, health, conservation, economics, public concerns and aesthetics (Nathanson, 2020). Open or unsafe SW dumping and selling sites (transfer station) outlined as a land or an area wherever solid wastes that came from totally different places that prepared for secondary collection. Also, these places use as separation of useful materials and living place for several families rely on waste for his or her living (Urban management model, 2019).

Waste is so far not supposed as a major challenge and an issue of main priority to city administrators. But waste is a noticeable and observable problem in many cities. Know a day's people produce more waste than ever before, because of the different nature of composition and the different consumption of waste. (Lilliana, et al. 2012).

A solid waste transfer station is one of the elements in SWM facility placed near to residential zones that is used to receive and keep waste temporarily till it's transported to the final disposal, landfill site or waste to energy facility. this station uses as a link between the collection program of the community and the final landfill site (waste disposal facility) (USEPA, 2002).

The primary objective of the MSWM is to determine the kind, location, and capability of facilities which will be used for disposal or handling of the waste, based on economic, social, environmental and health considerations (Rick, 2020). But, the unsafe and unsustainable technique of solid waste management through marketing on open areas while not applying any specific technology could be a common methodology that applies within the whole city (AASWMS, 2010). But different studies have focused on location of the disposal site alone, with small attention given to the location for solid waste transfer stations (Rick, 2020). In most developing country urban centers, less than half of the solid waste produced is collected, and 95 % of that amount is either randomly thrown off at different dumping sites, throughout the city (Ali, 2017).

Addis Ketema sub city started its SWM early 1980s. But the service cannot meet the changing demands. Waste collection service is unsatisfying, and scattered waste are common in most part of the sub city. Most of the waste is managed by the governmental bodies with small engagement of private sector. Communities that have poor access road receive small solid waste collection services. Because of this, communities use forms of disposal system are highly polluting. Data on the composition, volume and weight of solid waste generated and collected in Addis Ketema sub city carried out three decades back show that the estimation of waste generated per capita per day varies in volume. In each decade high volume of waste generated in this sub city, but the performance of the sub city solid waste collection and disposal system is very poor.

Currently in Addis Ababa city only 65% of the solid waste produced per day is collected and disposed by the municipality in the dumpsite, 5% is recycled, 5% is composted and the remaining 25% of the solid wastes are uncollected and dumped in unauthorized areas such as open fields, ditches, sewers, streets and many other available spaces in the city (AASBPDA, 2014). scattered garbage is a serious social and environmental hazard, particularly in areas where the roads are not accessible for collection by the municipality. These cause bad smells and attract various disease vectors and deteriorated aesthetic quality of the city. (Ali, 2017).

Addis Ketema sub city Wereda level municipal solid waste transfer sites are the most important aspect because of serious risk to environment pollution and it is also, very problematic for local people and the aesthetic view of the city. The development of cities and the dramatic

growth of population in urbanized areas must support environmental sustainability in Wereda level Solid Waste management practice. since it is the serious issue and important element for controlling the contamination of environment, soil and water pollution also health problem for the nearby residents.

Therefore, to protect the society from solid waste hazards the establishment of solid waste transfer stations plays the highest role. However, identifying a suitable site for a waste transfer station can be a difficult process. Site suitability analysis depends on numerous environmental, technical and social criteria. On the process of selecting a site, it requires a multiple criteria and objectives which require the use of spatial analysis models for its solution (USEPA, 2002).

Solid waste transfer station site selection process depends on several criteria that require different spatial analysis. So, problem-solving process relies on Arc GIS based spatial analysis environment. According to this, two procedures are commonly used. The first is by classifying each criteria map by its proximity and the second procedure is raster algebra calculation by over lay each classified map to reclassify it again. The suitability analysis map (image) simply has four classes indicating the high suitable, suitable, moderately suitable and unsuitable areas. Each map is standardized in terms of suitability in a numerical range, then combined using raster algebra calculation. In this procedure the final image is a continuous map that can be used as a useful tool for decision making.

1.2. Problem Statement

Solid waste management is fragment of a border urbanization problem. Day to day activities generate waste, and it is the way and the method these wastes are composed, handled, kept, and disposed of, which can reason for the environment and to public health hazards (The World Bank, 2019).

In most cases Poor people make their living space on waste, and they depend on waste for their living. The process of waste management usually, it is a means to create income for uneducated and unskilled peoples through waste gathering, sorting and reprocessing activities. And this can be helpful, as long as it is not done in a destructive way. The only ways of on hand elimination of solid waste in developing countries are, dumping on open sites. These transfer sites are worldwide and still very common. It's like a primary way of the municipal solid waste removal in the current decades because; it is the most economical and simplest practice of this type of wastes storage in a lot of developing countries (Algeria, et al. 2019).

Solid waste transfer stations are intermediate places at which solid wastes are stored until transported to the final disposal site. However, the Wereda level open solid waste transfer sites are a very serious issue in the city of Addis Ababa, Addis Ketema sub city in previous and even nowadays. Therefore, this sub city still lacks well developed transfer stations. However, the collected wastes are stored on the road sides until they are transported to the city's disposal site. Moreover, the collected wastes are totally kept open without cover and exposed to rain and sun making them to produce superfluous odor and the location is in unsustainable manner, using unrestrained space that cause a chain of problems like, polluting water bodies and affect the water quality, hosting disease vectors like rats and different insects that generates public health issues. Also, it affects the perception of public spaces and sick dogs that live on the area can attack the people around the site.

There are varied ways that to treat waste, however in developing countries for collected waste the foremost common method is dump at an open or unprotected site. And this approach constitutes a serious challenge for the directors and for urban populations. But waste doesn't appear as a problem yet. It seems that the majority of the people in Addis Ketema sub city is very careless about the use and disposal of solid waste. They easily can dispose and recycle their garbage in HH level. But they disposing of their garbage everywhere in ditches, roads and river side's and polluting their and others environment. And, the institutions like Addis

Ketema sub city sanitation and beautification project office are not played its part very well. It may be due to lack of proper technologies, controlling system, awareness in areas of segregation, recycling, and also lack of private and public partnership.

Solid waste disposal system should be socially acceptable and environmentally sound. However, the traditional and manual method used to select solid waste transfer site or container-based site is not environmentally and socially sound and time consuming. Also, they did not consider some very important evaluation criteria like road network, land use, proximity to sensitive areas, and distance from drainage. The site that can easily be analyzed using Arc GIS techniques. Several researchers have carried out solutions to waste management system in different parts of this country but, no research has been conducted on one of the basic elements of SWMS which is called solid waste transfer station at Addis Ababa, sub city level using GIS techniques.

Lots of informal waste pickers collect domestic waste daily in cities around the world to create cash and earn a living. And, the process will contribute to minimizing the carbon footprint of cities; recover the environmental conditions and health within the city. But, the Wereda municipality solid waste transfer sites are the biggest downside from every perspective. Therefore, this study conducted to select the most appropriate locations of solid waste transfer station sites for the Addis Ketema sub city by considering social and environmental factors to improve the performance of the SWMS.

1.3. Research Objectives

1.3.1. General Objective of the Study

To explore the present situation of Wereda level urban solid waste Transfer sites and analyze what kind of site would be adequate for the specific condition for both the people and the environment.

1.3.2. Specific Objectives of the Study

The specific objectives of the study include:

- To assess the practices of the Residents of the study area with regard to solid waste Sorting, Composing and Reuse.
- To assess the existing condition and identify the main problems associated with solid waste transfer sites.
- To identify local and international criteria used to select GIS based solid waste transfer station potential sites.
- To plan sustainable sites and develop appropriate strategies to solve the problem of solid waste transfer sites of the study area.

1.4. Research Questions

To reach the intended objectives that stated above, the following research questions were formulated.

- What are the practices of Residents of the study area with regard to solid waste Sorting, Composing and Reuse?
- What are the main problems associated with solid waste transfer sites during the assessment?
- What are the local and international criteria used to select GIS based solid waste transfer station potential sites?
- Which plans are sustainable to solve the problem regarding to solid waste transfer sites of the study area?

1.5. Significance of the Study

The quality of the human living environment is very important as well as peoples that use the area for Walking, Recreation and as Playground etc. And, the way in which waste is handled can affect the city aesthetic view and different natural bodies. According to this, this study will forward information to diverse sectors and planning institutes the existing unsustainable condition of Wereda level secondary solid waste transfer sites and explore a better (Sustainable) way to select appropriate site for solid waste transfer stations based on different international standards.

1.6. Scope of the Study

The scope of the research is to conduct an assessment on present Wereda level solid waste transfer site locations of Addis Ababa, Addis Ketema Sub City. The study also covers the practices of Residents regards to solid waste Sorting, Composing and Reuse. Finally, the study concludes by identifying sustainable locations for the Transfer site at the study area and give recommendations for concerning bodies to solve the problem of solid waste transfer sites of the study area.

1.7. Structure of the Document

This document is presented in 5 chapters. Chapter One is an Introduction part that contains the Back ground of the study, Problem statement, the Objectives and the Significance of the study. Chapter Two contains the Reviewed literatures. Chapter Three contains the research Methodology. Chapter Four contains the Analysis, Results and Discussion part of the study and the final chapter which is Chapter Five contains the Conclusion and the Recommendations part.

Chapter Two: Literature Review

2.1. Concepts and Definitions

2.1.1. Municipal Solid Waste

Based on the US Environmental Protection Agency's (US-EPA,2018) outline Municipal solid waste additionally referred to as garbage as a waste contains of standard substances like yard trimmings, product packaging, clothing, furniture, bottles, newspapers, appliances, food, and electronics. The most Bases of waste include suburban waste (waste from different households) and waste from insinuations, business locations, like hospitals, businesses and faculties. MSW didn't contain industrial, unsafe or construction and demolition waste (US-EPA, 2018).

For cities that found in developing countries Solid waste is a major drawback and it's measured as a huge challenge and it wants time and energy and commitment from completely different sectors like homeowners and business centers to follow reduction, use and usage. It conjointly wants main infrastructure growth furthermore as financial asset. Sustainable planned, assortment and transfer method will central to noteworthy reductions within the general value of waste management (Open University, 2016).

2.2. Municipal Solid Waste Management

Produced, MSW should be collected and managed well. Ordinary administration traditions that contain use, composting, burning with energy recovery and land filling. land crammed wastes that represent a loss of things that would be recycled or remodeled to energy to relocate the utilization of virgin resources (Ajaykumar, et al. 2016).Before the Nineteen Seventies, MSW management typically consisted of depositing wastes in open dumps, in the course of open burning to cut back waste volumes. Usually manufacturing venturous wastes were co-disposed with public trash and decline in open dumps or landfills. Older landfills cause to environmental issues connected with emissions of Nephrotoxic, spring water pollution, greenhouse gases, land dirtiness and will increases in illness vector populations, like mosquitoes and flies. Sustainable materials management (SMM) mentions a way to use and recycle of provides within the most property and productive way across their life, whereas to reduce the

impact on the surroundings. Necessary goal of Sustainable materials management (SMM) may be a decrease in material use without a decrease in economic wealth (US-EPA, 2018).

Municipal solid waste generated globally is between 1.7-1.9 billion metric tons. Time to time it going to increase approximately 2.2 billion metric tons per year by 2025. In sub-Saharan Africa case it's approximately 62 million tons of waste produce per year. But, the production of waste and the collection rates are not balanced it's lower than 70% in developing countries. 50 % of domestic collected solid waste is disposed on uncollected site while 15% of the solid waste processed by unsafe and informal recycling. "Adopting Environmentally Sound Management (ESM) of wastes focused on the promotion of the '3Rs' – Reduce, Reuse and Recycle is needed" (Ali, 2017).

2.3. Impact of Solid Waste Management

2.3.1. Socio Economic Impact

Poor waste management service has adverse effect on the economic development and productivity issue for the city development. Up to 300 waste collectors are living nearby the site and they work continuously for collection of salvageable equipment like scrap metals, wood and discarded food. (Modupeola, 2015) In most low standard and low-income societies, shortage of basic waste services is a major contributor for mortality rate and illness among the urban poor. Also, the collection method and the transportation system can cause multiple health impacts like water pollution, which lead to breeding grounds for flies and attract mosquitoes. Sharp materials cause injuries and may reason for transmission of HIV virus (Evangelia, et al. 2017).

2.3.2. Environmental Impact

Since the industrial revolution, unsustainable solid waste management and disposal system is one of the most critical environmental problems that developing countries are now facing. This improper solid waste management practices leads to different health problems like: drains blockage, unsightliness, unpleasantness and traffic congestion. The other environmental concern is the gas that released by the time of decomposing garbage this cause, a problem related to greenhouse gas effect and the enhanced climate change (Ejaz, et al. 2010). If solid waste management properly under taken, the process is not affecting the environment and not cause any health problems on peoples living nearby. Also, the first thing is beginning on segregation of

waste on the household level. For the prevention of the impact on human and environment the following steps may take: From the scratch (household level) the generation rate must be decreased, Increasing the recycling process of materials, Decreasing generation of waste after use and promote this kind of goods (productions), Increase plastic recycling usage, By increasing the level of service given by municipality bodies regarding on the sorting of solid waste, During the production of goods trying to minimize the use of hazardous chemicals, The waste sector should have its own legislation and Gathering of dangerous waste at collection points shall be protected, secure and performed in an environmentally sound manner (Pulp and paper, 2019).

2.3.2.1. Climate Change

As the name indicates, climate change defines as any change of climate over the period of time because of, different human activity and due to natural unpredictability. Usually human activities like unsafe dumping solid waste and fossil fuels burning upset the natural climate balance and produce extra greenhouse gases and lead to increasing worldwide temperatures. Over the past 100 years, the global temperature increases by 0.06C (UNEP, 2010). Waste management could be one of the potential impacts on the solid waste management industry and set a limited time for waste transfer sites that the waste could have a time frame is a better solution. In this case, policies and operational changes are needed. Any product before it becomes solid waste the management process has different phases that involves processing and removing raw materials like, manufacturing goods, transporting the goods, deliver to markets and transform the product by using energy. According to this, this activity has the potential to increase (generate) greenhouse gas emissions by the means of Methane Emissions: This type of gas produce on the process of organic waste decomposes in transfer sites (landfills), Energy Consumption**:** Processing and extracting raw materials, manufacturing and transporting products and materials to markets this process increase greenhouse gas emissions by consuming energy from fossil fuels and Carbon Storage: Prevention of waste, paper products and recycling of wood has the advantage by removing carbon dioxide from the air by letting most trees that remain standing in the forest which helps decrease the impact of climate change (Enete and Christian, 2010).

2.4. Objectives of Solid Waste Management

2.4.1. Public Health and Safety

At all stages in the solid waste management process from collection to transport to disposal, Public health impacts may arise. The main worries are, transmissible diseases spread from human wastes disposed. Exposed wastes endorsing infestations of disease vectors (insects and bacteria) and from the incomplete combustion of open burning there is a release of chemicals and breathing irritants. Satisfactory solid waste services must be maintained well and provided so that there will be no breeding of flies and no odors (James, 1999).

2.4.2. Environmental Protection

Proper sitting, design, and maintenance and operations of modified waste facilities are fundamental in minimizing the environmental impacts associated with solid waste (Kent, et al. 2003).

To manage solid wastes environmentally, the first priority is getting the refuse out from underfoot. “In cities of developing countries, 30 to 50% of the solid wastes generated is often uncollected”. Uncollected waste accumulates in pipes, on open lands and provides the area for disease vectors (Rick, 2020) Slum and shanty neighborhoods are receiving the lowest level of service. It seems Not only the urban poor receive less attention from the government which is, usually governmental bodies are accountable for the service they give, but most of the time employees who cans, paper, plastics and bottles from richer garbage, have no motivator for properly serve the urban poor. The other option is to give cheap materials and services, with the minimum cost and clear methods. Suitable and easy way to analysis of different collecting mechanisms also transporting and land filling solid wastes is best way of choosing appropriate technology. Also, governments must encourage the process of recycling, beside see other options like public sector, low capital resource regaining mechanisms at the end which land filling stage. The management or the mechanism system around the informal reusing sector by providing sustainable and suitable services to protect the informal worker’s health, organizing the recycling market of materials and improve workers output (Sandra, 1982).

2.4.3. Aesthetics

The Aesthetics of modified facilities, namely foul odors and unsightly facilities, are a concern for the public". The communities should place away from any solid waste transfer sites or stations. This process can protect the communities from unwanted odors. And the station site can be hidden from the nearby residents. Also, by any means the sites should be downwind of prevailing winds (Kent, et al. 2003).

2.5. Components of Solid Waste Management

Solid Waste Management (SWM) broadly, refers to the material flow stream of waste from generation to ultimate disposal and comprises storage, collection, transportation/ transfer, processing (reuse/recycling/ composting), and disposal (Petter, et al. 2002).

2.5.1. Storage

Storage is a system for keeping materials after they have been discarded and prior to collection and final disposal. The station should be free from different insects and animals and it must be washable. Also, there must be limitation time that waste can be stored according to the source of the waste and the type of the waste. Before breeding various disease-carrying vectors, solid waste should be composed and disposed from temporary stores to final disposal site. Community health problem also came from exposed or (uncovered) containers that exposed to scavengers, animals and the people use the site for different purpose (Petter, et al. 2002).

2.5.2. Collection and Transportation /Transfer

Collection merely refers to however waste is collected for transport to the final disposal site and transportation is once the waste transported to the final disposal site. The mechanism of clearing accumulated waste from generating supply whether or not it containerized or not is termed assortment of waste. Most of the time centralized location like for solid waste assortment that generators were deliver their waste or on an individual basis collect the waste from the supply this method that is centralized location will increase the expense of assortment. Because, the name indicates transportation refers to the method of transportation of solid waste from the gathering point to the last management facility (Petter, et al. 2002).

2.6. Waste Collection Systems

2.6.1. Waste Storage Containers

Container (instrumentation) sometimes use by a business worker and a possessor to place their waste. The number of the waste that produce and also the wealth of the family, that matter the selection of the container (instrumentation). Containers are simple for different sectors and for HH to transport a waste in to a shared waste storage bin for compilation. Some waste bins that may hold to 240 lit of waste want vehicle to empty the waste with lifting instrumentality. This kind of system that expend to 240 lit bins need wide and well-maintained roads that every property served with in ten m. from domestic containers, communal bins ought to be larger and that they even be healthier. Frequently, this sort of bins should empty by explicit lifting instrumentality that fitted by vehicle (Open University, 2016).

2.6.2. Primary and Secondary Collection

After domestic storage, consequent step is assortment. During this method there are two assortment strategies. Primary assortment isa form of waste assortment system from the supply of the waste that produces. The method done by the assistance of the person or by the organization. The placement of the garbage's should find outside of every home or sector. Public garbage containers will serve several households that find on the location if, the waste skips taking or grouping from the encircling space (households and businesses). The number of the waste, the gathering vehicle and therefore the distance to the landfill site (disposal site). The collected waste will transfer on to the ultimate final landfill site or to a transfer station. This assortment processes wiped out many ways, the acceptable technology (lower-technology) decisions are suitable for gathering waste from every home and transferring to a neighborhood landfill site. This all method advantages by serving narrow streets in jammed areas. Secondary collections – The method of those collections is from each primary collection, waste is taken from the transfer stations to the final landfill site (disposal site). In step with to the situation, secondary collections or use as primary collections (UN-HABITAT, 2011).

2.6.3. Solid Waste Transfer Stations

Solid waste transfer station is a processing site or a building used for temporary deposition of waste (The Open University 2016). Waste collection vehicles can carry waste within a short distance (a few kilometers at most) from the source. Most of the time they are so expensive and too large to collect waste from jammed neighborhood. Waste need vehicle to transport from primary collection to secondary collection unless, the waste disposal site is less than 3 km from the urban center. This process is done at transfer station. Only for short time that the waste can store in the transfer station, also materials that can be recycling will extract from the mixed waste. Its best for transfer stations are close to the community they serve but, must far away from factories, hospitals, schools and people's homes etc. Access roads are critical for the location of transfer stations that lead to the final disposal site (US-EPA, 2002).

(RohitGurjar au, 2017) explain that:

> A solid waste transfer station could be a building or processing site for the temporary deposition of waste**.** Transfer stations area unit typically used as places wherever native waste assortment vehicles can deposit their waste consignment before loading into larger vehicles. Typical activities at the waste transfer station concerned the unloading of garbage trucks, pre-screening and removal of inappropriate things like automobile batteries, compacting then reloading onto larger vehicles, as well as trucks, trains and barges to their final destination.

(Rick Leblanc, 2018) also explain that:

> A waste transfer station could be a lightweight industrial facility wherever municipal solid waste is staged within the course of its ultimate journey to the lowland or waste-to-energy facility. Typical activities at the waste transfer station concerned the unloading of per-screening, garbage trucks and removal of unsuitable things like automobile batteries, compacting, and so reloading onto larger vehicles, as well as trucks, trains, and barges to their final destination. In urban areas, the situation of waste transfer stations will be terribly debatable. Such facilities area unit thus generally totally surrounded. They will be co-located with a fabric recovery center.

Material recovery facilities are operating hand in hand with transfer stations. this process can allow to separate reusable materials from the garbage. on this waste management and transfer stations the processed wastes transfer to different end points like to waste to energy converting plant, landfill site, hazardous waste facility and to recycling center (Juliana, 2018).

2.6.3.1. Advantage of Solid Waste Transfer Stations

In the community waste management process, solid waste transfer stations play an important role. Because, this station uses as a link between the collection program of the community and the final landfill site (waste disposal facility). whatever is the station size, service and owner-ships, they all serve the community. In addition, setting new waste disposal sites (landfills) near to the community centers is very difficult. Also, most of the time suitable land is not available near urban areas or densely populated areas (US-EPA, 2002).

The basic advantages that having a solid waste transfer station are, Spring travel time and making additional trips by minimizing the little squander dumper vehicles traveling remove up to the ultimate transfer location which the normal area 20 to 25 km absent from the center of the town, Taken a toll of rubbish transport is minimized moreover, can sparing fuel utilization, Minimizing activity clog on the way of landfill location and can encourage great dispersion of waste too, give these destinations distant better, for good squander dealing with it permits screening(Janusz,et al. 2011) in most strong squander exchange stations (SWTS) approaching strong squanders screen by workers which partitioned unseemly squanders (recyclable materials) that are not satisfactory in waste to energy facility or landfill site. Also allows, the communities to drop-off their squanders straightforwardly to the exchange station. This solid waste change stations have planned zones (comfort center), where the communities can drop-off their solid squander within the given collection holders(Mondal, 2016).

2.6.3.2. Criteria to Identify Potential Sites for Solid Waste Transfer Station

Sometime recently recognizing appropriate location for the reason which is solid squander exchange station, criteria ought to be created. This strategy makes a difference to urge choices based on the objective criteria. These criteria connected on distinctive arrange (exclusionary, specialized, and community-specific criteria). The important thing that must consider isn't, all location can meet all the criteria, in which case, each standard’s comparative significance and weight must be measured (US-EPA, 2002).

A. Exclusionary Sitting Criteria

Finding a strong squander exchange station or other this kind of stations, on zones with preclusive sitting criteria is frequently illegal by state, government or neighborhood controls or laws, or needs requires administrations to incorporation common development strategies and designing plan. This prepares (the included designing plans or solid open restriction) can increase the construction cost (Debra, 1996). The following areas are best to avoid solid waste transfer stations or its best to add Exclusionary criteria: Endangered and protected flora and fauna habitats, protected sites of archaeological, historical, or cultural significance, Floodplains and wetlands, Parks and preserves and prime agricultural land (US-EPA, 2002).

B. Technical Siting Criteria

This category includes technical parameters that help to express the best potential site for solid waste transfer stations. This technical criterion offer direction on specific transport condition and engineering operations that should be measured to confirm that potential solid waste transfer sites that suitable from environmental, economic and technical perspectives (US-EPA, 2002).

C. Developing Community-Specific Criteria

In this category of criteria, the focus is on the impact of solid waste transfer stations will have on the surrounding area which is, the community. The criteria are characteristically less technical in nature and include local, cultural and social factors. Examples of these criteria include: Air quality impaction, Prevailing winds (wind direction), Local infrastructure impact, Environmental Justice considerations like: clustering and cumulative impacts, Different Environmental aggravation that already exist and adjacent land uses, Impacted number of residents, Capacity of expansion, Compatibility of traffic, Neighborhood character influence, Churches, schools, recreational centers and inhabitant's proximity, Location of existing natural buffers, Dimension of impact on existing businesses, Screening measures and Buffer districts, Impact on cultural features and historic places (US-EPA, 2002). To maintain objectivity in the facility sitting process, the community-specific criteria should be prioritized before potential sites are known. After potential sites are identified, the committee will apply these criteria to evaluate each potential site's suitability as a waste transfer station. These issues also factor into permitting

decisions concerning private facilities and should not be ignored by the permitting agency or transfer station developer (Debra, 1996).

2.6.3.3. Solid Waste Transfer Station Locations (Site Selection)

Potential site location for Solid waste transfer stations can be a difficult process. The criteria are depending on environmental, social, technical, political and economic criteria. When selecting the potential site, different needs must be achieved between the criteria that full fill the objectives (Lawal and Biswajeet, 2013) If the site has the ability to accommodate all the necessary criteria (required functions) and have a future expansion area, whether if it's not located at the central part where the waste is generated, this ideal site may still present the best option due to environmental, transportation and economic considerations. The other thing that put-on consideration is the communities that live and works near to the proposed site. Also, depends on the community's concerns and needs the process of selecting a suitable site can vary. On the final site selection, whether the location is in an urban, suburban, or rural setting will also play a role. During the decision making and site selection process, marginal or low-income populations must have full attention or decisions are not imposing unequal burden upon low-income communities. Overburden the communities with harmful impact facilities can create environmental, health and quality of living concerns. The impact of this process can create economic drawback by decreasing the economic value of the community revitalization plans. These are just a few of the reasons environmental justice concerns need to be addressed when selecting a site for a solid waste transfer station (US-EPA, 2002 cited in Ahmed M, 2018).

The location of a transfer stations is a turning point for local sentiment beside this, this transfer stations are a vibrant component for modern world waste management programs (Mondal, 2016). There are some main standard management measures and concerns of citizens: If transfer stations are located near to industrial zones they may get access to major transport routes, Most of the time noise (associated with conveyors, heavy trucks and front-end loaders) is the biggest challenge for the neighbors that live close to the transfer stations. According to this, some design considerations are made such as sound barriers, setback, and enclosures can play a significant role in minimizing this concern. Also, Odor is the other problem that creates by certain kind of trash like, organic wastes. In this case attention may give for garbage's may no longer remain at the station longer than it supposed to be. Also, focus on doorway location and

air venting systems. Birds and Rodents can be a problem if the facility left open (not enclosed) and if not regularly cleaned and emptied, also by having a hassle management program, Operators can play a bigger rule by take care filly tarp loads, according to this facility landscaping must provide a wind barrier to remove litter being picked up in gusts (Rick, 2018).

It prefers that the location of a transfer station should be near to the center of the served population and also, close the main haul route to the destination of landfill site. And this location shall be acceptable by the majority of people that locate around the site and the regional district board. Also, the location of the station should be listed on the regional solid waste management plan. In case, a new solid waste station is proposed by the regional solid waste management plans by regional districts, and it's not included under the approved plan body, the process must be the plan preparation, documenting what is the public discussion and acceptance of the site (Da Zhu. et al. 2008).

2.6.3.4. Requirements for Solid Waste Transfer Stations

Collection routes central location - To upgrade collection of waste effectiveness, solid waste transfer stations should be place centrally to solid waste collection routes. In most suburban and urban areas, solid waste transfer stations must be located from the end of all collection routes not more than 10 miles away (US-EPA, 2002).

Area Requirement–The general planning horizon on the particular site (at an alternative site) for the provision of a transfer station that give service must be minimum of 20 years. Also, for the existing needs and buffers, plus for possible future expansion, sufficient space must be provided. Depending on the rate that the waste delivered and volume of the solid waste that transferred, define the area of the transfer stations. To minimize the impact of solid waste stations to the surrounding society, locating a site of sufficient size is significant (Juliana, 2018).

Adequate space for on-site roadways, Parking and queuing - Roadways to move different size of vehicles is common around the solid waste transfer stations. Most waste collections trucks (Transfer trailers) are long in nature (typically 50to 70 feet long) to hold the waste effectively. This type of vehicles needs wide space roadways with curves to maneuver efficiently, gradual slopes and safely (US-EPA, 2002).

Traffic and truck compatibility - Solid waste transfer stations most of the time receive high traffic when the collection vehicles have finished their routes. As a result, the suitable sites

for solid waste transfer stations are placed far from areas that have midday traffic peaks and/or pedestrian traffic and school bus (US-EPA, 2002).

Expansion ability - Considering the daily tonnage of waste that the station can manage or the capacity for diversion and recycling is important when selecting a site for solid waste transfer station. According to this, from developing a new solid waste transfer station its less expansive to expand the existing transfer station because of the ability to use the existing facilities (Manitoba, 2016).A solid waste transfer stations should be locating in areas also conducive to composting or recycling activities. Solid waste transfer stations should be designed to allow businesses and residents to drop off yard waste and recyclables in adding up to trash. Some solid waste transfer stations include interpretive trails or education centers based on waste avoidance (US-EPA, 2002).

Buffer – In order to minimize any possible nuisance that related to dust, noise, odors or any oppositions based on visual aesthetics must be a landscaped buffer or vegetated buffer zone will be provided at least 15 meters must be open around the boundary of the active transfer area (US-EPA, 2002). Additional buffer zone may be needed when there are unmanaged, small and rural stations adjacent to forested areas also, if here is a threat of fires being set in the waste containers. There must be a cleared firebreak in the middle of vegetated buffer and waste bins which is 35 meters. In this case, based on local circumstances and adjacent land use Some flexibility should be allowed (Manitoba, 2016).

Access Roads – On the transfer station sites (inside and outside) access roads should be provided also the designs must consider and provide all season, all weather access. 8 meter is the minimum road width that should be provided. Vehicles on the highway or public roads need not stop when entering the site. According to this, sufficient space should be provided for queuing. for the anticipated traffic volume and speeds, Designs must be in accordance with standard practice. Depending on the local context, graveled surfaces may be acceptable but, if mud or dust be problem asphalt paving should be provided. Also, Traffic flow through the site should be considered (Samir, 2017)

Surface and Ground Water Quality - All waste garbage containers must be leak-proof, or should provide for the collection of illegally dumped liquids and impure water. Also, Provision should be made to stop storm water and runoff from contacting waste. To control wash

down water and illegally dumped liquids, tipping floors should provide drains and sumps. Also, Proper disposal of contaminated water should be ensured and Site Security **Between** and around the site, Fencing should be provided with a lockable gate at every entrance point. Fencing types may vary based on the natural site features (Juliana, 2018).

Gently sloping topography - Solid waste transfer stations most of the time have a multistory building that that require to have vehicle access at numerous levels. Full of gentle flat sites need bridges or ramps to let vehicle access to upper levels. Some solid waste stations that have Sites with fairly sloping land can use topography to their benefit, let access to the upper levels and the lower levels. Sites with steep slopes need additional costs regarding to retaining walls and earth moving (US-EPA, 2002).

Residents and Social services – Solid waste transfer station must far away from sensitive areas like residential zones and from different social services. According to US-EPA 2004, Residents, Hospitals, Food processing and Schools, must far away maximum 2000m to 5000m from the solid waste transfer station site and based on Alberta Environment 2008, solid waste transfer station minimum 30m to 700m away from the nearby solid waste transfer station site.

Zoning Requirements and Designations -Zoning ordinances normally categorize solid waste transfer stations as industrial uses, which restrictions their sitting to areas located for industry usually in combination with a special use authorize (Manitoba, 2016). Restricted use of prearranged land use requirements, however, this led to locating solid waste transfer stations in zones previously overcrowded with different industrial zones in areas adjacent to minority and poor communities. If regional zoning ordinances are so warning that they prohibit solid waste management facility sitting outside pre-established substantial engineering, industrial zones, and architectural design must be included into the solid waste management facility to decrease impacts on the surrounding environment (US-EPA, 2002).

2.6.3.5. When is a Solid Waste Transfer Station Justified?

According to (E. J. Fuller and Wayne Woldt, 2000):

> A solid waste transfer station is economically necessary when the savings in transportation costs will exceed its operational and finance prices. Enough savings are usually generated once the gap from the gathering space to the landfill

exceeds fifteen to thirty-five miles, however this distance varies greatly with the number of wastes, capital and finance prices, in operation prices, size of trucks, and native conditions. If the gap to the landfill is less than this, direct haul to the landfill is sometimes additional economical.

There are more reasons for incorporate a solid waste transfer station into a sustainable solid waste management system includes: To assist in the separation of reusable materials also, to assist the check up for harmful waste materials, and to keep small vehicles out of the final disposal site (landfill). In one specific site if the community need (considering) a solid waste transfer station, the community must have a feasibility study to forecast whether the benefits and economics will justify it (Fuller and Wayne, 2000).

2.7. Waste Generation and Management in Addis Ababa

Addis Ababa is the capital city of a state and vibrantly developing city and millions of people live and a lot of day to day migration happens know a time, the living standards is very low, luck of infrastructure and good governance because luck of good infrastructure and low side wake it has never been s sufficient waste management system accomplished of addressing the multidirectional waste problematic in the city they are a lot of reasons for luck of poor urban infrastructure and multidirectional service in Addis Ababa (Camila, 2012 cited in CheruMeaza, 2016). For a long time, the use of waste management system has not been seen by the government or authorities for long time, the reason for these matter is the number of population and migration is moderately low, and waste consumption is not grave in amount and type, so deposing waste at far from the city was an easy tactic for the habitat, but the high expansion of the city and the habitat are not compatible so far, the site become somebody's plot. The prime governmental body that took initiative for waste management is the city health bureau under the department of environmental health care. When central government decentralizes the responsibility for the given authority all the jobs on the waste management responsibility came under sanitation, beautification and park development Authority (SBPDA). As part of the improvement, cities and kebeles develops there on administration to develop on waste management and the bearer founded nearly. (The smallest administrative unit in the FDRE) level (Tessema, 2010). The indifference to the effect of solid waste on the society by both the

government and the people also plays a significant role to enhance Sanitation, Beautification and Park Development. Looking at the history of the government strategy, one can see high minded technique; by the by, the execution ought to be with investigate to tie the genuine circumstances of the city. In addition, in arrange to procure the benefits of changes executed, the changes upheld ought to be proceeded Capita Era Rate of strong squander in Addis Ababa is 0.4kg/c/day, more than 200,000t are collected each year. About 550t/day, 80% of the total waste collected also the municipality increased the collection rate from 60% to 80%. Sources of Waste Generated, 76% households, 18% institutions, commercial, factories, hotels and 6% is street sweeping (AASWMS, 2010).

Addis Ababa city's solid squander could be danger to the environment as it were 65% created per day is collected and arranged, 5% is reused, 5% is composted, whereas the remaining 25% is uncollected and dumped in unauthorized zones. All the domestic wastes that managed by the municipal offices (their related environmental impacts and the management) need so much more attention. 'koshe' is still the only choice for the city waste disposal site that receives over 750 tons of domestic solid waste per day (Ali, 2017).

2.7.1. Formal Waste Management Process

For each Kebele, containers are placed at 30-meter square of blocks, the container commonly placed near the main roads. The distance and the destination to these containers may be different for different households. For some it may be near to next door and for others a kilometer or more away because of shortage of disposal container. On the basis of programs from the Kebele, employees bring bags of waste to the containers with a trolley. This is the primary stage of collection in some kebeles the employers bring their bags to the house holders at the morning most of the time. Those who can't have enough money to pay the waste collection fees and those who live far away from the containers have to then bring their waste to the common place by themselves (US-EPA, 2015). The containers are yellow and have sizes of 8 m3. There are only 512 containers for the whole city of Addis Ababa; most of these containers are in a very depraved condition. Finally, the waste is put at Repi. When Repi was recognized in 1964, it was considered far enough not to be anybody's problem; however, with the fast expansion of the city, now the Dumpster has been surrounded by settlements and know it's more dangerously

placed area in the city and both the settlement and dump site affected each other which has cause social and environmental deprivation (Camila, 2012 cited in CheruMeaza, 2016).

2.7.2. Solid Waste Transfer Stations

Transfer stations use as a midway place that solid wastes are stored recycled and deposited until it reaches the final stage which is disposal site But, the city government didn't give much attention to be included as the main component in solid waste management in Addis Ababa development plan according to this the city lacks solid waste transfer stations (Rick, 2018). The domestic waste is put and stored on the side of roads and allover on the open spaces until the informal collectors transferred to the city disposal site which is 'koshe'. Also, the collected waste stored without applying any cover and exposed to the environment which is rain and sun and its produce urban panorama, odor, attract insects and vectors which Bother different human activities in the nearby area (Ali, 2017).

Sensitive areas which is churches, mosques and churches also population size, slope, and road accessibility according to these two platforms are prepared by Addis Ababa solid waste management agency that have two garbage containers in every Wereda's. In most areas of the city specially on the corner of the city, the placement of the garbage store sites is not appropriate and didn't consider the nearby communities. Most of the garbage containers are below 100m distance from the neighborhood areas. The other case is the households that found away from the garbage container site is dumped their waste on untreated open spaces also, the holding capacity of each garbage does not consider and match the highly rowing number of the city population. Generally, overall Addis Ababa solid waste management system pattern is not integrated with the settlement development of the city (Hayaldesta, 2014, p. 114).

2.8. Using GIS to Select Ideal Sites for Municipal Wastes Transfer Station: Case Study of Kenya: Embu Municipality

The municipality covers a total area of 80 Sq.k and is situated about 150 km north-east of Nairobi. According to the 2009 Kenya National Bureau of Statistics census survey, the township has a population of around 150000 people.

In Kenya, several local authorities have faced uphill difficulties in handling with waste mixing, volume reduction, waste segregation and proper disposal have continued to pose a problem.reduction and recycling of sources also play an integral role in the overall waste management system of every society. The problem of open dumping is further compounded by minimal solid waste segregation and recycling.

The aim was to find appropriate areas to consider within the municipality of Embu for the development of a multi-purpose waste transfer and recovery facility. A mixed approach design involving ground surveys, questionnaires,interviews, data modeling and analysis.The Geographic Information System (GIS) helps to determine the different proximity to waste receptacles as impact factors affecting the management of waste in the city.Relevant areas for the construction of waste transfer stations have been identified by GIS research. GIS has developed sufficient tools for the compilation, review and management of information relating to municipal waste generation, storage and disposal.

2.8.1. Present condition and management activities around waste

Not all the source points, especially the residential properties, but only the town center are covered extensively by the current waste collection services.The city has enormous piles of garbage dumped freely along the road, parks, open spaces and front yards. The current temporary waste receptacles are small and the increasing garbage load leading to open littering can not be handled.

2.8.2. Overview of Geographic Information System (GIS) implementations in Waste Management

GIS has been used extensively in the treatment of solid waste. In the areas of suitability analysis, preparation and optimal garbage truck routing research, several GIS integrated systems have been introduced.More use has been found for GIS because it can handle multiple data formats simultaneously. GIS has also been used in a layer-based approach to incorporate multiple datasets and help narrow down the quest for appropriate areas where a municipality transfer facility can be installed.

2.8.3. Site Selection Criteria

Several variables such as population, slope, road networks and administrative policies were considered most relevant. the need was to distinguish suitable areas from several wards in a municipality. The selection criteria employed were based on the requirements of the location.

A. Topography

As such areas allow fast drainage and reduce construction costs associated with the excavation and erection of retaining walls, a relatively gentle landscape has generally been used. A slope of not less than 15 percent and not more than 25 percent was therefore considered to be gentle slopes.

B. Space

The potential for expansion has not been overlooked because the amount of waste will continue to increase as more residential and commercial buildings are built to cater for the rising demand for housing for the urban population of the city.Suitable open spaces are considered to buffer the effects of traffic noise expected to be created from the facility in order to improve the isolation from sensitive neighboring land uses.

C. Transportation Routes

Entree routes to and from the Waste Transfer Station can help to reduce the risk of collisions, air pollution and noise significantly. The proposed transfer station should be situated, ideally less than 16 kilometers from the edge of all collection routes, within reach of most waste

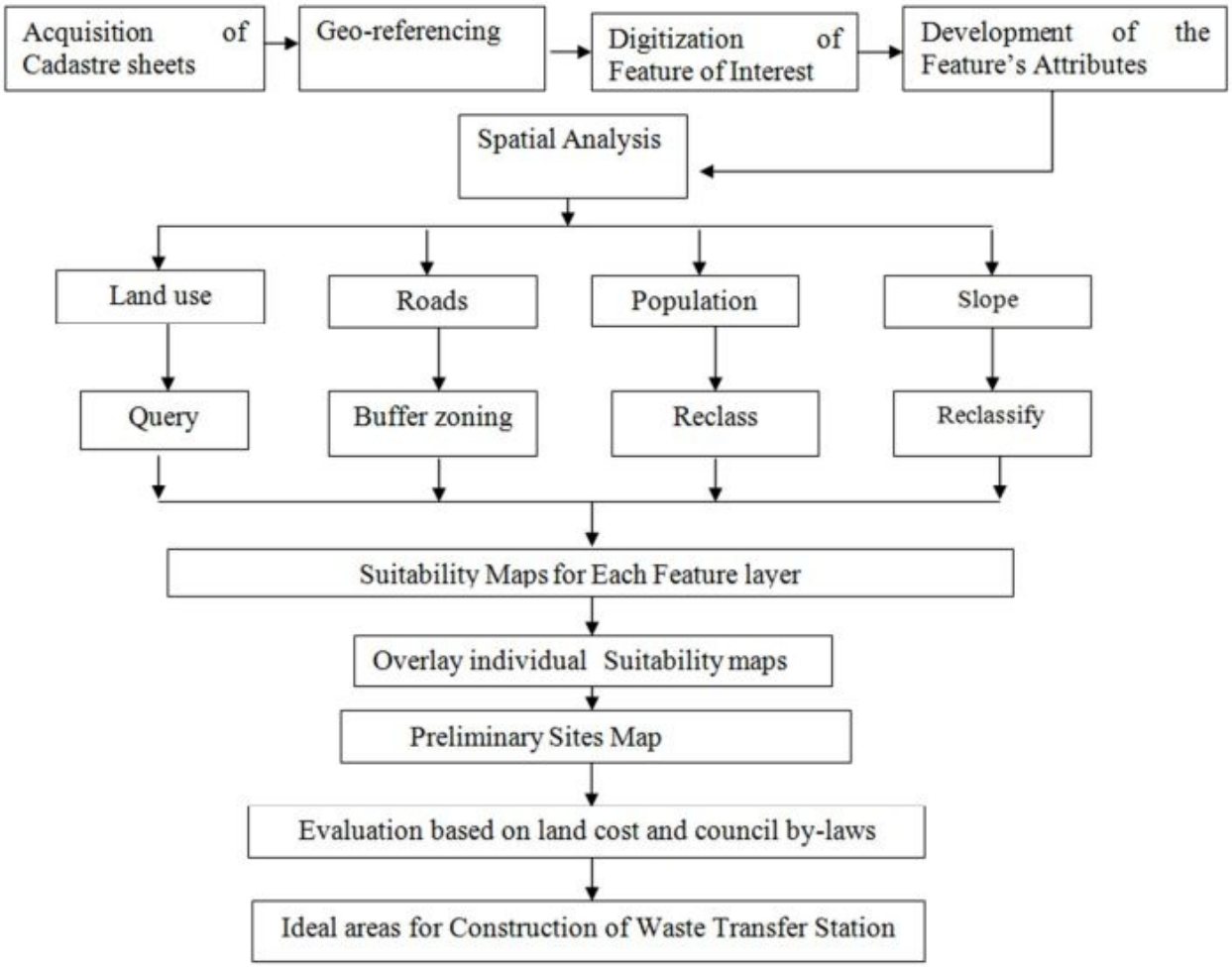
collection routes.

D. Land Use

As candidate sites for the facility, areas with limited residential activities and more industrial use were considered to be suitable.

2.8.4. Modeling and Analysis Within a GIS Platform

From the field survey, most of the attribute information was gathered. Municipal land use maps, road networks, population and slope layers for use in spatial analysis were the resulting products.asterization was performed on the vector layers for the analysis, exported and converted to Raster. To measure the zones outside the current container and paths, buffering was used.To classify the land uses existing in a given area, query by attribute was used. The following figure is the concept of GIS methodology



Reclassification was then used to construct images with a value of 1 assigned to appropriate land use and a value of 0.0 assigned to non-suitable areas. To get preliminary sites for consideration, then the resulting map layers were overlaid together. The final suitability map was obtained by rating the sites based on the bylaws of the Council at that time (Dickson and Daniel, 2017).

Chapter Three: Methodology

3.1. Study Area

3.1.1. Location

Addis Ababa is located in the central part of the country (Ethiopia). The population density is projected to be near 5,165 individuals per square kilometer available. The longitudinal and latitudinal extent of the city is from 38º 39' 00" – 38º 54' 15" E and 8º 50' 18" – 9º 6' 5" N. Addis Ababa is a chartered city and as such, is considered both a city and a state. It is the largest city in the world located in a blocked-in country (UN-World, 2019).

From the 10 sub cities "Town divisions" that found in Addis Ababa, Addis Ketema sub city is one of the smallest sub cities that found in the center of Addis Ababa, bounded from north by Gullele sub city, from south by Ledeta sub city from east by Arada sub city and from west by Kolfe Keranyo sub city and the area coverage is 8.63 sq.km. But, the density (36,659.1 per Sq. M) and number of populations (271,644) (A.A city government 2018). This is very high comparing to the other sub cities. Also, the biggest market place from Africa which is 'Merekato' found on this sub city. Slums and low-income communities cover the highest percentage of living standard. Because of this reason, the researcher chooses this sub city to assess Wereda level solid waste transfer sites existing condition from and its environmental and social impact.

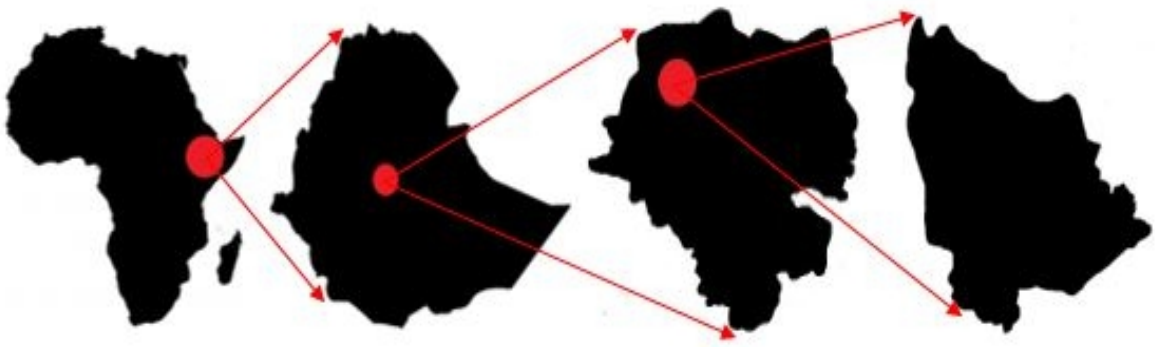


Fig 3. 1 location map of the study area (source: Organized by the author, 2020)

3.1.2. Population

Addis Ababa is one of the metropolitan cities in Sub-Saharan Africa holding 25% of the country's urban population (World Bank, 2015).

According to UN-World population prospects, the current metro area population of Addis Ababa in 2020 is 4,794,000, a 4.4% increase from 2019 which is 4,592,000. And projected to be 5.1 million by 2037 (UN-World, 2019). From this population 271,644 no of population found in Addis Ketema sub city which is 132,825 male and 138,819 females (A.A city government 2018).

3.1.3. Climate

Addis Ababa lies on 2350m above sea level, the climate is warm and temperate that is 'WoinaDega' with mean yearly temperature 16.02 °C/ 61.4 °F and annual usual downfall of concerning 1150mm from 1951–1998 and therefore the summers area unit abundant rainier than the winters in Addis Ababa (UN-World, 2019).

3.2. Research Design

To accomplish the goal of this study, its implemented different methods and approaches by both quantitative and qualitative methods. The rational of using this mixed approach was collecting data that increase the understanding of different options also can avoid the influence of one type of approach can balanced by the strength of the other approach and help to dive deeper into the problem.

According to the main objective of this research, Qualitative data collected through both observation and interviews. Descriptive and explanatory methods are suitable for the case to describe and explain the existing situation by both primary and secondary data. (Taboola, 2018) recommended explanatory research conducted for a problem which was not well researched before and which focuses on explaining the aspects of the study in a detailed manner. Also, the explanatory research is not used to give us some conclusive evidence but helps us in understanding the problem more efficiently. Due to this research idea, which is Wereda level solid waste transfer site impact assessment explanatory research design method used to understand the problem more efficiently to be a guide document for the other researchers. And, Quantitative data presented using tools like tables, figures and maps.

3.3. Data types and Sources

In this research, the researcher used both primary and secondary data types from primary and secondary sources. Primary data sources for this research include: Both Wereda and sub city administrative offices, Scavengers and collectors live near to the waste transfer site, Community live near to the waste transfer site, passing by peoples on the area and different peoples that work around the site and different Service providers are used. Addis Ababa city plan and development commission office: is the main source for this study, because this office has the right to prepare different land related maps for the city.

Secondary data sources: are integrating from the literature review (reports, journals, different data's and reports from governmental bodies and from other documents) both published and unpublished. As a secondary data different SP map and lane maps are used that to know the location of waste transfer sites that located by sub city level Solid waste management office.

3.4. Sample size and Techniques

In order to collect primary data from different bodies that related to the topic which is: Wereda Administrative office employees, People live and work around the transfer site. The researcher uses both random and non-random sampling technique.

Random sampling technique use due to the size of samples based on the people live around the solid waste transfer site, informal collector employees and other related association. And the other sampling technique which is non-random sampling technique use due to select different Wereda's by different parameters like by the affected area geographical location and based on neighborhood people density.

The population that was targeted for the analysis is defined as; all elements that meet the same criteria included in the study. The study population is, a selective people that live under the impact of Wereda level solid waste transfer sites and various actors working under solid waste management system in Addis Ababa, on the selected sample sub-city which is Addis Ketema sub city. The sampling frame contain different managers and employees that working in the sub city and Wereda level administration offices, peoples live around the solid waste transfer site also, Formal and informal waste collectors are included in the frame.

The sample size is totally Sixty-Seven samples are used for the study. Administration office on Wereda level Three office managers and on Sub city level One office manager from solid waste management office, under general office were participated. From Addis Ababa plan and development commission main office, two officers and from Addis Ababa plan and development commission Addis Ketema branch office, one officer were participated by non-random sampling method. In addition, fifty peoples that live and work around the site and Ten scavengers that work and live on the site were participated by random sampling method.

3.5. Data Collection Techniques

There are numerous tools and instruments through which data's can be collected. In this research, different data collection instruments were used like physical observation and both formal and informal interviews.

For the primary data collection, both formal and informal Interviews are prepared for the relevant bodies, formal interview prepared for: Addis ketema sub-city under General office manager-solid waste management office, Wereda level solid waste management office, Addis Ababa plan and development commission main office, Addis Ketema sub city-plan and development commission branch office. And the informal interviews have done on people that live around the waste transfer site, passing-by peoples on the site and solid waste collectors and scavengers that live and work on the site.

The researcher also used observation and site survey as one type of data collection instrument. That used for identify spatial allocation of solid waste transfer sites and to observe, how the entire system works like collection and transportation. The data collection method done by filed observation - By using GPS (To locate selected solid waste transfer sites) and Camera (To better display the current situation).

Secondary data collected before the primary data are collected. This data was collected through different hard and soft copies, from different governmental offices and from appropriate web-sites.

3.6. Data Analysis

This research explores and explains the main problems of solid waste management regarding to solid waste secondary collection sites or transfer stations and the data collected from both primary and secondary data sources are use as the main input for the analytical process. To

analyze the existing condition of Addis Ketema sub city Wereda level urban solid waste transfer site the emphasis was given to studying and exploring each Weredas solid waste transfer site regarding to the location of each site, the accessibility, compatibility of adjacent land uses, human and environmental risk, the material they constructed and their size and expansion ability were analyzed.

The Research also has conducted GIS based spatial analysis for measuring the proximity by narrowing down the potential choices based on international criteria that reviewed on the literature and weights and permitting sensitivity analysis of the results. In each analytical stage Land Use, Drainage system, different infrastructures especially Road network, Slope and special consideration for Social Services like: Education, Health centers and Recreational sites are including in the process. The suitability map was produced by Raster algebra calculation on Arc map. This method was employed to identify the most suitable solid waste transfer stations potential sites in the study area and all maps are analyzed as a map. Auto cad and SPSS software also used for analyzing the data. Also, Microsoft office word, micro soft excels is used to write different texts and tables.

3.7. Data presentation

All data are interpretation with the help of different Pictures, Maps, Satellite images and Tables. All maps are produced on Arc map GIS environment and pictures are taken on the time of site survey. All the reclassified maps are present with the help of different tales.

3.8. Ethical Consideration

The researcher received a letter of introduction from Addis Ababa University, Ethiopian Institute of Architecture, Building Construction and City Development department of urban and regional planning post graduate programs office. According to this, all targeted participants for the study were informed about the purpose of the study and all given information's will be used only for the intended academic purpose. Respects were given to all the participants and politely ask their permission or the response.

Chapter Four: Results and Discussion

4.1. Characteristics of Respondents

In this study the interview was conducted among 67 samples. From governmental office seven employees, from the community 50 samples and 10 formal and informal waste collectors are participated. Among those sample respondents 100 % sanitation administration employees are males, 2 of Addis Ababa Plan and development commission office employees are females and 1 is male and 72 % of the local people is female and 28% are male, while the respondents who manage and collect solid waste are 100% male. Three of the employees in the governmental office are at the position of Wereda level solid waste office managers and one is at the sub-city level office manager. The other three employees work as team leaders in the Addis Ababa plan and development commission. Among the people who participated in the interview, peoples who collected solid waste from the HH and work on a solid waste transfer site by sorting have been engaged in this filed for more than five years and 54% of the people live around the solid waste transfer site area have lived on the environment for 1-10 years, 32% of the people live10-20 years and 14% have lived on the environment for more than 20 years.

4.2. Practices of Residents Regarding to Solid Waste Sorting, Composing and Reuse in Addis Ketema Sub City

Addis Ababa is the capital city of Ethiopia, the current population of the city is 4,794,000 (united-nations world populace prospects, 2020) live in 10 sub-cities and 118 Wereda'sseparated for regulatory reason (Urban Improvement in Africa 2018). It is center for distinctive social exercises and advanced financial advancement moderately from diverse cities of Ethiopia. In any case, the improvement of the city is as well moderate to fulfill the request of the expanding populace. In particular, the full inadequate of the solid waste misuse organization is the foremost social and environmental issue in Addis Ababa.

Most issues of solid waste management in Addis Ababa remaining unsolved especially secondary solid waste transfer sites. Solid waste management departments have been founded on each sub-city and Wereda level. But this sector also struggling with lack of budgets, competent manpower and experience in waste management. The current SWM system in Addis Ababa relies mostly on the municipality which is expected to deliver the highest range of waste

collection and disposal. It's clear that the current waste collection and disposal capacity is not matched with the growing generation rate of Addis Ababa which is 4.40% (united-nations world population prospects, 2020). Typically demonstrating to be an unfeasible task that the services to be had are found to be mostly inadequate. This method neglects the actors that the waste management needs to tackle the existing problems in order to achieve environmentally and socially responsible waste management. Coordinating approach to SWM appears to be the leading alternative to effective and feasible squander administration framework system in developing cities like Addis Ababa.

4.2.1. Sorting

Based on the activities done in Addis Ketema sub city, it generates large amount of solid waste materials which is 33,749,090 kg of solid waste per year. On secondary solid waste transfer sites some of the waste has been sorted out and sold for reuse. With regard to sorting in Addis Ketema sub city, the households practicing sorting are very few. In developed nations waste isolated at the HH level. But the study distinguished that nearly all chosen participants which is 96.7% of SW generated in HH is disposed together i.e. there's no sorting practice of organic waste at the HH level.

Sorting is a fundamental component of SW administration. It could be a kind of action which is isolating diverse sorts of waste in their individual nature (inorganic and organic). It makes waste administration simple and straight forward. However, it's not one-time activity it stays as the waste exists. According to this, this activity needs a proper place (site) that free from environmental and human health risk.

Fig 4. 1Wereda 2, solid waste collectors sorting plastic bottles on solid waste plat forms (Source: Filed observation, 2020).

4.2.2. Composting

With regard to composting, it is a common way to prepare the waste for use. During the study, it was observed that 3.3% of households know at least the use of organic waste for soil fertility improvement. As the respondents shown the major confinement for not practicing compost is need of market and a bit of land for city cultivation. There are also some peoples who practicing composting and use as an income and sell out 1 kilo composed waste by 100br.

Fig 4. 2Households that compos organic solid waste (Source: Filed observation, 2020).

Currently, Ethiopia has decided to expand city agriculture and encouraging green development. According to this, the government decided to develop any open land that found in Addis Ababa city. Based on this, composing organic waste on house hold level can play a big role for this development.

4.2.3. Waste Reuse

Reuse is a vital factor to diminish the amount of waste to be dumped at the final disposal site (transfer station). The study result demonstrates that there is practice of waste reuse for distinctive purposes like plastic bottles for different purpose.

Fig 4. 3waste reuse: used plastic bottles for vegetables (Source: Filed observation, 2020).

4.2.4. Collection, Transportation and Disposal

Base on the results in Addis Ketema sub city waste collected in two ways: large enterprises clients by block collection system and for household's door to door collection system. And almost all house hold respondents say waste is collected door to door twice in a week and around market place which is "Mrekato", waste is collected every day by private waste collectors. As the researcher observed Private companies may too have more practice of waste collection and get to better equipment than local government and solid waste Containers are actually emptied in more than two-week period on average. Besides, some households are located on unsuitable access road people tend to through their waste in sewer and ditches. From secondary collection site waste is transferred by compactor to the final disposal site Reppi or "Koshe", the sanitary landfill that located 9.58 km away from Addis Ketema sub city.

4.3. Existing Condition and Problems of Solid Waste Transfer Sites in Addis Ketema Sub City

For this specific analysis, different materials are used. The materials are: GPS, Arc-map (GIS), Auto cad, Google earth image, 2003-line map of Addis Ketema, Structure plan of Addis Ababa land use, Structure plan of Addis Ababa street and transport network.

In the last 10 years (i.e. since the early 2000s), the city has experienced a tremendous development within the number of huge commercials teach and industries. As the recent, development activities are likely to increase in construction waste that has not been taken into thought both by the individuals and by administrative bodies.

Level of solid waste generation rate on this sub city is high as its central market place of Addis Ababa; different new products have entered to the market daily. Accordingly, the amount of solid waste increased dramatically. The destitute solid waste circumstance is worsened by the lack of technical and institutional capacity to bargain with the expanding era of waste in the sub city.

Addis Ketema sub city divided by 10 Wereda's. Within this Wereda's, there are 13 legal solid waste secondary collection open platforms except Wereda 7, there is no secondary solid waste collection site on this Wereda. Beside this, 2(Two) sites that constructed as a transfer station were found. Based on Addis Ketema sub city solid waste management office information, 48 (Forty-eight) small sized secondary solid waste collection platforms are proposed.

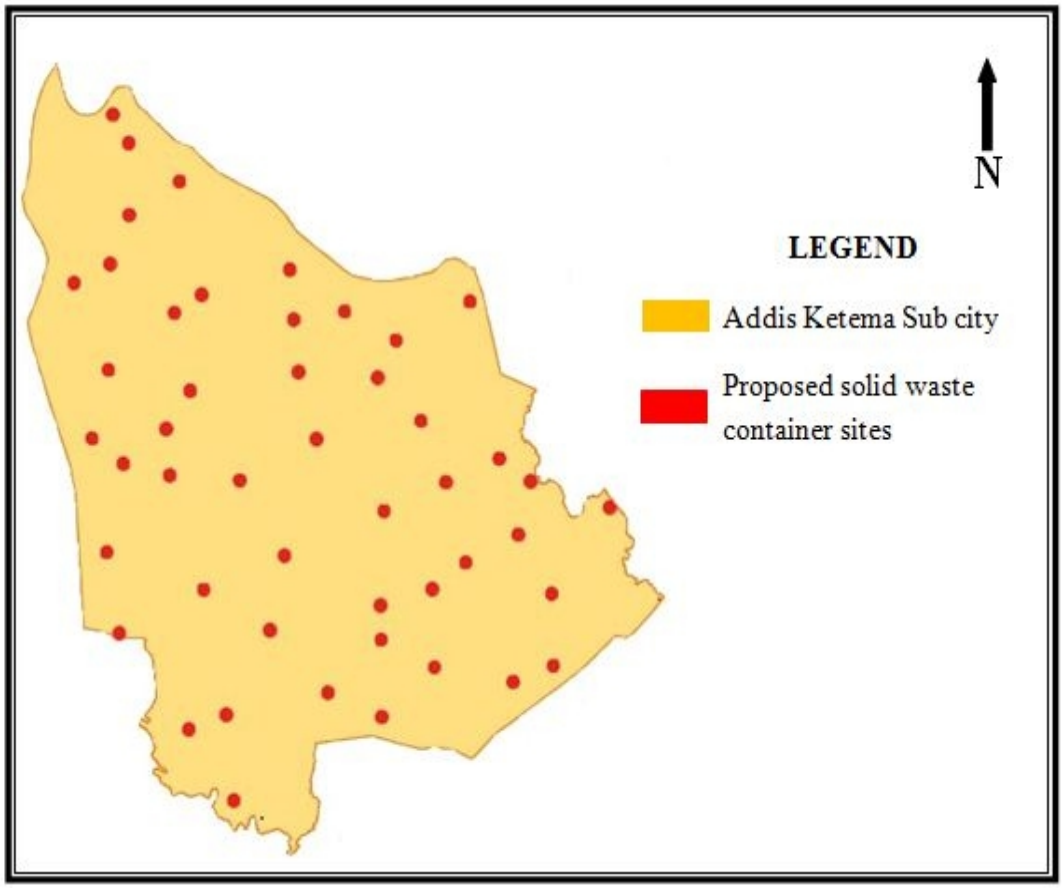


Fig 4. 4 Location of proposed solid waste secondary collection sites (Source: AKSWM).

These 48 proposed Solid Waste Container storage sites are received a legally permitted map from the concerned body. But the construction not started yet.

According to the existing analysis, only 13 Secondary solid waste collection sites are available. And this site has legally permitted paper and contains a proof of possession from the concerned body. And the other two sites (constructed as a transfer station) that found on Wereda 8 and Wereda 10, have no legally permitted paper and proof of possession. AAPDC office, Addis Ketema branch office has no information on this specific solid waste transfer station sites.

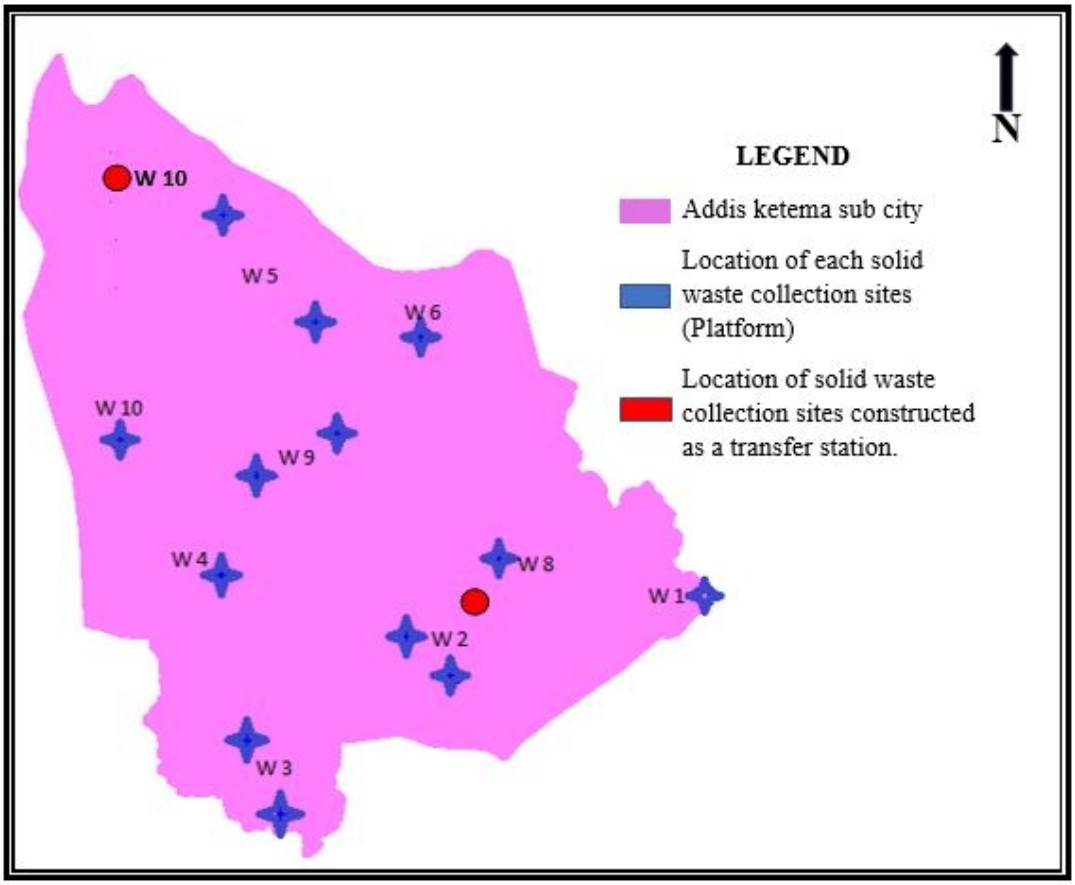


Fig 4. 5 Location of solid waste secondary collection sites in each Wereda's (Source: filed survey, 2020).

4.3.1. Assessment on Technical Issues

4.3.1.1. Land Use (Addis Ketema)

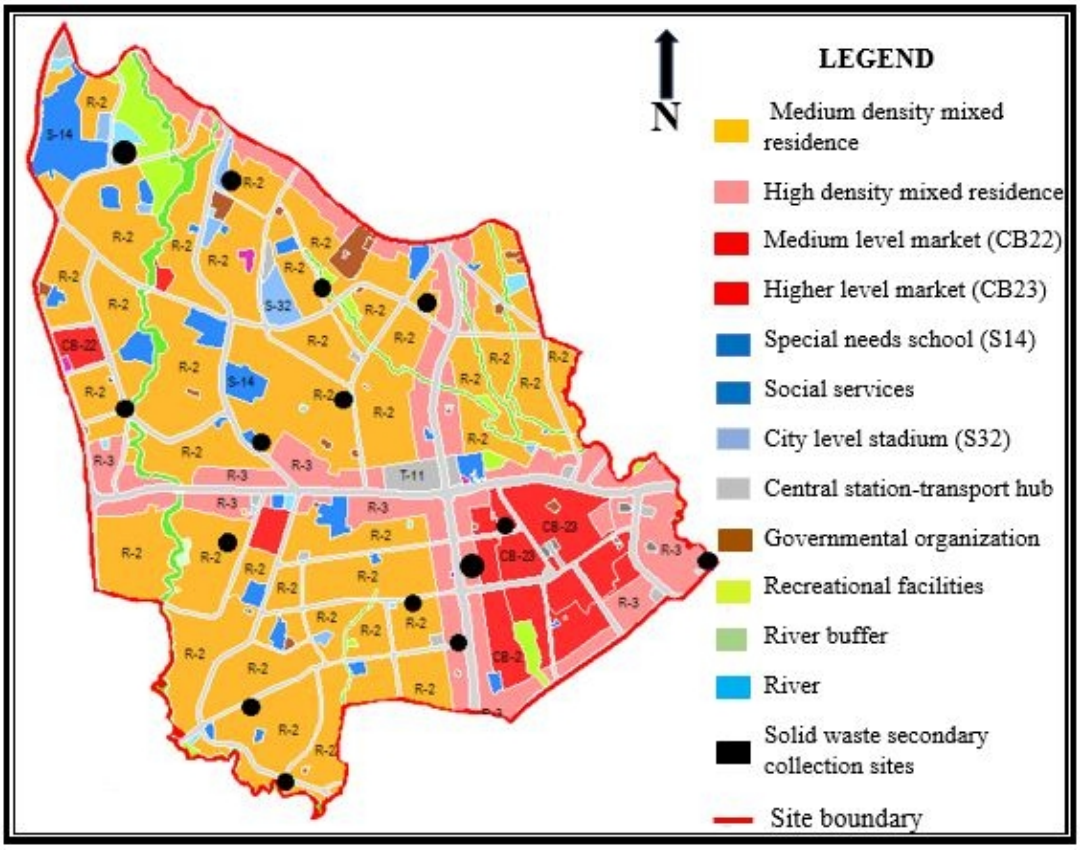


Fig 4. 6 Addis Ketema Land use (Source: Digitized from AAMP).

According to the structural plan land use, the location of solid waste secondary collection sites: 11(eleven) are found on Medium density mixed residence zone, 2(Two) found on High density mixed residence zone, 1(one) found on Higher level market area and 1(one) find on Social care center. Therefore, these solid waste transfer platforms should not be problematic as it allows within the specified land use zones except the one that found on social care center.

4.3.1.2. Access Roads (Addis Ketema)

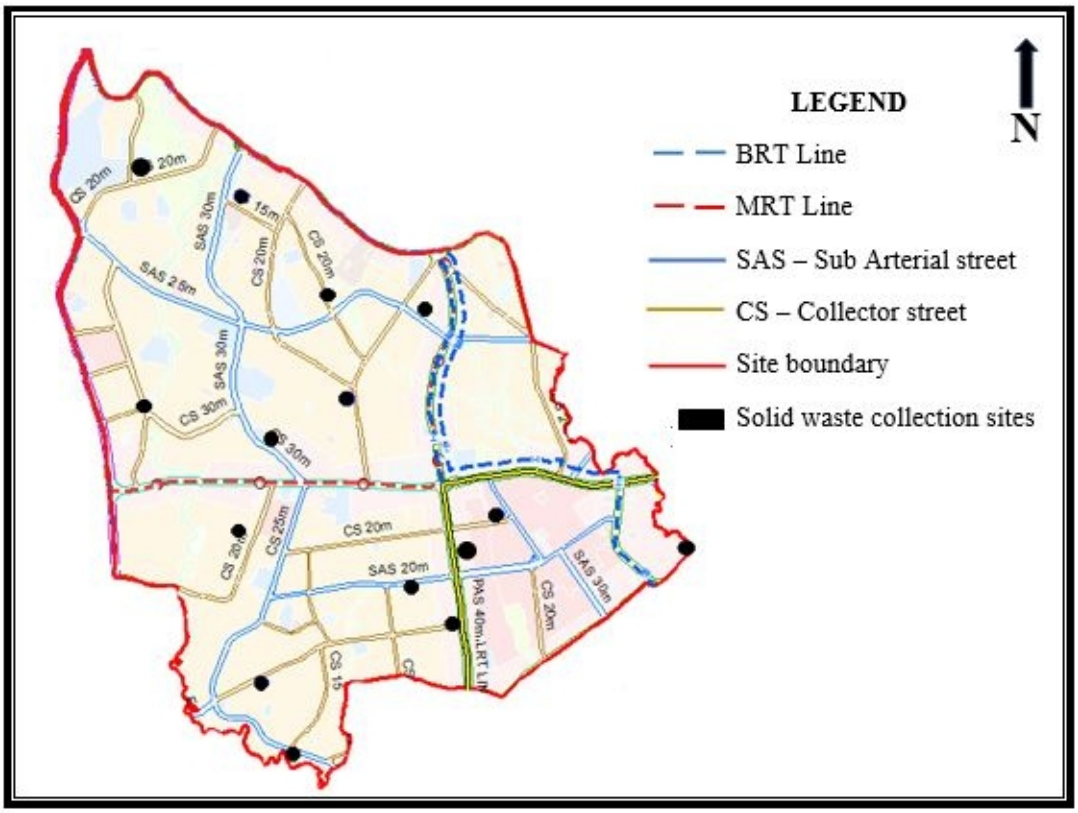


Fig 4. 7 Addis Ketema Road Network (Source: Digitized from AAMP Road network).

Each solid waste secondary collection platforms which is built in each Wereda's in the sub city are accessible to the street.

According to the road width, 2 (two) platforms are near to 25-meter-wide Structural Plan road, 4 (Four) platforms are near to 20m wide Structural Plan road, 4(four) platforms are near to 10m Access Road and 5(Five) platforms are near to 8m Access Road.

4.3.2. Detailed Analysis on Technical and Environmental Issues

4.3.2.1. Accessibility

Accessibility analyzed based on access to solid waste transportation vehicle types which is Compactor. And, it's not easy for trucks to access roads, which increase haul times and cause impacts on nearby communities and businesses. As the research result showed, on each HH level door to door solid waste collection system is done twice within a week. Regarding to these, peoples no need to drop their waste on collection sites. But, in some parts which have very poor access road wastes were dumped illegally in open places, and sensitive areas like water bodies. In addition, since their geographical distance to the urban area is not set by guiding standards it's difficult to compare the existing condition to the standards.

4.3.2.2. Adjacent Land Uses

There are different land uses that found around the platform sites. According to this, there is inconsistent land uses are found. Among them, in Wereda 5, Wereda 9, Wereda 1 and in Wereda 3 Existing solid waste secondary collection sites are considered as an example.

This plat form found on Wereda 5, That Locate near to River buffer (only 8m difference).

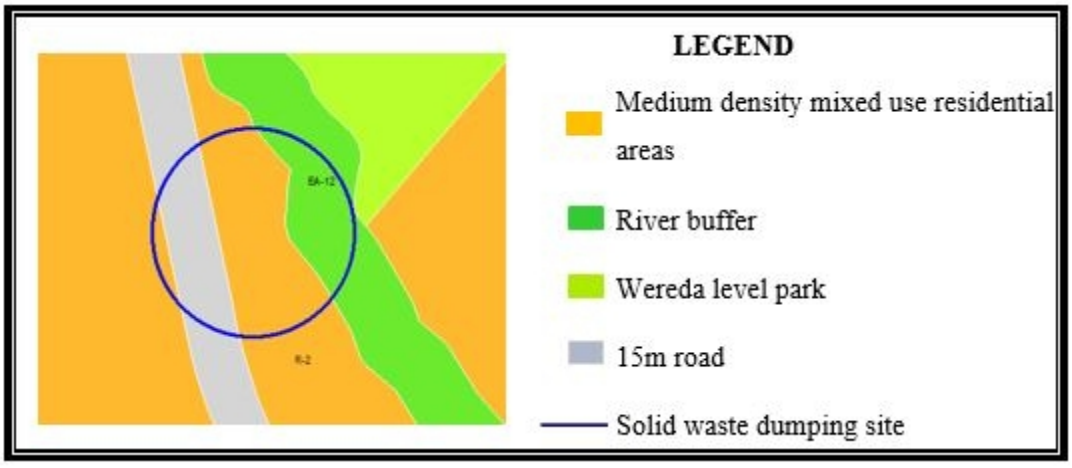


Fig 4. 8 Addis Ketema W5 Solid waste transfer site adjacent land uses (Source: Digitized from AAMP).

This plat form found on Wereda 5, That Locate in front of Sport Center. There is 6m access road between them.

Fig 4. 9 Addis Ketema W5 Solid waste transfer site adjacent land uses (Source: Digitized from AAMP).

This plat form found in Wereda 9. That Locate close to Wereda 9 Governmental health center. Only 4m difference between them.

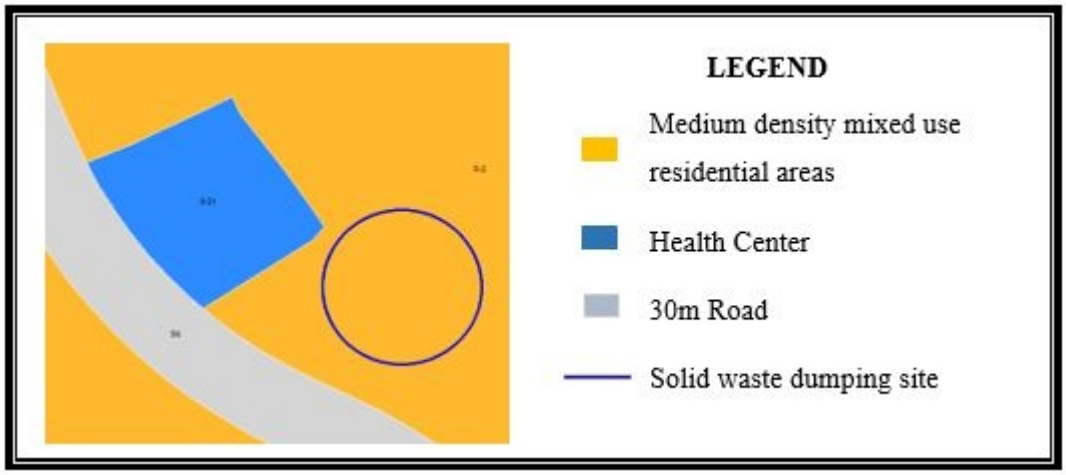


Fig 4. 10 Addis Ketema W9 Solid waste transfer site adjacent land uses (Source: Digitized from AAMP).

This platform found in Wereda 9. That Locate close to 30m SP Road and River Buffer.

Fig 4. 11 AK W9 SW transfer site adjacent land uses (Source: Digitized from AAMP).

This platform found in Wereda 1. That Locate close to 25m SP Road and River Buffer.

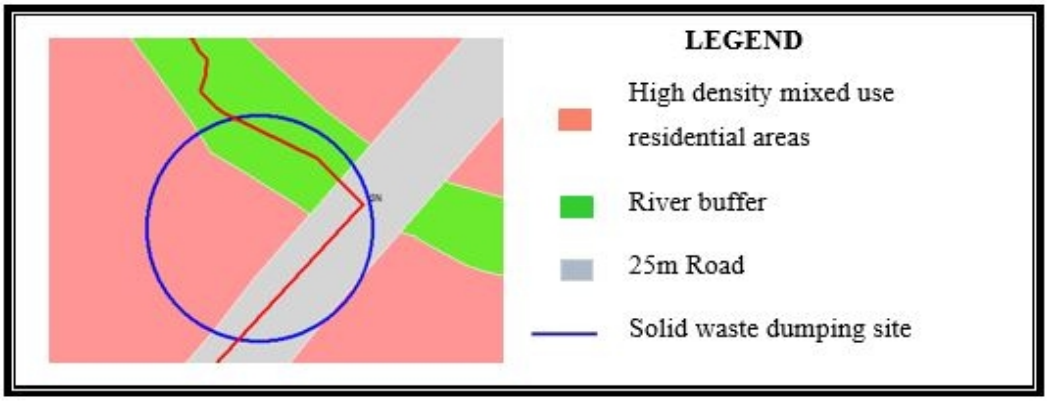


Fig 4. 12 AK W1 SW transfer site adjacent land uses (Source: Digitized from AAMP).

This platform found in Wereda 3. That locates close to 25m SP road and river buffer.

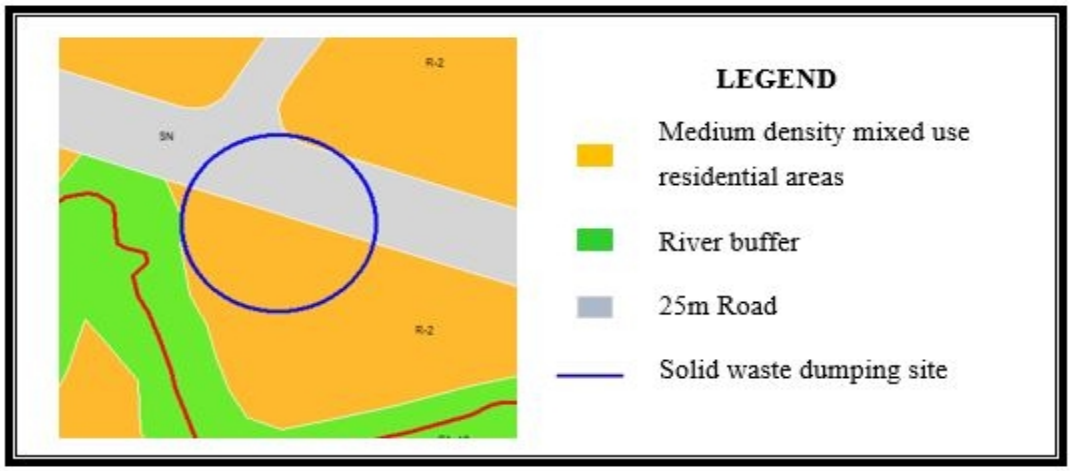


Fig 4. 13 AK W3 SW transfer site adjacent land uses (Source: Digitized from AAMP).

This solid waste transfer site found on W 5. Fig 10, try to show in detail how this site is close to sensitive areas like Residence and Recreational areas within 100m radius.

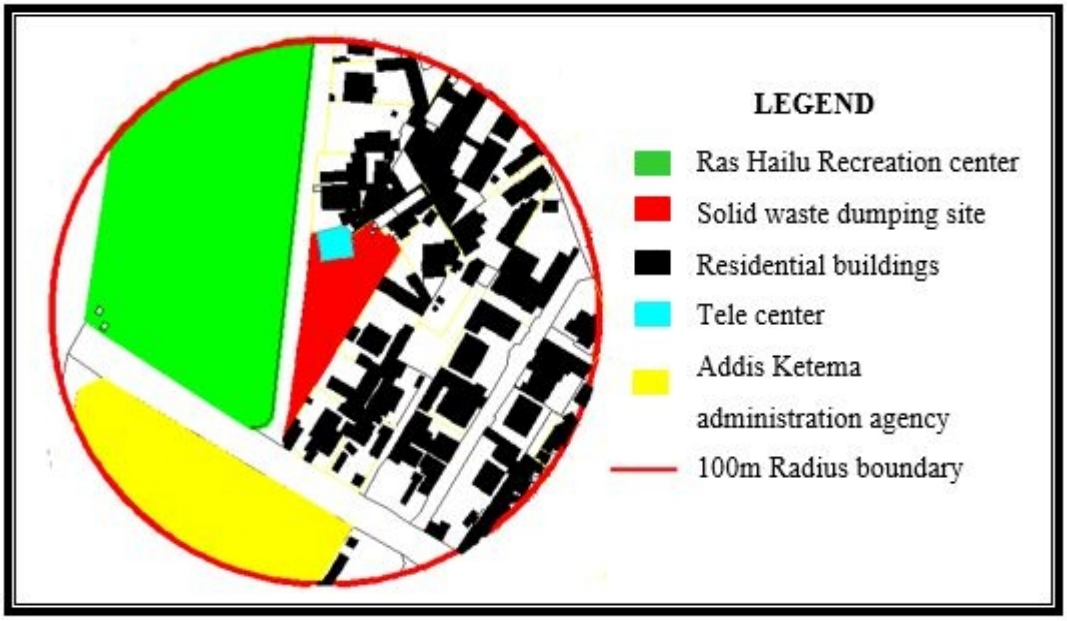


Fig 4. 14 AK W5 SW transfer site and its surrounding areas (Source: Digitized from AAMP).

This under construction standardized solid waste collection sites is found on Wereda 10 that constructed as a solid waste transfer station.

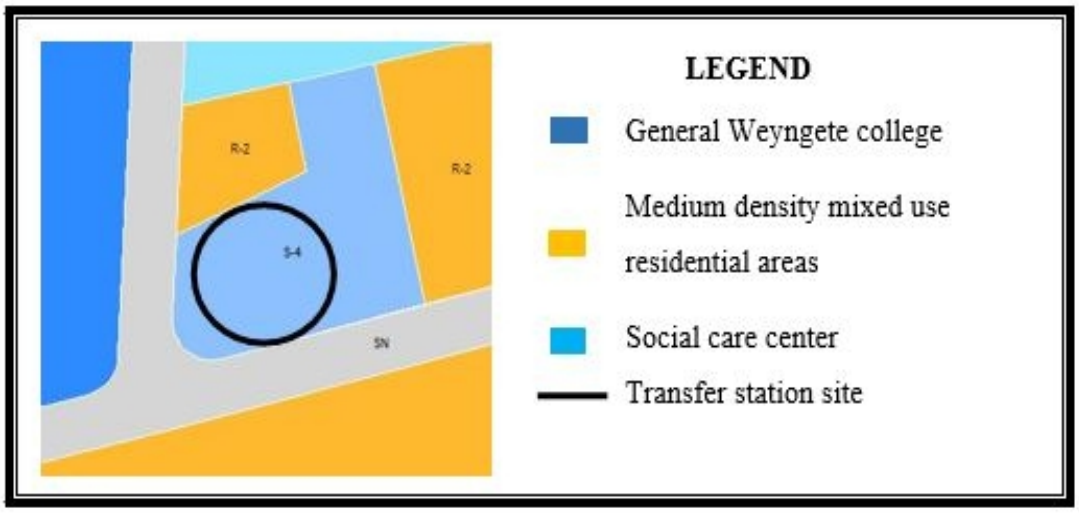


Fig 4. 15 AK W10 SW transfer station site and its surrounding areas (Source: Digitized from AAMP).

Fig 4. 16 Addis Ketema W10 Solid waste transfer station building (Source: Filed observation, 2020).

Based on the SP of Addis Ababa, this Transfer Station that found on Wereda 10 are, constructed on proposal site for Social care center.

The other transfer station site is found on Wereda 8 that Locate on high density mixed residential zone. And, AAPDC Addis Ketema branch office has no information about these transfer station site locations. and, this location has no legal evidence.

Fig 4. 17 Addis Ketema W8 Solid waste transfer station building (Source: Filed observation, 2020).

4.3.2.3. Human Health and Environmental Risk

Solid waste has a great impact on day to day human activity especially in Residential areas and also on Commercial activities. From the 13 solid waste secondary collection platforms that found in Addis Ketema, 9(nine) are close to residential areas, 3 (three) are close to commercial areas and 2 (two) are close to schools. Almost all plat forms that found on this sub city are too close to residential areas commercial centers and schools. This is less than 5 meters.

Coordinate - X=469304 Y=1000086 X=469475 Y=998677


Fig 4. 18 SW transfer site, around residential areas (Source: Filed observation, 2020).

Coordinate - X=471912 Y=998026 X=469419 Y=997241


Fig 4. 19 SW transfer site, Around market place (Source: Filed observation, 2020).

Fig 4. 20 SW transfer site, Around Betelhemschool (Source: Filed observation,

Coordinate - X=470375Y=999432 X=468741 Y=998861


Fig 4. 22 SW transfer site, Around Gebesmedacondominium (Source: Filed observation, 2020).

Fig 4. 21 Around Tayewan Market Place (Source: Filed observation, 2020).

The failure of municipal solid waste management system has resulted in serious environmental and health troubles. For instance, in congested neighborhoods, access roads are small and organic. Also, due to lack of proper solid waste secondary collection sites uncollected waste is dumped in drains and on the streets, by this means, it contributing to breeding of insect, flooding and spreading of diseases. Garbage is frequently dumped outside due to be short of capability, poor collection, and public selfishness. Also, some collected waste is disposed of in unrestrained dump-sites or burnt openly. This process has been identified to cause environmental and social problems.

Almost all platforms found on this sub city didn't consider the environment (Population density, Urban Habitation size, Commercial goods consumption rate, Climate, Geographical location, and Living standards). Residents and commercial center owners complain about bad odors that lead them to diseases like Colds and other Infectious. Starting from their Construction technique and Materials they use, it's very poor and easily spread unwanted smell on the environment. The existing little range of containers that additionally act as a transfer station for the solid waste is broken. Often, the garbage is strewn around, where children that live around and on the site, wondering dogs, birds and other lost animals, searching food on the platform and spreading the waste around. Also, by this all unorganized situation, waste kept on these platforms up to 15(fifty) days without any protection.

4.3.2.4. Material

All legally built solid waste platforms which is 13 platforms all are constructed by block and most of them has no roof cover and closing gate. Four of them have low standard gate which is around RasHailu, GebesMeda Condominium, Wereda 9 health center and Around Betelhem School. Animals like dogs can easily access this area because, there is poor closing gate and this gate can easily open and most are remaining open. And this animal can scare and attack the people live and passing on the area.

Almost all dry waste platforms have no roof covers. Because of this, rain easily gate in and cause very bad odor.

Coordinate - X = 469292 Y = 998130 X = 469419 Y = 997241

Fig 4. 23 SW transfer platforms with no closing gate(Source: Filed observation, 2020).

Coordinate - X = 469475 Y = 998677 X = 470381 Y = 999433

Fig 4. 24 SW transfer platforms that have poor standard gate(Source: Filed observation, 2020).

4.3.2.5. Size of Plat forms, Buffer and their Expansion Ability

From 13 platforms, 12 plat forms site area is only 30 m2, but the platform that found around RasHaillu market place is 60 m2. The average number of garbage pools that found on the site is limited which is 1(one) garbage pool per site. Also, some platforms have no garbage pool, the garbage just dumped on the platform. The plat forms that have a garbage pool, waste is clean from the surface by the help of compactor. When this process happens, mostly on residential areas both vehicular and pedestrian movement was blocked. Because, those sites have no parking space for loading and unloading process.

Compactor is that the most expensive assortment and transfer vehicle and this Hydraulic compaction instrumentality not appropriate for residential waste (which already features a high

density) and this hydraulics want specialist maintenance. Solely appropriate for collecting low-density waste in huge quantities where road conditions are suitable.

Coordinate - X=469926 Y=998902 X=468743 Y=998865

Fig 4. 25 Loading and unloading process Around Kuasmeda condominium and Ttayewan market place (Source: Filed observation, 2020).

There is no expansion ability around the platforms. Because, it's crowded by Residents, Commercial areas and different Social Services. Also, the biggest market place in Africa which is 'Merekato' found on this sub city. According to this, it's difficult to expand those platforms to bigger stations. Also, there is no area for recycling and compacting. Because of these solid waste collectors complain and says, it's impossible to separate the waste by their categories and prepare for recycling process on this small plat form space.

4.4. Local and International criteria used to select Solid Waste Transfer Sites

All peoples deserve Green, Clean and Safe environment to insure their quality of life. According to this, sustainable solid waste management system is one of the best options to improve quality of life. Sustainable solid waste management can use waste as a resource. Proper implementation of such strategy creates job opportunities, raises image of the city and minimizes burdens on the natural environment. Secondary solid waste collection sites should be developed and operated in such a way that it would not pose threat to public and environmental health. They must be sited as they constitute both environmentally and fiscally sound waste disposal options. Such transfer stations shall serve as a bridge between community-based solid waste collection endeavors and a waste disposal facility.

As the Addis Ababa city structure set up outline report 2017, varied ideas and principles have been used in developing the environmental proposals of the SP. And one of the specific proposals ensures:

- Develop 3 transfer stations with material recovery facilities (south, east, west)
- Ensure three-way waste separation at supply (recyclable, bio-degradable and hazardous) in 2025 and five-way waste separation at supply (paper, plastic, alternative recyclables, bio-degradable and hazardous) in 2040.
- Increase the proportion of utilization to 10% in 2025 and 20% in 2040.
- Increase the proportion of organic waste transformation to 25% in 2025 and 40% in 2040.
- Close down the Repi rubbish dump and convert it into a public recreational space.

To insure the above specific proposals, sub city level solid waste transfer stations play the highest role. Because, this transfer stations can minimize the burden of the final disposal site which is "Repi". Which separation and recycling process can easily do in this transfer stations (sub city level transfer stations). The structure plan has a plan to Develop three transfer stations with material recovery facilities (South, East, West); and develop a time location to Develop Two transfer stations – in the 1st five years – Repi, Bole Arabsa and Akaki. This station is high in size material and capacity. But, only these stations can't eliminate the existing environmental and social problems that caused by the existing Wereda level solid waste secondary transfer sites that more close to the community. This site must be located carefully with standard and guiding principles to upgrade the quality of life.

As city government of Addis Ababa works and urban development bureau office there is Norms, Standards and Guidelines of the Addis Ababa SP and its components on solid waste location of dumpsters. It's based on the container size and type:

For $1.1m^3$ container size: Maximum Catchment population (HH) is 60 , Maximum Catchment radius is 65 m and assumed emptying interval is 5 days.

For $8m^3$ container size: Maximum Catchment population (HH) is 150 , Maximum Catchment radius is 100 m and assumed emptying interval is 8 days.

And these dumpsters should locate at appropriate places where public areas and transport lines could not be disturbed Location of landfill sites and treatment plants should respect safe limits and buffer zone with necessary precaution for Water Wells, Rivers and Streams.
As Addis Ababa city SP summary report, 2017 they try to put some guiding lines: that to locate waste separation points:

- Space necessary for Solid waste points for separation must depend on type and size of the waste. At least the space must accommodate three trash bins (for Harmful Wastes, Organic Wastes and Recyclable Waste), and extracting space.
- Trash bins must be located in diverse housing areas with a 10m width minimum access road. According to this, it shall locate away or not located near to Water bodies, Playgrounds and Recreational areas.

The study identified that on the case sub city each solid waste transfer sites only have average 1 garbage bins for all Organic Wastes, Hazardous Wastes and Recyclable Waste. On the SP summary report, each solid waste transfer sites must provide a space for waste extraction, which is not happen on the actual sites. Also, the report restricts not to locate those areas around Play Grounds, Green areas and Water bodies but, what is in place is the opposite.

As the researcher mention on the above topic, Addis Ketema solid waste management office have a plan to construct 48 plat forms on Addis Ketema sub city to minimize the shortage and consider the increase number of solid waste generation rate. But, the sites are located randomly on any open spaces without any specific considerations. This process can increase the impact on the environment and the surrounding communities in highest manner. But, locating a smaller number of sustainable solid waste transfer stations by considering different perspective which is technical, environmental and social is better than construct unsustainable 48 platforms on this sub city.

4.4.1. What Type of Transfer Station?

Based on the literature's that the researcher reviewed generally there is 2(two) type of transfer stations apply worldwide which is Small to medium transfer stations and Large transfer stations.

Small to medium transfer stations area unit additional like direct-discharge solid waste stations that offer no in-between waste storage (cargo) area. The capacities are usually small

which is less than 100 tons/day and the medium sized capacity is 100 to 500 tons/day. And, this garbage container sites are Depending on site aesthetics, social and environmental concerns, this type of transfer stations are located either indoor or outdoor (protected or not protected). On the opposite hand, Medium transfer stations are frequently attended throughout hours of operation and should embrace some easy waste and materials process facilities. It includes, processing center and a recyclable material separation. The next sort of solid waste transfer station referred to as advanced or massive transfer stations, that designed for serious commercial use by private and municipal assortment vehicles (The open University, 2016).

Accordingly, when a solid waste storage site was selected for a particular sub city first, the situation must be clearly seen like, Population Density, Natural Habitat, etc. Based on this and other related criteria, solid waste transfer stations can be identified. For example, based on the 10 sub cities of Addis Ababa which is: Arada, Ledeta, Kirkos and Addis Ketema sub cities with their presence in central Addis Ababa, they are much smaller in size than the other sub cities (Bole, Yeka, Guleli, NefasSelek, KolefeKeraniyo and AkakiKaliti sub cities) that difficult to find a place for this type of development. Especially in the case of Addis Ketema sub city, which have a densely populated and highly commercial sub city. Based on this, the researcher studies some international and domestic standards based on different Parameters like: Land cover, Road network, Social services, Residences and Ground water based on the Addis Ababa structural plan and 2003-line map of Addis Ababa. All parameters are analyzed by Arc GIS - suitability study.

4.4.2. International Standards and Guiding Principles to Proposed Sustainable Site for Solid Waste Transfer Stations

Site selection for any solid waste-related station can be a sensitive issue, especially for those living close by. In principle, such stations are required and will be required in the future. The need for these stations may differ from place to place and also determined based on other stations and services in the area. Solid waste transfer stations are a vibrant component for modern world solid waste management practice. There are some main standard measures and concerns of society.

Table 4. 1 Standards for large size transfer stations (general site selection criteria)

No	Consideration	Criteria	Source
1	**Land use**	Appropriate development areas may include industrial areas and rural areas.	Alberta environment 2008
		Less economic lands like open spaces.	UNEP 2005
		Governmental homes 'kebele houses' (very low standard).	A.A master plan 2017
		Forest and bare land	Ahmed. M. 2019
2	**Access roads**	Vehicle types, sizes and weights should be considered.	EPA 1995
		5000 m away is more suitable	Ahmed. M. 2019
3	**Airports**	Generally, 8km from an airport	
4	**Residents, hospital, food establishment and school**	1000- 2000 meters away	USEPA 2004
		5000m away	Ahmed. M. 2019
5	**Slope**	Less than 4-11% is suitable	Makhdoum 1993
6	**Distance from road net works**	Areas above 500 m is suitable	EPA 1995
7	**Surface and ground water**	2000m away	Ahmed. M. 2019
		500m away	UNEP 2005
8	**Fault areas**	Prohibited within 200 feet of fault areas	EPA 1993
		3000m away	Ahmed. M. 2019

These criteria applied on different stage (Exclusionary, Technical, and Community-specific criteria). The important thing that must consider is, not all site can meet all the criteria, in which case, each standard's comparative importance and weight must be measured (USEPA, 2002).

Table 4. 2Standards for small size transfer stations (general site selection criteria)

No	Consideration	Criteria	Source
1	**Land use**	Appropriate development areas may include industrial areas and rural areas.	Alberta environment 2008
		Less economic lands like open spaces,	UNEP 2005
		Governmental homes 'kebele houses' (very low standard). Mixed residential areas	A.A master plan 2017
2	**Access roads**	Vehicle types, sizes and weights should be considered. Minimum 10 m width and highly suitable to access main roads.	A.A master plan 2017
		700m away	Ahmed. M. 2019
		30 m	Manitoba 2016
3	**Residents**	30 m away	Alberta environment 2008
		700m away	Ahmed. M. 2019
4	**Hospital, Food establishment and School**	30 m away	Alberta environment 2008 Manitoba 2016
		700m away	Ahmed. M. 2019
6	**Surface water**	30 m	Manitoba 2016
		500m away	Ahmed. M. 2019

4.5. Sustainable Sites and Appropriate Strategies: Suitability Analysis

Based on table 4.3 which is Standards for small size transfer stations (General site selection criteria), Restrictions are made. This restriction helps to classify the proximity in to four categories, from Minimum buffer distance to Maximum buffer distance.

Table 4. 3Proximity suitability restrictions

No	Restriction source	Minimum buffer distance (m)	Moderate buffer distance (m)	High buffer distance (m)	Maximum buffer distance
1	**Rivers**	30	265	500	> 500
2	**Streets**	30	365	700	> 700
3	**Social services**	30	365	700	> 700

Based on the Five criteria maps which is Land Use, Slope, Drainage, Road and Social Services, procedures are made in GIS. The procedures are leading the researcher to the desired conclusion that to locate potential site for Solid Waste Transfer Station. Based on this, the procedures are described in detail on the next section.

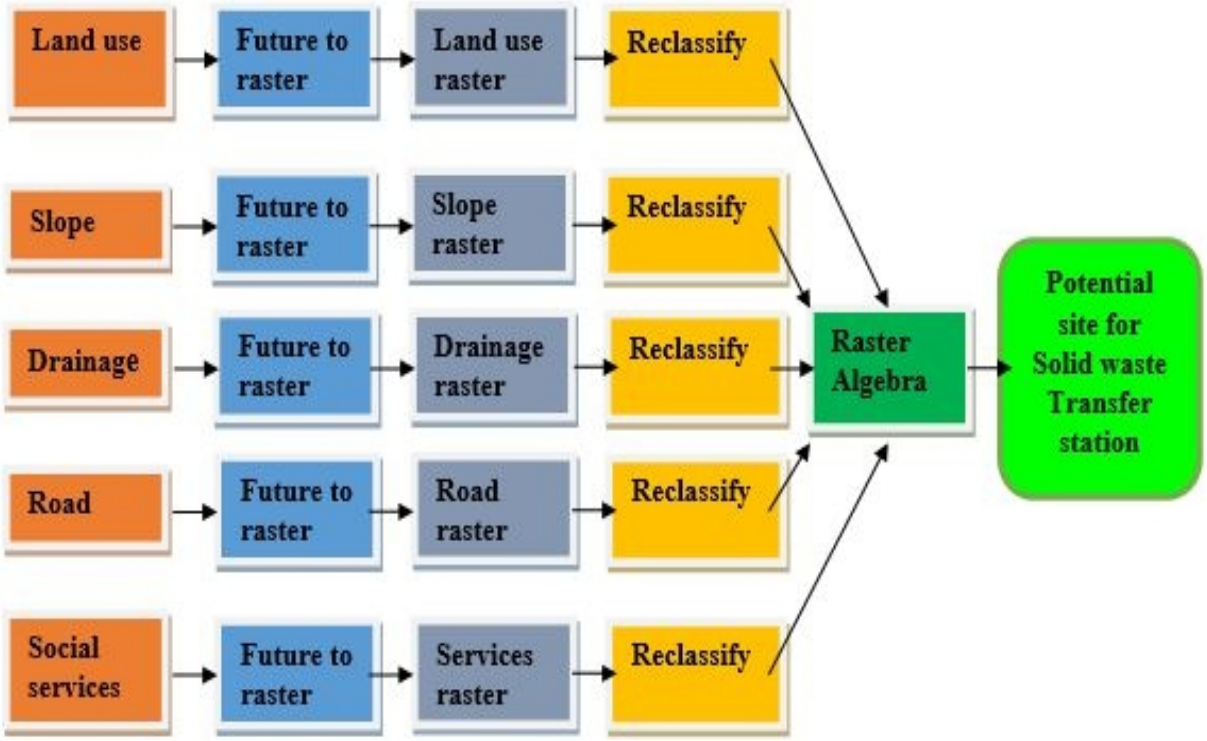


Fig 4. 26 procedures to select solid waste transfer station site.

4.5.1. Drainage of the Study Area

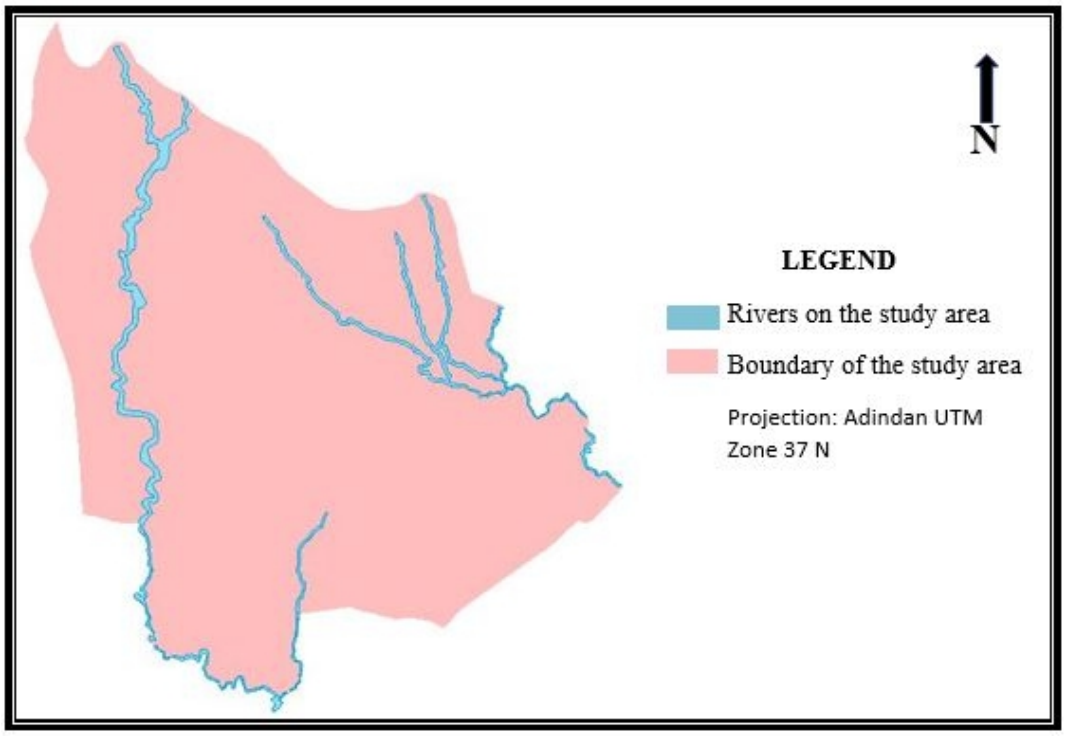


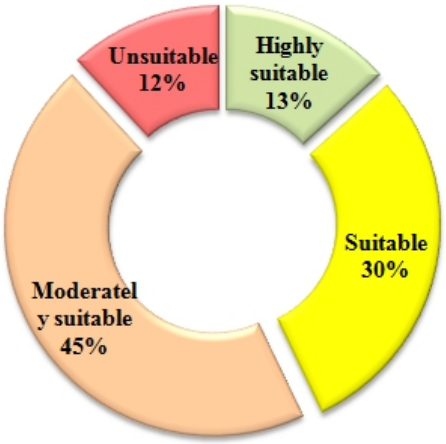
Fig 4. 27 River network map of the study area (Source: Digitized from AAMP).

4.5.1.1. Drainage Suitability Analysis

As the literature's showed, solid waste transfer stations should locate far from streams. The buffer distance was restricted as table 4.4.

Table 4. 4 Drainage suitability area coverage

No	Class	Buffer distance (m)	Area in (ha)	Area in (%)
1	**Highly suitable**	> 500	115.25	13.3
2	**Suitable**	500	255.56	29.6
3	**Moderately suitable**	265	391.24	45.3
4	**Unsuitable**	< 30	101.8	11.8
Total			**863.92**	**100**



Source: Extracted from reclassified drainage map attribute table.

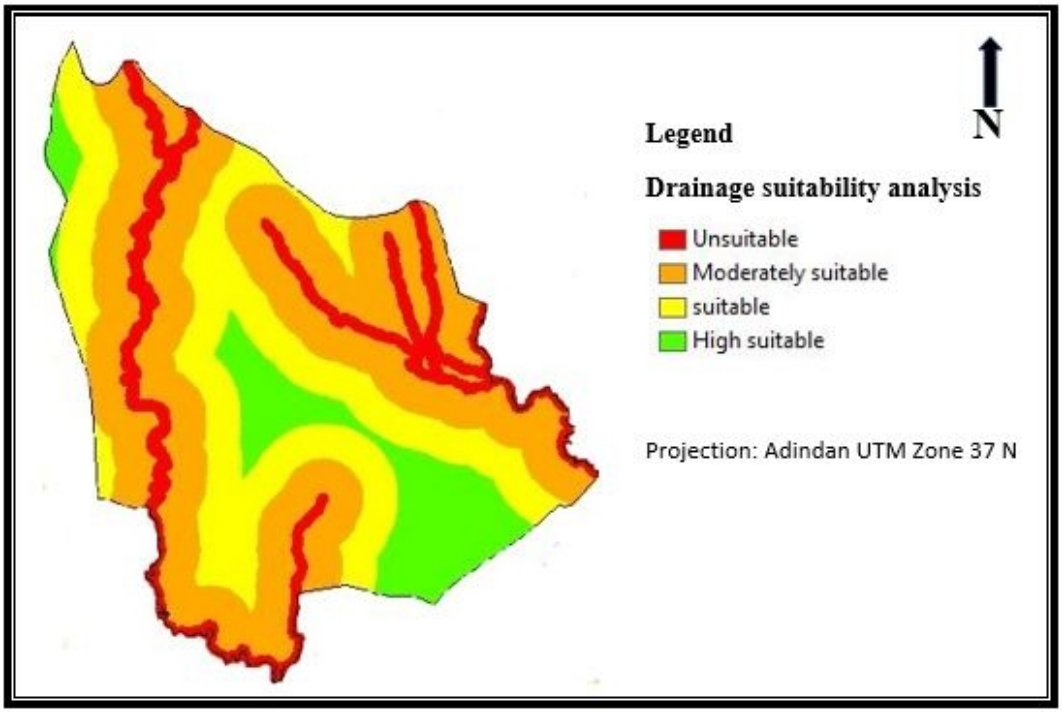


Fig 4. 28 River suitability map of the study area.

4.5.2. Land Use of the Study Area

This land use map was, collected from Addis Ababa plan and development commission office and clipped from the structural Plan of Addis Ababa.

The land use map helps us to know, which locations are more suitable for solid waste transfer station. The highest portion of the map is covered by medium to high residential areas and commercial areas.

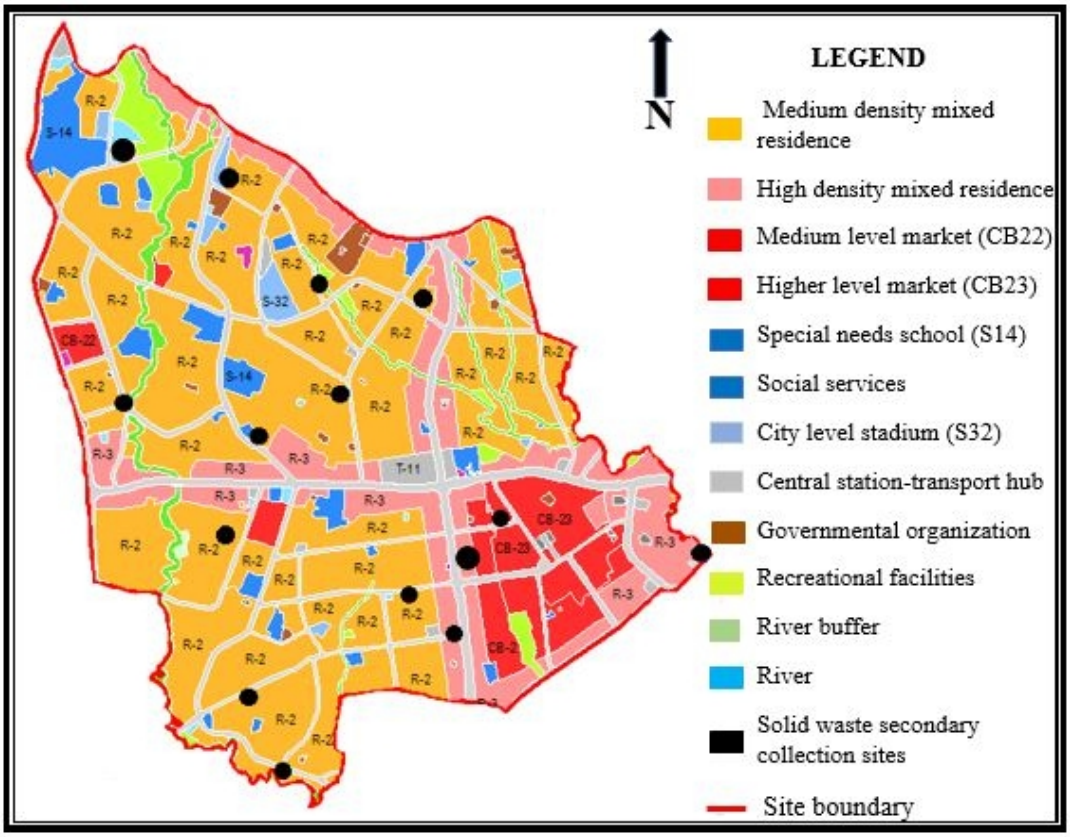


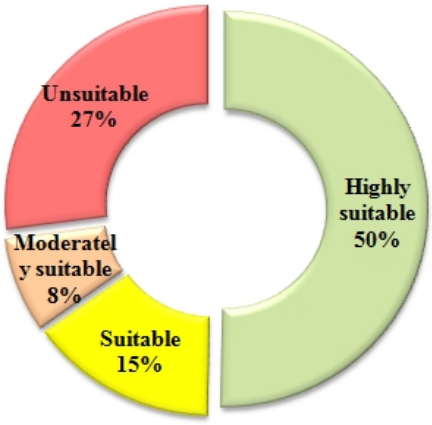
Fig 4. 29 land use map of the study area (Source: Digitized from AAMP).

4.5.2.1. Land Use Suitability Analysis

As the literature's explained, Solid Waste Transfer Stations should locate far from Social Services, Water bodies and Residential areas. And it's more suitable to be locate on low economic value lands like open lands. As the structural plan of Addis Ababa, it's preferable to locate solid waste transfer station on Low and Medium densities mixed residential zones without disturb the nearby Residents. The Buffer distance was restricted as table 4.4.

Table 4. 5Land use suitability area coverage

No	Class	Area in (ha)	Area in (%)
1	**Highly suitable**	434.39	50.3
2	**Suitable**	129.5	14.9
3	**Moderately suitable**	66.25	7.7
4	**Unsuitable**	233.76	27.1
Total		**863.92**	**100**



Source: Extracted from reclassified Land use map attribute table.

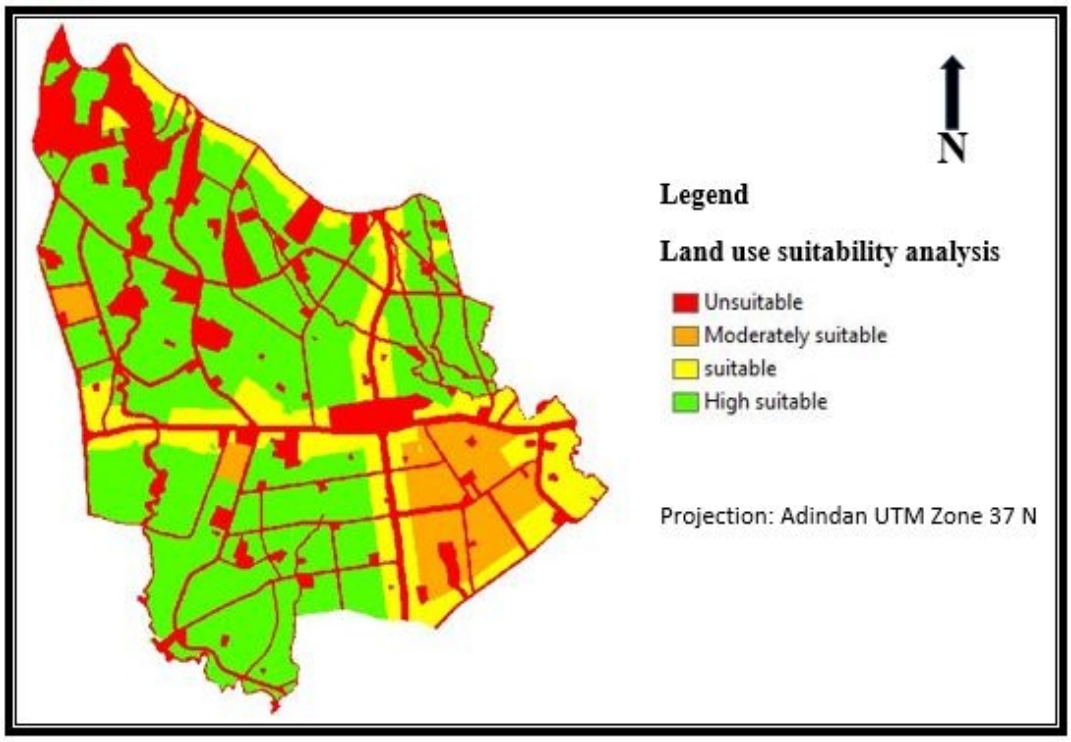


Fig 4. 30 land use suitability map of the study area.

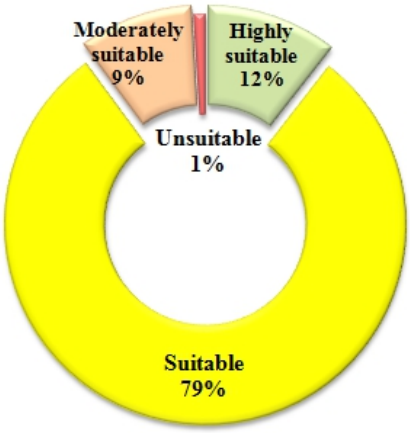
4.5.3. Slope of the Study Area

4.5.3.1. Slope Suitability Analysis

As the above suitability maps, the Slope of the study area also classified in to four categories.

Table 4. 6 Slope suitability area coverage

No	Class	Area in (ha)	Area in (%)
1	**Highly suitable**	90.97	10.5
2	**Suitable**	686.27	79.4
3	**Moderately suitable**	79.31	9.2
4	**Unsuitable**	7.35	0.9
Total		**863.92**	**100**



Source: Extracted from reclassified Slope map attribute table.

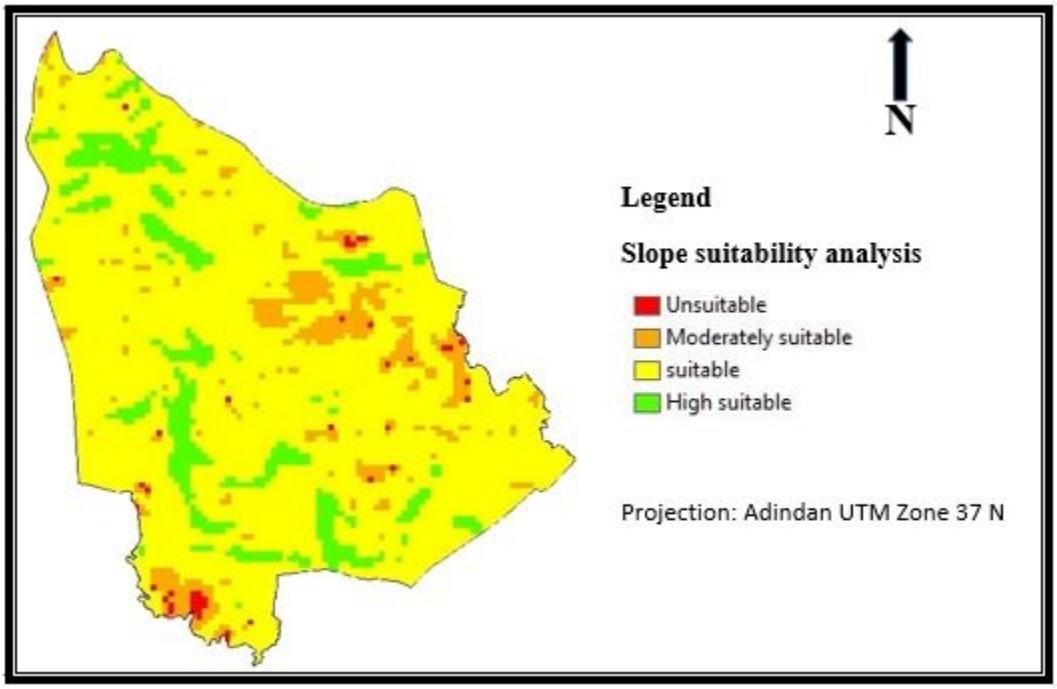


Fig 4. 31 Slope suitability map of the study area.

As the table shown, the study area has more suitable (have gentle slope) and its very suitable to locate solid waste transfer station.

4.5.4. Road Network of the Study Area

The Road map of the study area was clipped and digitized from the structural map of Addis Ababa. Road network is, one criterion for locating solid waste transfer station potential areas.

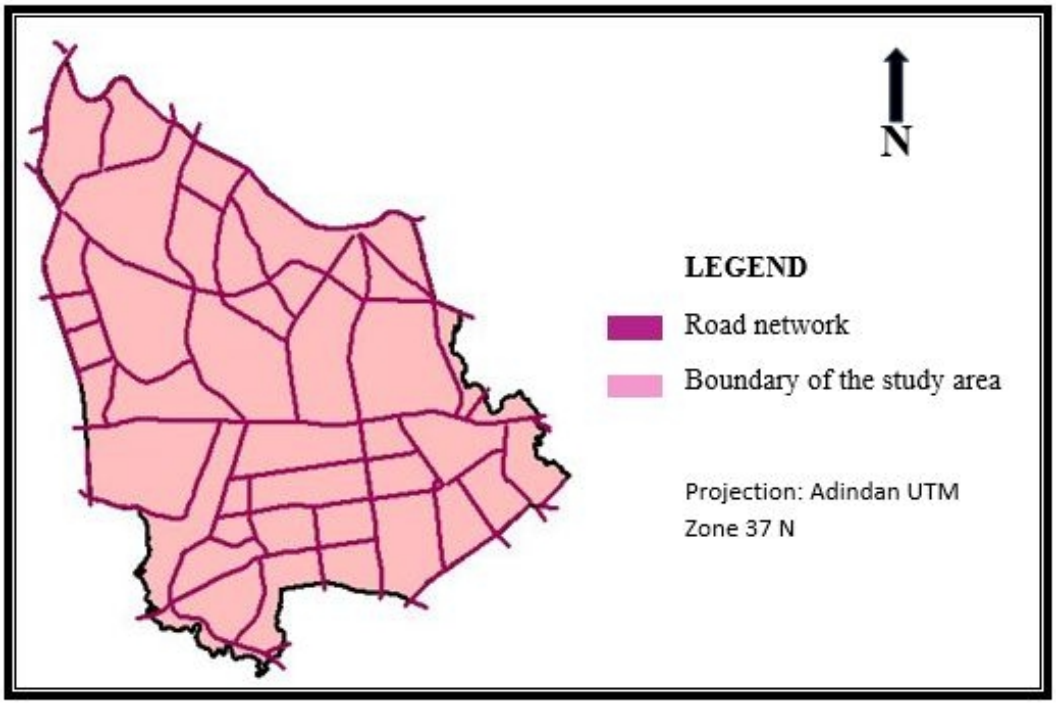


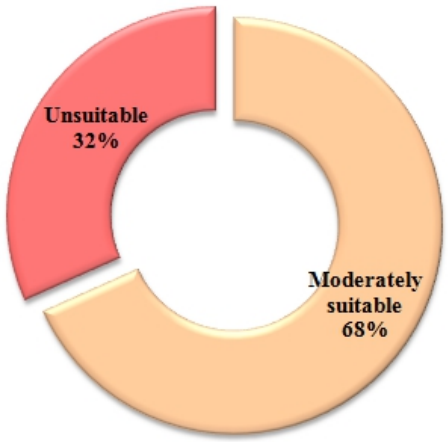
Fig 4. 32 Road network of the study area (Source: Digitized from AAMP Road network).

4.5.4.1. Road Network Suitability Analysis

As the literature's explained, solid waste transfer stations should locate far from road networks. The buffer distance was restricted as table 4.4.

Table 4. 7Road network suitability area coverage

No	Class	Buffer distance (m)	Area in (ha)	Area in (%)
1	**Moderately Suitable**	365	589.92	68.3
2	**Unsuitable**	< 30	274	31.7
Total			**863.92**	**100**



Source: Extracted from reclassified Road network map attribute table.

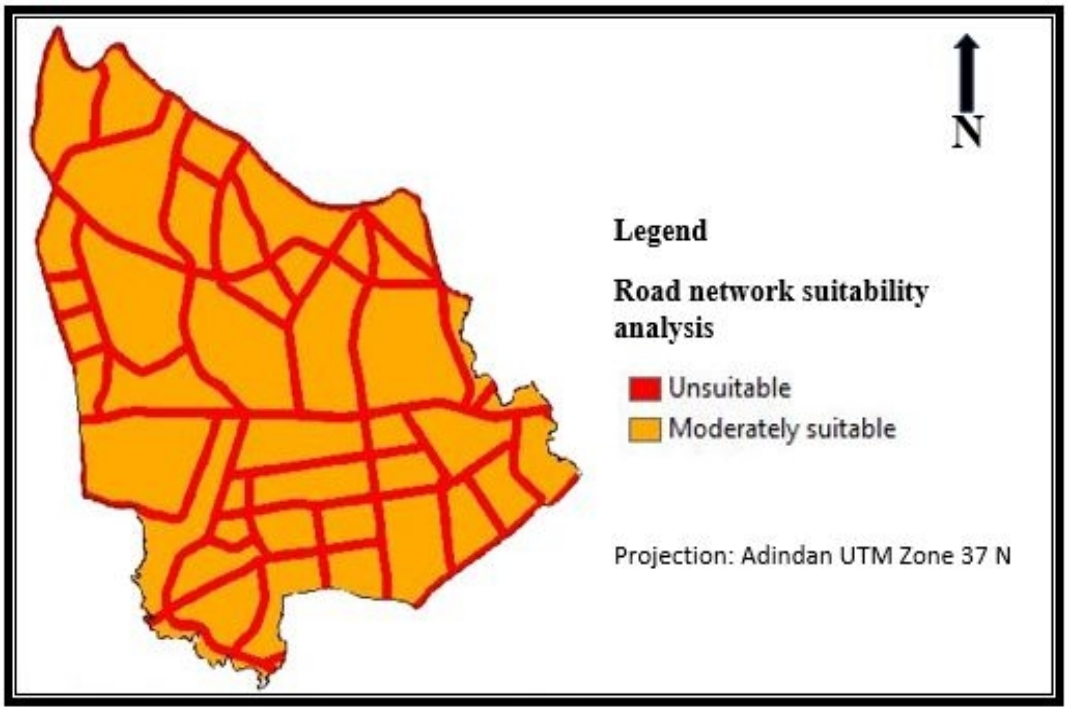


Fig 4. 33 Road network suitability map of the study area.

Based on the Proximity suitability restrictions table, areas found less than 30m is unsuitable and equals and more than 700m is high suitable. As fig 4.32. Showed, Road network suitability map only covers two categories which is unsuitable and moderately suitable.

4.5.5. Social Services Map of the Study Area

All social services found on the study area, which is Secondary School, Social care center, Health Center, Cultural and civic center, Sub city Administration, University and Colleges are digitized from the existing 2003-line map of Addis Ababa: Addis Ketema sub city.

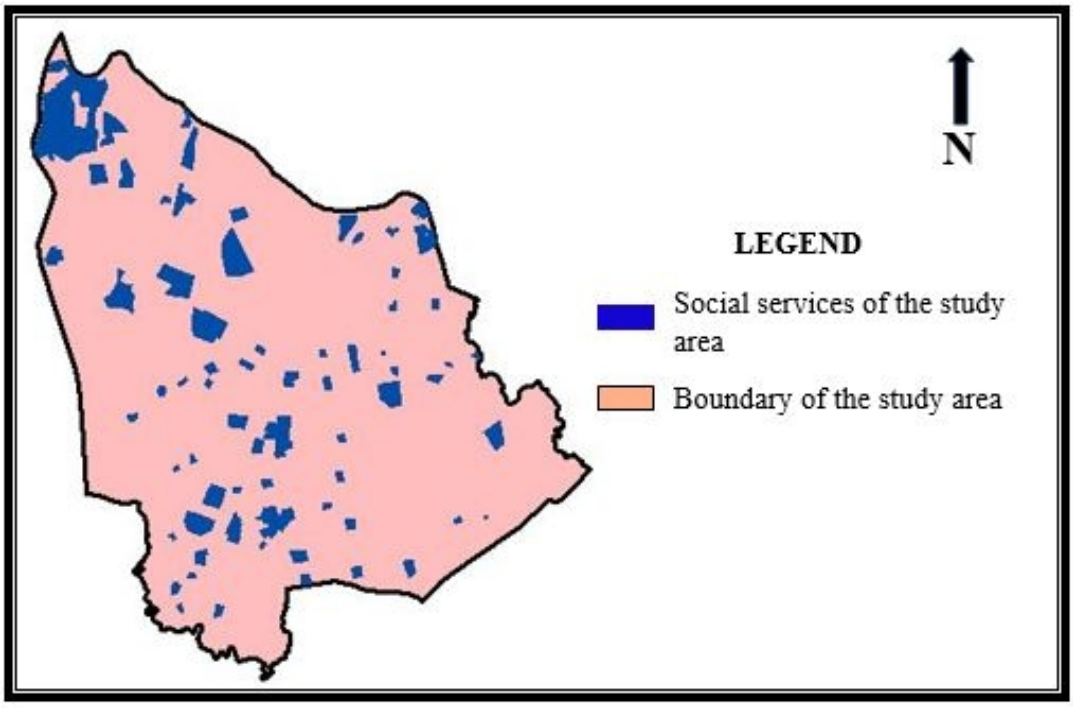


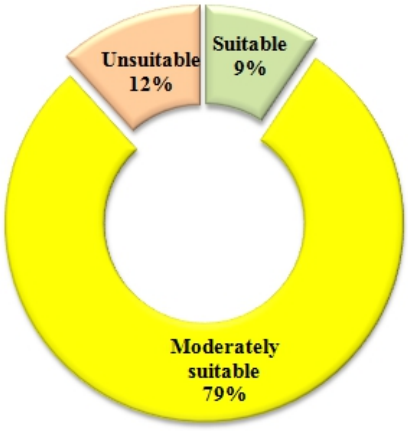
Fig 4. 34 location of social services of the study area(Source: Digitized from AK line map 2003).

4.5.5.1. Social Services Suitability Analysis

As the literature's explained, solid waste transfer stations should locate far from social services. The buffer distance was restricted as table 4.4.

Table 4. 8Social services suitability area coverage

No	Class	Buffer distance (m)	Area in (ha)	Area in (%)
1	**Suitable**	700	81.64	9.4
2	**Moderately suitable**	265	680.47	78.9
3	**Unsuitable**	< 30	101.8	11.7
Total			**863.92**	**100**



Source: Extracted from reclassified Social service map attribute table.

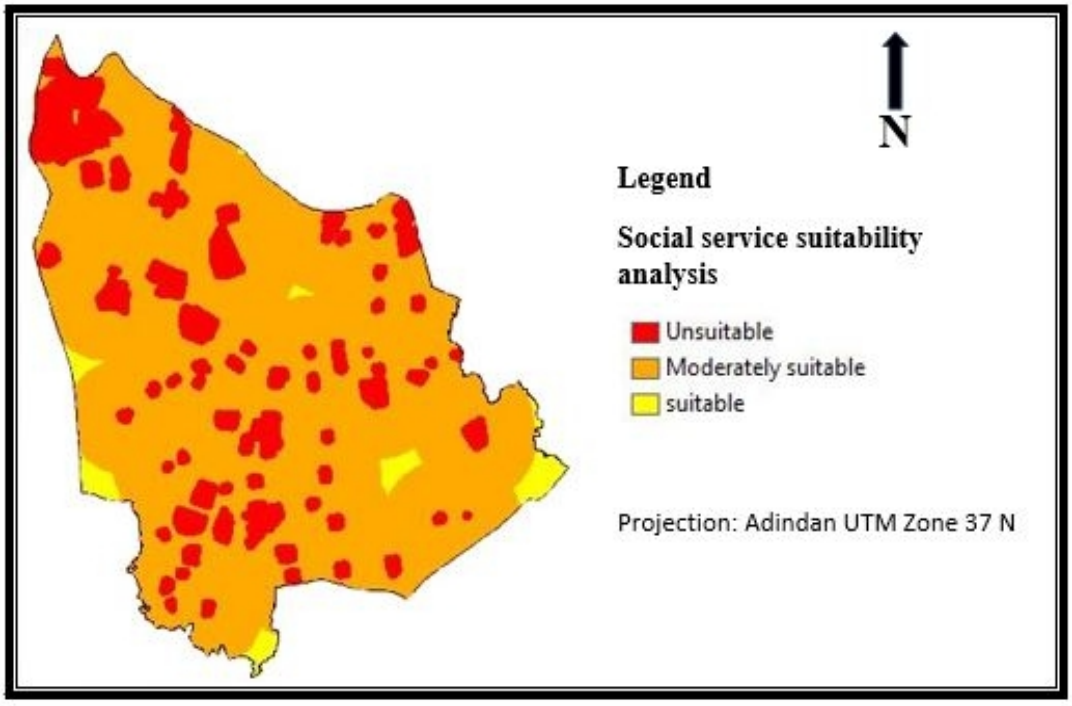


Fig 4. 35 social service suitability map of the study area.

Based on the Proximity suitability restrictions table, areas found less than 30m is unsuitable and equals and more than 700m is high suitable. As fig 4.34. Showed social network suitability map only cover three categories which is unsuitable, moderately suitable and suitable.

4.5.6. Summary Analysis of the Study Area

The mixing of waste at the HH level in Addis Ketema Sub-City has continued to pose a problem in terms of volume reduction and waste segregation. The reduction and recycling of sources plays an integral role in the overall waste management system of every society. Therefore, if most urban solid waste was separated, reduced or recycled, a large quantity could be diverted from dumpsites and processed into products for revenue generation instead.All these operations will also reduce the amount and weight of the waste ending up in the landfill sites and minimizing both the transportation and disposal costs. The study found that the current methods of waste management are labor-intensive, old-fashioned and not based on any technology.This document has clearly demonstrated the need for properly located solid waste transfer station in this sub-city based on adequate standards and principles.

On this section, the researcher combined all reclassified maps to locate suitable and sustainable site for solid waste transfer station in Addis Ketema Sub city. The researcher came up to this solution based on the existing site analysis that done on 15 solid waste collection sites that found on Addis Ketema sub city.

As the researcher explains, there are large and small to medium sized solid waste transfer stations worldwide. Based on this and as the character of the study area (It is a very densely populated area), the researcher uses the small to medium sized solid waste transfer station. According to these, restrictions were made which is Minimum buffer distance, Moderate buffer distance, High buffer distance and Maximum buffer distance based on standards for small to medium sized transfer stations criteria that listed on table 4.4. This restriction made in each map (Land use, Road, Drainage, slope and Social services) by classified as High suitable, Suitable, moderately suitable and Unsuitable. These Classified maps are discussed as follows.

- Based on the Drainage suitability analysis and the Classified map, it addresses the four class which is High suitable, Suitable, Moderately suitable and Unsuitable. According to drainage line of the sub city, it's moderately suitable for locate solid waste transfer station which cover 391.24 ha of land (45.3%) from 863.92 ha land of Addis Ketema sub city.

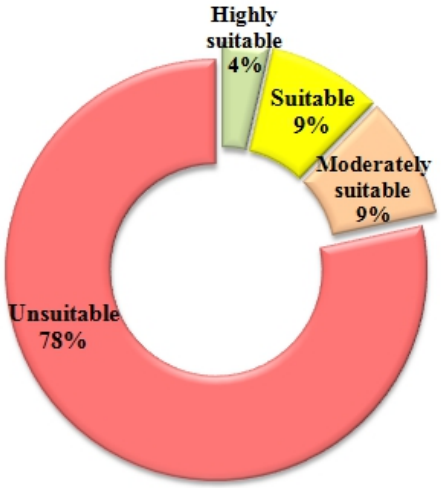
- Based on the Land use of the study area suitability analysis and Classified map, it addresses the four class which is High suitable, Suitable, Moderately suitable and Unsuitable. And, its Highly suitable for locating solid waste transfer station which cover 434.39 ha of land (50.3%) from 863.92 ha land of Addis Ketema sub city.
- Based on the Slope of the study area suitability analysis and Classified map, it also addresses the four class which is High suitable, Suitable, Moderately suitable and Unsuitable. And, its Suitable for locating solid waste transfer station which means its highly covered by Gentle slope that cover 686.27 ha of land (79.4%) from 863.92 ha land of Addis Ketema sub city.
- Based on the Road network of the study area suitability analysis and classified map, its only address two class which is moderately suitable and Unsuitable. And, its Moderately suitable for locating solid waste transfer station which cover 589.92 ha of land (68.3%) from 863.92 ha land of Addis Ketema sub city.
- Based on the Location of Social Services of the study area suitability analysis and Classified map, it also addresses three class which is Suitable, Moderately suitable and Unsuitable. And, its Moderately suitable for locating solid waste transfer station that cover 680.47 ha of land (78.9) from 863.92 ha land of Addis Ketema sub city.

According to the Classified maps (Land use, Road, Drainage, slope and Social services). The researcher uses Arc map GIS: Raster algebra, to reclassify each map again. This calculator tool helps to create and execute a map algebra expression that will out put a raster. According to this, the researcher adds all the above Classified maps on Raster algebra calculator and calculate each layer to reclassify again on the range of High suitable, Suitable, moderately suitable and Unsuitable to find potential site for solid waste transfer station on the case area.

Based on the Raster algebra calculation result (figure 4.35) the North, West and North East parts of the study area were unsuitable for locating solid waste transfer station. The rest part of the study area which is North Western, South Eastern part and the Central part of the study area were found Suitable and Highly suitable for the potential site for solid waste transfer station.

Table 4. 9Raster algebra results suitability classes and area coverage

No	Range of potential sites	Area in (ha)	Area in (%)
1	**Highly suitable**	31.65	3.6
2	**Suitable**	74.92	8.7
3	**Moderately suitable**	80.27	9.3
4	**Unsuitable**	677	78.4
Total		**863.92**	**100**



Source: Extracted from reclassified Raster algebra result map a

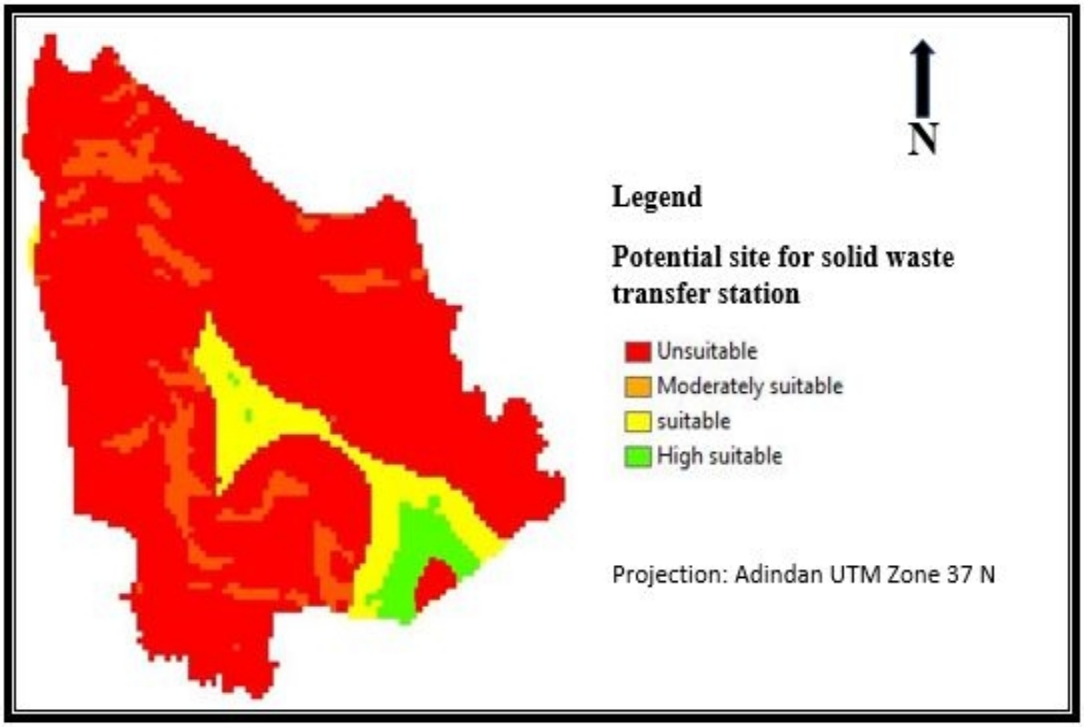


Fig 4. 36 Raster algebra calculator result map of the study area.

Based on the above Raster algebra result, from the total study area 78.4% were found as unsuitable for locating Solid Waste Transfer station. Because, those areas were failed to achieve the Land use, Road, Drainage, Slope and Location of Social Services proximity suitability norms and standards that formulated by different sources that described on small to medium sized solid waste transfer station site selection criteria that listed on Table4.3.

Standard Solid Waste Transfer stations location must not be placed within those areas which can opposition from communities that live near to the transfer station due to bad odor. In addition, this unpleasant odor can disturb people moving around too. Also, must far from water bodies because, it can easily contaminate the water. And, it must faraway from main road networks because garbage trucks can create traffic congestion when they in and out from the area. Social services like Schools, Health centers, Recreation areas and Food subsidies areas are found, in addition to this, the identified unsuitable sites were unable to meet land use norms and standards.

In the opposing of this, 3.6% of the study area was found as highly suitable and 8.7% of the study area was found Suitable for solid waste transfer station potential site. Those areas were fulfilled the physical Drainage, Road networks, Slope and Land use and social proximity from Health centers, Education and Recreational zones. Even though moderately suitable parts of the study area which is 9.3 % shown in the raster algebra calculator result incapable to meet the most suitable and suitable class standards of the criteria used in this analysis, they can be used as last substitute potential sites for Solid waste transfer station for the case.

The fact that, it should be underlined here does not mean that, Solid Waste Transfer stations can be located directly in the preferred locations. As Addis Ketema sub city is a very densely populated area, the distance between each of the residential areas is not determined. As a result, there may be housing in the so-called potential area. According to this, decision makers must separate Governmental houses (Kebele Homes) and Privately-owned Homes from these locations and can locate the standardize solid waste transfer stations at a distance of at least 30m far from privately-owned homes.

As Addis Ababa plan and development commission office, 67% of residential houses that found in Addis Ketema sub city are in very low standard and owned by Government (kebele homes). Based on this, decision makers can upgrade this kebele homes to different housing options and use the area for sustainable development like, solid waste transfer stations.

4.5.6.1. Thematic Map of the Selected Potential Sites

To make the thematic map of the highest Suitable and Suitable potential locations, shape file was creating and all Highly Suitable and Suitable locations were digitized in the Arc Map (GIS) Environment. This thematic map of the study area is visibly shown in the next figure.

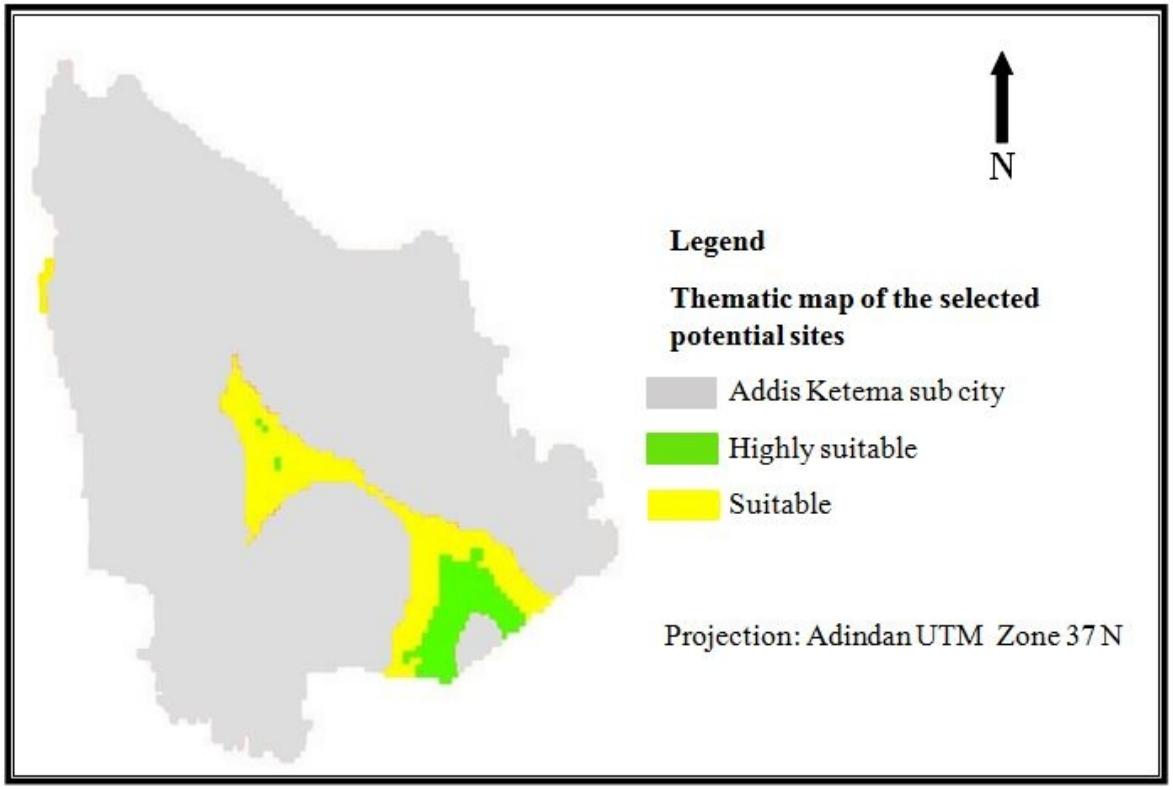


Fig 4. 37 Thematic map of the selected potential sites.

These potential locations are adjacent to kolfekeranio and Ledeta sub cities. From North Western side (from KolfeKeranio sub city) they have common 45m SP road and from South Eastern (from Ledeta sub city) they have common 40m SP road. And this SP road proximity which is, minimum buffer distance 30m and maximum buffer distance 700m and above were analyzed on Road network suitability analysis. This means that, these potential sites do not pose any problem in neighboring sub cities.

Chapter Five: Conclusion and Recommendations

5.1. Conclusion

Solid waste management especially on developing country like Ethiopia, Addis Ababa is in very low condition from the community level to the government. There is very limited awareness on, minimizing solid waste from the house hold level which is, solid waste Sorting, Composting and Reuse. Beside this, solid wastes are dumped in open areas around Roads, Streams, and near to Residential areas. Also, legally constructed solid waste secondary collection sites or platforms are the other creation of problems to the environment and for the surrounding community in the study area.

The researcher found it significant to designate issues requiring serious attention of concerned bodies that, Selection of suitable site for solid waste transfer station is the necessary and complex process that requires careful consideration of a number of environmental and social factors on the study area. According to this, the researcher analyzing the process of solid waste, from the source to the secondary collection sites and the existing condition of this secondary collection sites on Addis Ketema sub city. Based on different factors which is, Location of each legalize plat forms, Land use and Access Roads, Human Health and Environmental risk, the materials that these platforms are constructed, the size and their expansion ability. Beside this, the researcher analyzes the use of solid waste transfer stations on this targeted case area and which type of station suitable for the case and search international standards to locate sustainable solid waste transfer stations.

The Analysis finding shown, the awareness of the community on the process of solid waste and each secondary collection sites have their own negative effects on the environment and on the community. Standard procedures must be exercised to control pollution of surface and ground water in addition to air. But, none of these does are visible in each platform site of the study area. Therefore, new transfer station site is urgently needed with proper selection of the site and environmental impact assessment and construction.

The Research findings of this study also explore different solutions for the existing problem, which can minimize the impacts from different perspective. Like, there is different solid waste transfer station types that can be suitable for different parameters (cases), there is an international guidelines and standards that use for both small size and large size transfer stations. And also, identifying candidate sustainable sites that highly suitable for solid waste transfer stations that minimize the impacts of the solid waste on the environment and the community health in Addis Ketema sub city. Regarding to this, the research finding shown that 3.6% of the study areas were highly suitable and 78.4% were not suitable for solid waste transfer station potential sites. The selected most suitable and sustainable sites were accessible to road networks, far away from streams and protected areas. According to this, it can fulfill both the environment and the people need.

5.2. Recommendations

Based on the Research Findings the following Recommendations have been made:

- First and for most, concerning bodies (Governmental and Private) should give Awareness for the communities to control or to minimize solid waste from the source.
- This Research paper clearly shows that, the lack of strong guidelines on solid waste disposal and utilization is seen as a major weakness. According to this, there is a need for clear Guidelines for the site selection of solid waste storage facilities (Solid Waste Transfer Stations). Following this, the problem can be solved by using, the potential site locations that located based on the standards and principles included in this research. Only then can one step forward to solve the problem in this regard.
- Constructing solid waste transfer station should be stopped only because; vacant land is available without due process.
- This study, only give attention to solid waste transfer station potential site location. But, construction cost also an issue to consider.
- From the Ten Sub cities that found in Addis Ababa, this study only focuses on Addis Ketema Sub city. According to this, further studies must conduct for the other sub cities.
- Generally, the existing small-scale solid waste storage sites should remove and concerned bodies must work to ensure that, each sub city has its own risk-free solid waste transfer station according to its profile.

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Appendix

Ground control points of existing solid waste transfer stations (GCP_S)

Wereda	Location	Coordinate	
		X	Y
1	SumaleTera	471910	998025
2	Sebategna Total	470539	997589
	Around ShawelDema School	470292	997802
3	Around Betelehem School	469419	997242
	Around Koka bridge	469606	996830
4	Behind EhelBereneda	469290	998131
5	Behind RasHailu	469304	1000090
	Around KetelTera	469803	999514
6	GebesMeda condominium	470375	999432
7	-	-	-
8	Around SatenTera	470794	998227
	Around bus station (Autobus tera)	470593	998013
9	Around KuasMedaCondominium	469924	998907
	Around Wereda 9 Health Center	469479	998673
10	Around Tayewan Market Place	468741	998861
	Around General Weyngete Vocational college.	468676	1000196

Source: Survey 2020.

INTERVIEWS

MUNICIPALITY

1. Gender

   A. male B. female
2. Position -
3. Amount of solid waste generation rate per year?
4. Number of legal solid waste secondary collection sites?
5. What are the main obstacles to the services currently provided on solid waste collection sites?
6. In terms of creating a healthy environment, what is the government doing on those areas?
7. What does the government think about the future?
8. Why the Government didn't give attention to these areas so far? And if there is a problem that the Government can't develop those sites?
9. What does the government think about people live near to the site?

For city government of Addis Ababa plan and development commission

1. Gender

   A. male B. female
2. Position -
3. Are there designated sites for secondary solid waste collection?
4. If yes,

   Is there any guiding principles and standards for proposing solid waste secondary collection sites?
5. If there is a guiding principles, what criteria and considerations that you follow? According to
   - Technical criteria
   - Environmental criteria
6. The proposed sites are temporary or permanent?
7. Do you think the proposed sites are completely solved the existing secondary collection sites problems?

   If no, why?

For formal and informal solid waste collectors

1. 1. Gender

   A. male B. female
2. Name of the site?
3. How long have you been working on this sector?
4. Process of solid waste from the source to the final disposal site?
5. For how many days' waste kept on these sites? And What is the reason?
6. Do you have any other work to do in this area?

   If yes…
7. Is the site comfortable for the job or for the process?
8. What kind of challenges that you face on this site? According to
   - Shortage of equipment
   - Health
   - Transportation - According to traffic
     - Transportation coverage
     - Shortage of vehicles
9. How much time takes to transport the waste to the final disposal site?
10. Do you think this garbage cans or the site are enough to handle all the incoming wastes?
11. What do you think should be done in order for you to have better working condition?
12. Do u have income? Based on the waste?

For nearby communities

1. 1. Gender

   A. male B. female
2. How long have you lived in this environment?
   A. 1-10
   B. 10-20
   C. 20-30
   D. Above 30
3. How do you manage the waste generated by the household?

   A. disposes of it in containers B. dispose of in open space C. burn

D. disposes of it in the river

4. Do you separate solid waste into three streams which is (organic wastes, hazardous wastes and recyclable wastes)?

   A. Yes B. No

5. Do you compost solid waste?

   A. Yes B. No

   If no, why?

6. Have you face any problems with being close to this garbage dump?

   If yes, what kind of problems?

7. Do you ask governmental bodies to give you some solutions regarding to the location?
8. What kind of solutions that you want?
9. If there is any benefit that you get that been close to the site?

CHECK LIST

Objective: Assessing the existing situation of solid waste secondary collection sites.

- **What type of data**
  - ✓ Geographic
  - ✓ Map based
- **From where the data are collected**
  - ✓ Municipality office (Solid waste management office)
  - ✓ From informal solid waste collectors
  - ✓ From nearby communities
  - ✓ Site
  - ✓ internet
- How the data are collected?
  - ✓ GPS
  - ✓ Internet
  - ✓ interview
  - ✓ Observations

- ✓ From different books

Technical issues

- **Land use**
  - ✓ Adjacent land use compatibility
    - Social services
    - Water bodies
    - River buffer
    - Open spaces
- **Road**
  - ✓ Accessibility
  - ✓ Road width

Site condition

- Site area
- Buffer
- Expansion ability

Construction Material

- Wall
- Roof
- Gate
- Floor