Solid Waste Recycling Practices in Adama City:

The Case of National Appropriate Mitigation Action Waste Compost Project

Kidist Zergaw Berega

A Thesis Submitted to the Department of Architecture

School of Civil Engineering and Architecture

Presented in partial fulfillment of the requirement for the Degree of Masters in Environmental Architecture

Office of graduate studies

Adama Science and Technology University

Adama, Ethiopia

June, 2022

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I the advisors of the thesis entitled "**Solid Waste Recycling Practices in Adama City: The Case of National Appropriate Mitigation Action Waste Compost Project**" and developed by **Kidist Zergaw** hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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I hereby declare that this Master thesis entitled "**Solid Waste Recycling Practices in Adama City: The Case of National Appropriate Mitigation Action Waste Compost Project**" is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

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RECOMMENDATION

I the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "**Solid Waste Recycling Practices in Adama City: The Case of National Appropriate Mitigation Action Waste Compost Project**" prepared under my/our guidance by **Kidist Zergaw** submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Environmental Architecture. Therefore, I recommend the submission of a revised version of the thesis to the department following the applicable procedures.

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DEDICATION

I would like to dedicate this to my previous advisor **Dr. Fikirte Demise** may her soul rest in peace with the all-mighty God for her support and love in all of my studies. Without her encouragement and allowing me to follow my dreams, this all would not have been possible as she was my great mentor though out my journey not only in education but also in life giving me advice and support.

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LIST OF ABBREVIATIONS AND ACRONYMS

AACA	Addis Ababa's City Administration
BEA	Bio-economy Association
CDM	Clean Development Mechanism
ESCAP	Economic and social commission for Asia and the pacific
ESRI	Environmental Systems Research Institute
EPA	Environmental Protection Agency
FDRE	Federal Democratic Republic of Ethiopia
GBN	Global Business Network Programme
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GTP	Growth and Transformation Plan
IBE	Integrated Bio farm Enterprise
ISWM	Integrated Solid Waste Management
IWM	Integrated Waste Management
MSE	Micro and Small Enterprises
MSW	Municipal Solid Waste
MUDC	Ministry of Urban Development and Construction
MUDHC	Ministry of Urban Development, Housing, and Construction
NAMA	National Appropriate Mitigation Action
NFCCC	Nations Framework Convention on Climate Change

NGO	Non-Governmental Organization
SPSS	Statistical Package for the Social Sciences
SWDS	Solid Waste Disposal Site
SWM	Solid Waste Management
SWRDPO	Solid Waste Recycling and Disposal Project Office
UGI	Urban Green Infrastructure
UIIDP	Urban Institutional and Infrastructure Development Program
UN	United Nation
UNDP	United Nations development plan
UNEP	United Nations Environmental Plan
UN-ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UN-HABITAT	United Nations Human Settlement Programme

ABSTRACT

Today there is a need of integrating architecture, waste, and the city but it is a problem both in the developed and developing worlds as waste generated from cities increase with the increased consumption of goods and services leading to difficulties in management of their municipal solid waste. Adama is among one of those cities in Ethiopia facing these problems thus, the research study area focuses on the problems in the city's solid waste management systems regarding the basic deficiency of infrastructures and services such as recycling plants and facilities and the compost project in the city. Hence, the main objective of the research is to assess the current solid waste management of the National Appropriate Mitigation Action (NAMA) Compost Project to provide a solid waste recycling center for the project. The research involves the collection of both primary and secondary data presented both qualitatively and quantitatively. The research uses descriptive analysis (quantitative approach) to narrate (Qualitative approach) the data obtained from the direct involvement of the researcher in the study area and case site. The perception of the sample population was achieved through convenience sampling technique through questionnaires. The views of stakeholders and higher-ranking officials were focused upon as well, through in-depth interviews. The use of documents was employed to further broaden the studies through desk reviews. The study further presented the major findings based on Services Provisions, Infrastructure Provisions, Aesthetics, Building Design Quality in Terms of Architecture, Building Design Quality in Terms of Health, Economy, and Social Affairs concerning the National Appropriate Mitigation Action (NAMA) Compost Project and found that it is lacking in basic requirements of infrastructures and services required for the line of work, it is not integrated with architecture, economy and community of the city. The result of the research indicates that the future of Adama city waste generated is directly proportional to the population increase. which is an evident fact of the need for a proper solid waste management system and the enhancement of existing NAMA compost project. The research develops a planning and design solution for the enhancement of the current compost project's condition towards a solid waste recycling center to create an integrated solid waste management system for the city. Therefore, the research works in linking the public's awareness to the architecture of waste to points out that it is a necessity for the identification and execution of proper laws and regulations regarding the promotion of waste reusing and recycling.

Key Word: ***Solid Waste Management, Composting, Solid Waste Recycling***

CHAPTER ONE

1. INTRODUCTION

This research is done on the solid waste management system of the NAMA compost project in Adama city for the city's current solid waste management and its existing trend of recycling/composting to provide an appropriate design solution for the solid waste management of the city in a form of well organized, self-sufficient and sustainable solid waste recycling and management center for the NAMA compost project of the city.

Due to its social, economic, and environmental repercussions, solid waste management is a serious challenge worldwide, particularly in major cities of developing countries. Different human activities undoubtedly result in the production of waste, which tends to rise at the same time with fast urbanization, increased living standards, and shifting consumption patterns, making waste generation inextricably related to urbanization and economic development. Consumption of goods and services rises with rising standards of living and disposable incomes, increasing waste generation (Bekele et al, 2017). Therefore, when a city grows it is crucial to think about and re-examine the need for waste infrastructures (Muller, 2018). Making the provision of infrastructural support for the solid waste management of any city a necessity for the promotion of waste reducing, reusing, and recycling.

Adama as a city in Ethiopia is facing problems related to a proper solid waste management system due to the frequent change in the city's attributes which include its rapid population growth, expansion of trade, high rural-urban migration, and fast physical expansion all of which resulted in the increased generation of waste. The city is also lacking infrastructures that show the relation waste has with architecture and with the public at large. As a permanent resident of the city of Adama, an urban planner, and an environmental architect the researcher has direct experience and awareness of the city's solid waste management system and the city's lack of infrastructure dedicated to waste recycling. The researcher is motivated to carry out a study on programs towards recycling/composting hence, the NAMA compost project of the city for further evaluation and understanding.

Hence this is the chapter that is concerned with the background of the study, the statement of the problem, the general objective and specific objective of the study, its research questions, the scope of the study, the significance of the study, the limitation of the study, organization of the report and a general operational definition of the research.

1.1. Background of the Study

Humans are facing a critical problem of growing waste generation. The management of the waste generated is a major environmental problem for various countries all over the world by which the management of the municipal solid waste has the biggest share for cities in developing countries because the municipal is incapable through its institutions, administrative ability, and the cities lack in a well-developed infrastructure (Alemayehu, 2021).

Because of the rising rate of growth in developing countries and the day-to-day activities of their residents, they generate a significant amount of waste. According to UN urban population projections, the population of cities in developing nations would grow from 2 billion in 2000 to 4 billion in 2030 G.C., bringing the urban population percentage to roughly 87 percent and resulting in a fast urban shift, and in 2025, the amount of rubbish generated is expected to be 0.85, making Africa the region with the least waste, even though the amount of waste collected is only around 41% of the total amount generated. Sub-Saharan African countries are the least urbanized and populated in the world, with fewer than 40% of the population living in cities and an annual growth rate of 4% to 5%, but urbanization is accelerating in this region. The current projected average waste generation in Africa is at 0.65 kg/capita/day, with organic waste accounting for 57 percent of total waste (Bekele et al, 2017).

The area in cities where many activities of management of waste are done are areas that are not visible to the view of the community as they are engulfed by areas of the industry to be easily forgotten which creates this great mismatch and detachment between waste and architecture which has led to the disregard for the positive effects of design in space and its impacts on the connection of people and the waste they generate (Muller, 2017).

Even though infrastructures for the management of waste are often disregarded and invisible from the eyes of the public, they are very important for the general planning of any city which is due to the obvious loss of integration and link between waste management and architecture. Therefore, architects can “engage and bridge the invisible infrastructure of urban environments back to the interconnected realm of public activity" (Feng, 2020). The community need not view waste management as a separate entity from the systems of the city because cities are continuing to become ever more complicated and need a stable integration of the systems through a planned, designed, and sustainable manner (Muller, 2018).

The management of solid waste is a serious challenge for many different cities all over the developing world (UN-HABITAT, 2009). As the waste in many developing countries is still very much based on the uncontrolled dumping of the waste in different areas and the different burning activities in domestic areas that has led to a great mismatch of management and resulted in very serious environmental and health issues (Di Maria, 2018).

Growing urbanization has become a great challenge for most cities in the horn of Africa such as Ethiopian cities, mostly related to the city's solid waste management system. Therefore, the effectiveness of the solid waste collection and disposal systems of the cities is declining due to the rising generation of waste. Because of the limit in infrastructure, staff, and public knowledge about source separation of the waste to be collected, the municipalities of cities are struggling to collect all the MSW created. Because Adama is among one of the country's largest cities, a transit hub for nearby cities, the seat of various governmental and non-governmental offices, and, its thriving economy with a vast population a lot of waste generates (Bekele et al, 2017).

Due to its variety of sources and diverse and complicated composition adequate management of the solid waste is becoming a challenging issue for the Adam city's administration which has resulted in the city authority in Adama becoming unable to manage the increasing volume of SW created by homes and various organizations (Hailemariam et al, 2014).

Collective waste management and adoption of the 3R (Reduce, Reuse, and Recycle) policies and initiatives would be a viable alternative for an integrated approach to waste management (UNEP, 2009). Sustainable solid waste management can be possible and achieved through the integrated solid waste management system (ISWM) (UN-HABITAT, 2009).

Waste recycling is a system that involves the process of improving materials from the waste department and then returning the to the economy as such recycling and or composing make plausible sense when there is the existence of market for the processed product (UN-HABITAT, 2009). Waste recycling provides an encouraging solution to the rising constraints on the natural resource (Magram, 2011).

The developed world has shown an ever increase in the number of the waste recycled because of the growing awareness of the society on concerns of the cost of disposal and its health and environmental implications, and that recycling can be a useful convention on resource conservation. The developing world is still having problems on the recycling trend as it has not given attention and recognized recycling as an alternative to waste disposal and that they are still in the process of making regulation for waste recycling (Beukering, 1998). In many developing countries such as Africa, there is a very limited marketing availability of recycled materials. Based on the international companies of recycling the shortage of marketing is due to the lack of sufficient materials to establish local recycling plants, transportation costs are high, and deficiency of awareness towards the potential of recycled materials (Liebenberg, 2007).

The significance of waste recycling in the developing country such as Ethiopia consists of two conditions which include the lack of raw material and existence of informal recycling systems. The country has challenges as well in the implementation of rules and regulations because there is no law that directly regulates recycling (GBN, 2020). Well designed and well stepped-up formal systems of recycling can have opportunities of saving yet in the developing world these formal recycling systems are not properly designed and not fully optimized (UN-HABITAT, 2009).

Therefore, the integrated waste management works in completing the sequence of restoring the waste materials towards the process of production. In order to deliver requirements of integrated solid waste management there needs to be: involvement of all stakeholders, cost effectiveness and affordability for achievement of sustainability, and good governance through proper organized arrangement of policies. Recycling makes sense both for the sake of economy and environmental sustainability. Sustainability in terms of waste sector involves the initial extraction of waste natural resource, towards processing of the materials and then the general manufacturing of the materials into various products that are then distributed for further consumption (UN-HABITAT, 2009).

The UNDP Ethiopia office is currently involved in creating a project known as the National appropriate mitigation action (NAMA) compost project which works in the solid waste composting system to promote greater use of Integrated Solid Waste Management (ISWM) and Urban Green Infrastructure (UGI) approaches in the cities and towns of Ethiopian, which will help the Ethiopian government achieve its Growth and Transformation Plan objectives (GTP II). The project's major goal is to transform solid waste from residential and business waste into natural composts that can be used as land fertilizers (UNDP, 2016).

Therefore, this research is going to find a system to look at the relationship between waste management, architecture, and the population by focusing on the planning and designing of recycling centers and facilities that work on waste reducing, reusing and recovering. This dramatically enhance and refine the views of the public on issues of waste because if cities can view waste as an income rather than unwanted rubbish and if cities can work in harnessing waste as an energy source, waste can be a resource on its becoming source for instance for energy as biogas for the cities by recovering, reusing and recycling it.

1.2. Statement of the Problem

The proper waste management system is a rising problem in cities of developing countries as these countries are exhibiting significant growth through their population increase. The population size of Adama city is increasing from time to time creating difficulties for the municipality in controlling the solid waste generated by the community. As Adama cities household and population increase the amount of waste generated increases. It is also obvious that the city does not have a standard center working on the recycling and reusing of the waste generated.

There are many researches done on the solid waste management practice of Adama city. Among these researchers Mengistu Hailemariam and Assegid Ajeme (2014), Asefa Abahumna Woldesadik (2017), and Eshetu Bekele, Teshome Geremew, and Lema Assfaw (2017) revealed the inability of the solid waste management of Adama city to cope with the fast-urbanizing needs of the city; and conveyed information on the lack of space with sufficient equipment regarding the management system of the municipal solid waste of the city as the city is short on harmful waste separation plant, storage depot, well-defined recycling or composting plants respectively. According to the studies conducted by Bekele et al, (2017), there is insufficient collection equipment, a lack of infrastructure and facilities, no support from institutions, and low promotion and incentive for recycling/ composting in the city of Adama.

Hence, different researches have proven that there is a Signiant lack of infrastructures in the institution of waste management. Among the infrastructures lacking are standardized, regulated, recognized centers of recycling that work in reducing waste, and that fulfill the basic requirements of a recycling center. The city doesn't have any existing center that works in recycling the waste materials generated by the population which if addressed would be of great benefit in the management system of the city's waste except for the recently opened NAMA composting project. The NAMA compost project is working in the system of organic waste recycling process. The NAMA composting project was first coined in the year 2008 EC. It acquired recognition and officially started work on the year 2012 EC. The NAMA composting project is deficient on basic requirement needed for any production purpose companies such as standard services and infrastructures. There is no architectural involvement in the provision of the site for the project Adama city municipality office. The project even though is in movement it has not shown recordable advancement on its ability to collect and process organic waste by the same amount of organic waste is still collected and processed through its existence of more than 2 years.

The NAMA composting project doesn't not have sufficient marketing opportunities even though it is a recognized project of recycling and composting in the city of Adama. There is also an absence of public involvement and awareness of the project which has hindered the growth and advancement of the company.

Waste management infrastructures and services are not well appreciated by the population of the city but these elements are very important for the general planning of the city to enhance the sustainability and health of the city and its citizens. As there is an increase in the population of a city there is a rise in the consumption of goods and services thus there is a need for the consideration of architecture and waste management to integrate them with the general city planning and the population as a whole.

In the Socio-Economic profile of the city of Adama (2019), to create a supporting framework in the current system of waste management, it is very important to identify appropriate policy measures, economic policies implementation, and monitoring of the identification of proper methods of residual solid waste treatment and disposal and the promotion of waste recycling ("Socio-Economic Profile of Adama", 2019).

Therefore, it can be observed that there is no information and data documented in the city and the country regarding Solid waste recycling centers. There are no centers created solely for the purpose of recycling solid wastes, hence the significance of solid waste recycling centers should be given great notice by the municipality and the community itself to improve the municipal solid waste management of the city.

In general, the study is intended to fill the above-observed limitations concerning the mentioned features to provide better insight and carry out a solution by the development of a better self-sufficient and sustainable solid waste recycling center for the NAMA compost project of Adama city to enhance the project self and further aid to the waste management system of the city.

1.3. Objective of the Study

1.3.1. General Objective

The general objective of the research is to assess the National appropriate mitigation action compost project (NAMA) of Adama city to propose a solid waste recycling center plan and design solution for better enhancement of the project.

1.3.2. Specific Objectives

- To assess the existing solid waste management (organic waste management) practice of the case site with respect to Adama city.
- To assess the respondent's preferences and perceptions regarding to the National appropriate mitigation action (NAMA) composting project in terms of architecture and waste.
- To develop planning and design solutions for the National appropriate mitigation action (NAMA) composting project in the form of a solid waste recycling and management center.

1.4. Research Question

- What is the present status of solid waste management in the case site in relation the Adama city?
- What is the perception of the respondents towards the integration of architecture and waste in the case site?
- How to properly plan and design a solid waste recycling center with self-sufficient and environmentally friendly programs for the NAMA composting project?

1.5. Significance of the Study

The research will work on linking and integrating architecture and waste through the creation of a better understanding and awareness of solid waste recycling centers' benefits and try to provide a design recommendation for a well-organized, self-sufficient and sustainable center for the betterment of the existing solid waste management system of Adama city.

It will further look into the following aspects in order: To try and understand and improve the solid waste management system of the city in its current trend regarding recycling and composting programs; It will work on the enhancement of the existing NAMA composting project of Adama city into a more organized solid waste recycling management center; To address the awareness issues facing the community in the solid waste management and improve their interaction with the municipality of the city, and it will also be a baseline for the further study of solid waste management and aid in the decision making of appropriate technology for solid waste management and reuse in order to profit environmentally, economically and socially Adama city.

1.6. Scope of the Study

The scope of this study focuses on assessing the existing solid waste management system of the National appropriate mitigation action (NAMA) composting project with respect to Adama city and its provisions of infrastructural service requirements in order to design sustainable and self-sufficient solid waste recycling and management system. The case site of the NAMA compost project was selected because the project is working in the organic waste recycling or composting process and it is currently in a movement to promote recycling throughout the city and because it has its own basic problems that are aimed to be fulfilled through the process of this research.

Spatially, the study is limited and confined to kebele 05 (Dagaga) of Adama city as the case site where the NAMA compost project is located.

Thematically, the study will assess the existing solid waste management system of the NAMA compost project in order to link it with solid waste recycling programs and further look into the availability of certain provisions in terms of infrastructural services requirements for production purposes. The NAMA compost project will be viewed with respect to Adama city's future solid waste generation through the growth of the city's population i.e., future 15 years from 2011 to 2025.

1.7. Limitation

As explained above the study is concerned with fulfilling the objectives but because of many problems such as the current pandemic in the country, it was difficult to contact direct informants regarding the solid waste management system of the city. Not only it was also difficult to conduct field surveys and direct observations required for the study due to the above reason.

1.8. Organization of the Report

The research has fourth parts. The first part is concerned with background, Problem, Objective, Research questions, Significance, Scope and organization of the research, and operational definitions of the research. The second part deals with the literature review of relevant documents related to the research. The third part of the research deals discusses the Research design, the Sources and type, Sampling Techniques, and Procedures of Collecting Data and analyzing it for the study generally referred to as the methodology of the research. The fourth part focuses on the result and Discussion of the Data gathered and presents the Summary of the conclusion and draws Recommendations. Finally, Appendixes and References are presented.

1.9. Operational Definition

The terms that are emphasized highly in the study are solid waste management, and solid waste recycling/composting

Solid waste: A variety of activities including agricultural, landscaping, and other home and commercial processes are the main areas in which solid waste is created with a variety of categories (Amasuomo et al, 2016).

Municipal Solid Waste: MSW is a term used to describe waste collected by local governments from both home and commercial sources (Amasuomo et al, 2016).

Waste Management: Waste management refers to the collection, transportation, processing, recycling, or disposal of waste items, as well as the management and monitoring of waste materials created by human activities (Tadesse, 2012).

Solid Waste Management: The collection, transportation, storage, recycling, or disposal of solid waste, or the re-use of a decommissioned disposal site (Cheever, 2011).

Municipal Solid Waste Management: This is a System design and implementation for managing MSW (UNEP, 2009).

Recycling: Any activity that contributes to the return of waste material to the economy after some sort of processing is referred to as recycling (UN-HABITAT, 2012).

Recycling infrastructure: Refers to a varied span of types of equipment and amenities that assist recycling (Institute for Local Government, 2015).

Composting: Is the biological degradation of solid organic materials into a soil-like substance by bacteria, fungi, and other organisms (UNEP, 2009).

Integrated Solid Waste Management System: ISWM stands for Integrated Solid Waste Management, which is a strategic initiative for the long-term management of solid waste based on a comprehensive integrated format developed through a long-term preventive and consultative approach to the complimentary use of a variety of practices to handle solid waste safely and effectively (UNEP, 2009).

CHAPTER TWO

2. LITERATURE REVIEW

Theoretical Literature Review

2.1. Introduction

For countries all over the world, collecting and managing solid and human waste is a major concern. This problem is frequently exacerbated in cities, where a dense population leads to significant trash generation. The main causes of solid waste issues are related to trash creation excess, as well as mass manufacture and consumption of products without regard for their ultimate disposal (Cheever, 2011). World cities currently produce roughly 1.3 billion tons of solid trash each year. By 2025, this number is predicted to reach 2.2 billion tons, and by 2050, it will be 3.40 billion tons. There is a persistent difficulty with municipal solid waste (MSW) management in all cities in developed and developing countries (Weldeyohanis et al, 2020).

The developing countries are on the top of mention when looking into the waste management systems because these are the countries that are growing at a rapid rate both in their number of habitants and economy. Due to the different issues such as the financial, regulatory, and community cooperation, the solid waste generated in these countries is not managed appropriately.

In the process of a city's increased growth through its expansion and population growth, the issue of waste and energy is becoming more and more pressing as waste is increasing and energy is becoming scarce, there is a great need for employment of innovative, new and more sustainable measures of managing them through the education of citizens and improving the habits of these citizens (Nobile, 2018).

Even though design i.e., Architecture and landscape architecture; and waste management are not commonly linked and associated together, it is clear that waste management shapes our habitat as waste management infrastructures are indistinguishably bonded with the city’s planning. But the city’s waste management is designed to be an infrastructure that is invisible to the public’s eye as it is hidden away in industrial zones of the city that are not given proper attention and that are simply neglected (Muller, 2017).

2.2. Solid Waste Management

The waste management practices of developed and developing countries, urban and rural locations, and residential and industrial producers are all different. The goal of waste management is to recover resources from the waste in which all types of waste which include solid, liquid, gaseous, or radioactive wastes can all be managed, with distinct procedures and fields of knowledge required for each and every one of them (Tadesse, 2012).

Tchobanoglous et al. (1993) describe solid waste management as the proper handling, storage, collection, transportation, treatment, and disposal of waste in a manner that protects the environment and the public and also added that, in the day-to-day operation of waste management challenges, solid waste management employs skills and expertise from numerous disciplines such as legal, financial, and administration, among others (Amasuomo et al, 2016). Municipal or other governmental authorities are usually in charge of Municipal Solid Waste Management (Zhu et al, 2008).

Due to the volume of waste created, disposal, and treatment methods, solid waste management (SWM) is affecting the environment, health, socioeconomics, aesthetics, and infrastructure of low-income countries. Municipal Solid Waste (MSW) management is a persistent challenge in all cities of industrialized and developing countries (Weldeyohanis et al, 2020).

2.3. Solid Waste Recycling

Recycling is the process of converting waste into useful resources is known as Recycling (Wong et al, 2016). Recycling, according to the Solid Waste Association of North America, is defined as the collecting, sorting, marketing, processing, and transformation or remanufacturing of Recyclable Materials into Recycled Materials and Recycled Products, as well as the purchase and use of Recycled Products. Recycling is the process of converting waste materials into raw materials for the creation of new items that may or may not be identical to the original (UNED, 2009).

Recycling of waste has two basic dimensions which recovery, the system of taking waste through the diversion system from landfills, or other disposal methods including incinerators, and utilization, the system of reusing and changing the diverted waste in to a useful and brand-new material or product, (Beukering, 1998).

Recycling, according to the EPA, is the act of gathering and processing items that would otherwise be discarded as trash and repurposing them into new products in order to benefit both the community and their environment. Material reprocessing through production and manufacturing that comprises of physical, chemical, mechanical, and thermal processes to yield initial or other products is referred to as recycling (Oke & Kruijsen, 2016).

Waste recycling has two basic categories that are considered as factors that lead to waste recycling this include environmental concerns and economic and social concerns. (UN-HABITAT, 2012). There are two kinds of solid waste recycling i.e., Product recycling and Material recycling. Product recycling produces the same purpose products. Materia recycling produces new raw materials. Environmental benefits of recycling include; reduces raw material demand, reduce pollution, reduce damage to habitat, and reduce transportation costs. Economic benefit of recycling include: reduce waste disposal costs, saves energy, creates jobs, and so on (Magram, 2011).

In general, the benefits of recycling include, the reduction of waste going into landfill sites; For the creation of jobs; and Reduction of pollution and conservation of natural resources, and the reduction of formal salvaging of waste-by-waste pickers from landfill sites.

2.4. Composting

Composting is a natural way of recycling organic waste and waste-treatment technology that helps to reduce the amount of garbage transported to landfills by recycling organic components from biological waste land into new soil that can be used for gardening, planting flowers, and landscaping (Mat Saad, et al, 2014).

Composting procedures are the sole way to decompose solid organic waste and produce compost as an end product. The natural decomposition of organic compounds is known as compost. Organic material is broken down by physical and biological processes in this process, resulting in a finished product that can improve soil and release nutrients in a form that plants can use (Rostek, 2016).

Composting is a controlled, aerobic, or oxygen-requiring process in which microorganisms decompose organic materials such as leaves, grass, brush, wood, manure, agricultural residues, food scraps, and so on in order to produce carbon dioxide gas (CO2), heat, water, and humus or compost or a stable, soil-like product (Chardoul et al, 2015).

Major systems of composting include:

Anaerobic composting is composting that decomposes organic matter without oxygen resulting in significant amounts of biogas being released which is the same process as that in landfills which generates energy output. **Aerobic composting** is pile composting in a labor-intensive manner requiring constant turning and forced airflow to ensure decomposition in presence of oxygen (Rostek et al, 2016). **Vermicomposting** uses earthworms in a system of worm casting which requires more space and is work-intensive. **The aerated static-pile system, enclosed system, and windrow system** are the three basic centralized composting technologies. **An aerated static-pile system** creates piles of organic waste that are occasionally covered with screened compost. Blowers and air diffusers are used to provide aeration (Aziz et al, 2018).

Enclosed composting systems are two in type: soil and agitated bed. Temperature, oxygen concentration, and scents are all controlled by the enclosed container. The **windrow system** of composting is just a pile of rubbish that has been allowed to decompose and is the most common method for making compost from organic waste. A windrow composting system is necessitated properly managing the large amount of organic waste generated as a result of the rapidly growing population. A windrow is just a pile of rubbish that has been allowed to decompose and is the most common method for making compost from organic waste (Aziz et al, 2018). It involves building big stacks of organic materials in a simple and versatile manner and turning them on a regular basis. Turning the windrows regularly helps oxygenate the pile, breaks up particles to increase surface area, improves porosity to avoid settling and compaction, and allows trapped heat, water vapor, and gases to escape (Hoornweg et al, 2000).

2.4.1. Composting In Developing Countries

Composting is a straightforward process in which the compost operator assists nature is taking its course. In a developing country, almost half of a city's municipal solid waste stream might be composted easily. Through efforts to accelerate the rate of decomposition, there is access to lowering of costs and reduction of possible annoyance, in order to create a clean and easily marketable end product. Organic matter makes up a large component of municipal solid waste in developing countries. Organic waste diversion from landfills extends the landfill's life by reducing the amount of waste that must be disposed of. Composting will also enhance fertilizers' effectiveness, improves the city’s overall waste collection system as well as being environmentally sound practices by reducing methane generation with being a cost-effective measure (Hoornweg et al, 2000).

2.5. Nationally Appropriate Mitigation Action (NAMA) Compost Project

2.5.1. Integrated Waste Management (IWM)

Integrated waste management (IWM) is the process of selecting and implementing relevant techniques, technologies, and management programs in order to achieve specified waste management objectives and goals.

IWM has four fundamental management choices (strategies) identified by the Environmental Protection Agency (EPA) (Aziz et al, 2018): Source reduction; recycling and composting, combustion (waste-to-energy facilities), and landfills.

Integrated waste management (IWM) is founded on the idea that all components of the waste management system which include both technical and non-technical approaches should be examined together because they are inextricably linked and integrated into such changes in one area will result in a change in the other areas that will usually affect practices or activities in that area (UNEP, 2005). The integrated waste management approach will involve the implementation of the 3Rs (reduce, reuse, and recycle) and the management of all sorts of waste (UNEP, 2009).

2.5.2. Integrated Solid Waste Management System (ISWM)

ISWM stands for Integrated Solid Waste Management and serves as a framework for developing and implementing new waste management systems, as well as analyzing and improving existing ones by which a strategic initiative for the long-term management of solid waste is used in a comprehensive integrated format which are as well developed through a consultative approach to the complimentary use of a variety of practices to handle solid waste safely and effectively (UNEP, 2009).

ISWM is a concept that has been established as a complete approach to SWM management that covers multidimensional aspects of SWM management in an integrated manner of both technical and non-technical components of SWM. ISWM's goal is to find a long-term solution that balances environmental effectiveness, social acceptance, and financial affordability (Annepu, 2018).

Waste prevention, waste creation, source separation for materials recovery (recycling), temporary on-site storage, collection, transport, transfer, materials recovery (recycling), treatment/processing, and disposal are all components of an integrated solid waste management system (“Department of Environmental Affairs and Tourism of South Africa”, Nd).

Reduce the quantity of solid waste generated, recycling as much waste as possible, environmentally safe waste transformation, and continued safe landfilling are all elements of an integrated solid waste management strategy, which can be further described using the 3R (reduce, reuse, and recycle) approaches (Abdul-Rahman, 2014):

Reduce - Reducing the amount you buy is the most significant of all the options to manage waste. The key is to only purchase goods that we need and in the right amount.

Reuse – Reusing starts with the presumption that the materials used that flow throughout our lives could be resources rather than refuse.

Recycle - When discarding your waste, find ways to recycle it instead of letting it go to the landfill. This has many benefits which include industry generation, job creation, and cost avoidance for recycling to become a cost-effective disposal option.

2.5.3. Nationally Appropriate Mitigation Actions (NAMAs)

Nationally Appropriate Mitigation Actions (NAMAs) are a set of programs, methods, and projects that are voluntarily undertaken by developing countries as a reduction measure for the rising greenhouse gas emission in their country and serve as a sustainable and long-term development goal in their country. The concept of NAMA was initially introduced in 2007 during the 13th Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) in a meeting held in Bali, Indonesia. Developing countries are using NAMA as a crucial instrument of support in their combat against their GHG emission reduction efforts (UN-ESCAP, 2016).

2.6. Architecture and Waste

Architecture is the art and science of planning, designing, and constructing spaces, structures, and environments with aesthetic features to achieve a certain goal that thrills onlookers. The plan, process, pattern, and product are all examples of the process architecture undertakes (Janetius, 2020). Most human activities produce waste, which is an unavoidable by-product (UN-ESCAP, Nd).

Architecture is an instrument for building, changing, and shaping the world around us (Feng, 2020). As cities grow in size and population, the issue of waste and energy becomes more essential in terms of defining new innovative and sustainable waste management and waste reduction solutions, notably through improved citizen education and habits. Nowadays architectural project is a tool for the convergence of disciplines, which involves its collaboration with other abilities in order to work towards evolving a city, restructuring activities, and involving inhabitants in the building of a society that strives for resource efficiency and the common good (Nobile, 2018).

It is difficult for the general public to comprehend and accept improvements in waste-to-energy technology due to the fact that the built environment that houses waste management processes is frequently hidden from view and lacks environmental and economic motives. Architects can add value to industrial environments and encourage healthier communities by participating in discussions regarding waste management and waste-to-energy potentials. "New design concepts can offer hybrid solutions to create clean energy, contribute to cities' social and cultural activities, and protect wider urban atmospheres and microclimates during this window of opportunity" (Muller, 2017).

Cities are self-sustaining ecosystems that contain complicated and interlinked systems of organisms. While cities are increasing in size land and natural resources face scarcity because of the rise in the demand for them (Muller, 2018). By employing architectural design in a sustainable manner, we can promote the use of waste and the importance of waste.

2.6.1. Recycling Centers

Recycling centers are a relatively new typology that has only lately acquired traction as a result of worldwide sustainability movements (Jia Jiunn, 2017). Although they are often used interchangeably in ordinary English, the terms "recycling center," "recycling facility," and "solid waste facility" all have separate legal definitions. The term "recycling infrastructure" refers to a wide range of facilities that aid in the recycling process. Facilities that collect, sift, and process recyclable materials, convert organics or green trash into compost or fuels, or manufacture with recycled materials are examples. "Recycling centers" handle recyclable materials that have already been separated for re-use and are not meant for disposal. Different types of recycling facilities are included in solid waste facilities (Institute for Local Government, 2015). Households must be involved in the development of waste management programs such as recycling and composting systems because they must adapt and adjust their current practices (Bekele, et al, 2017).

2.6.2. Sustainable Waste Management

Sustainable development could be attained if society in general, and industry in particular, produces “more with less” i.e., with less use of the resources in the world and less pollution and waste to provide more goods and services. An ecological and sustainable design works in integrating the human world with the natural world to counteract the harm that the human world has brought upon nature.

A technique for developing and implementing new waste management systems, as well as analyzing and improving existing ones is known as integrated waste management. Integrated waste management is a concept for designing and implementing new waste management systems and for analyzing and optimizing existing systems. Basic principles and current improvements for handling solid waste in an environmentally sustainable manner are described in sustainable solid waste management (Wong et al, 2016).

Sustainable waste management faces its own set of issues, towards recycling. The concept's rising tendency is one of these issues (recycling), The recycling materials' marketing restrictions, The widespread belief that recycling is an expensive system, and the requirement for more storage space. In order to address these issues, The following are five major incentive factors for sustainable waste management: (“McGraw-Hill Construction”, ND):

1. Waste is full of useful resources.
2. Waste diversion can be less expensive than landfilling: Diverting garbage to a professional environmental services provider can be more cost effective than landfilling, as it eliminates undesired costs such as transportation.
3. The increasing awareness of the impacts of waste on the environment with a growing public knowledge regarding waste and a concern for environmental responsibility about having to live with what we throw away. Creating and sustaining positive public relations can have enormous brand and marketing value.
4. Waste regulation is becoming more rigid: There is an increase in federal, state, and local response focused on particular waste stream reduction goals and measures.

5. Incentives towards taxes, permitting bonds, plan reviews, inspections, and others.

2.6.3. Infrastructures of service

The space allocation and layout can be based on the production or the process of production of the center. If a company produces a large quantity of a few products, then you function on a product layout. If a company produces a great number of products, each with relatively small runs but similar processes, then you design on a process layout. In developing a new-plant project, it is very unwise to consider immediate needs only. The wise management will consider its needs on a long-range plan. Generally, the common area and space allocation for centers of production are (Chiara, J.D., & Calleder, J, 1980):

Administration

These services include Reception room, Executive area, Departments or Divisions, Private Offices in Each Department, General Work Areas in Each Department, and Special-Purpose Rooms/Areas (Conference room, library, Projection room, Mail and shipping, Reproduction room, Secretarial pools, Telephone equipment rooms, Hospital areas, File room, Private toilets and showers, Stock and storage rooms, and Restrooms), General Information spaces (Clothing space, Time clocks, and Interrelationship of person and department) (Chiara, J.D., & Calleder, J, 1980).

Employee Facilities

Employee facilities can also be defined as staff and amenity areas that are supplied for those including overall managerial purpose, clerical, maintenance engineering, staff on the site, and somewhat for drivers (Pickard, 2003).

Employee facilities should be easily accessible, light and sound should be dealt with in accordance with their need, and areas of crowdedness and quietness should also be considered in their placing arrangement. The areas considered as employee facilities include Cafeteria and kitchen, Coffee lounges, Recreation areas (indoor and outdoor), Quiet lounges, Factory men's and women's lockers, and toilets, Office men's and women's lockers and toilets, Meeting rooms, and First Aid and Nurses Station (Chiara, J.D., & Calleder, J, 1980). Training rooms, rest areas, medical rooms, cleaners' stores, and workshops can also be mentioned as the staff and amenity areas (Pickard, 2003).

Manufacturing

For the production of effective center and plant layout, the following are lists of criteria for production-line evaluation (Chiara, J.D., & Calleder, J, 1980):

Ease of flow of materials, Degree of flexibility, Ease of expansion, Ease of personnel movement, Ease of supervision, and least initial investment

Research And Central facility

In the modern plant areas for research (product development) and control, laboratories are a must (Chiara, J.D., & Calleder, J, 1980).

Warehousing

The warehouses are part of the production processes and material flow (Neufert, Nd). A warehouse is necessary for any production area for which small-scale materials are made and stored. A warehouse must be designed in order to accommodate the expected expansion program and it should be compressible (Chiara, J.D., & Calleder, J, 1980).

The common warehouse is comparatively defined as being a facility that works in storage and is created to hold as many goods as it can through a system that provides protection from the climate which has a wide extent in order to allow flexibility for the purposes of the storage (Pickard, 2003).

Internal engineering

These areas include the provision of Adequate space for mechanical and electrical installation which is a prime and vital consideration in industrial design (Chiara, J.D., & Calleder, J, 1980).

External engineering

All the outside utilities and storage facilities are required for a plant to operate properly. Parking, truck docks, tank farms, sewerage disposal plants, electrical transformer pads, pumping stations, water storage facilities for sprinkler systems, and industrial waste disposal plants are a few of these requirements (Chiara, J.D., & Calleder, J, 1980).

Contextual Review

2.7. Solid Waste Management in Adama, Ethiopia

2.7.1. Overview of solid waste in Ethiopia, Adama city

Ethiopia confronts pressures on scarce resources and environmental implications due to inefficient energy and waste management as a developing country with population expansion and urbanization rates that are now outpacing economic growth (Kneeland et al, 2012). Rapid urbanization and population growth in Ethiopia have resulted in an increase in solid waste generation (Tadesse, 2012). Ethiopia is now dealing with waste management issues such as overcrowding on open land, water contamination, and general public nuisances such as bugs, diseases, and odors. Municipal solid waste, defined as any material thrown by a primary user in a city, accounts for over 70% of total trash produced in Ethiopia (Kneeland et al, 2012).

Adama is a city that has served as the capital of the East Shoa Zone, the Oromia Regional State, and the Special Zone for various periods. Adama is a strong economic center for conferences, tourism, and industry, and it houses a huge population that generates a lot of waste.

Residents increased from over 100,000 in 1990 to around 213,995 in 2014. This was due to changes in status. According to the country's third population and housing census, the city's population nearly doubled between 1994 and 2007. According to projected demographic figures from 2010 EC, the population of the shining city of Adama was 413,236 people, with 206,153 men and 207,083 women, indicating the city's strong urban growth. The present household population is 85,000, up from previous years ("Socio-Economic Profile of Adama", 2019).

2.7.2. Solid Waste Management Practice in Adama City

Waste management begins with the handling and storage of waste at the source. Waste collection, waste transfer, transportation, recycling, composting, and disposal are all part of Adama City's current solid waste management practices ("Solid Waste Generation Rate and Characterization Study for Adama City", 2019). There is an increasing number of economic activities that occur in the city of Adama that provide an ever-increasing generation of waste by its population as the city is considered a center of tourism, industries and mainly a sit for different meetings and conferences (Alemayehu, 2021).

Onsite handling of the solid waste generated describes the different activities undertaken until that waste is placed and stored in containers. Further handling is undertaken based on the way the collection service is undertaken so that the waste is placed in containers and transferred to the point of collection and then the container is taken back to the place they were before for a further cycle of this process (Alemayehu, 2021).

The main supply streams for the municipal solid waste in Adama city are; Households, with more than half of that being biodegradable organic stuff; business centers, health facilities, factories, street sweepings, hotels, and restaurants (Bekele, 2017).

The solid waste collection system works in three operations which are the primary operation, secondary operation, and the third operation which are generally the door-to-door collection from households and organizations executed by both MSEs and street sweepers, collected waste transportation by both the municipality and the MSEs, and disposal of the transported waste respectively (Hailemariam, 2014).

From the information acquired from the Adama municipality office the Solid Waste Generation Rate and Characterization Study for Adama City of the year, 2019 describes that there are about 65 Small and Micro enterprises (MSEs) that perform waste collection activities on daily bases from hotels and restaurants and once in two weeks from Households. About 42 (8m3) area-based Containers are used for different Institutions like abattoirs, prisons, and around peripheries of the city. Tractors and hand pull carts are used for primary waste collection services throughout the city. whereas Compactors and skip loaders use as secondary waste collectors for the transportation of waste to the landfill. In the city and there are three old skip loaders and Two Compactors for Secondary waste Collection, in addition to this there is 7 Tractor, one loader is working on the landfill permanently, but one excavator and For Dum trucks were giving service by shift with the Construction department in the Municipality (“Solid Waste Generation Rate and Characterization Study for Adama City”, 2019).

The city has 10 existing and 4 newly built transfer stations which the MSEs use as a proper collection area or a storage area by which they store and safely transfer the waste that they have collected. The trucks or skip loaders pick and transport the dumped waste to the final disposal site. The secondary collection is done by two parties i.e., the Municipality and secondary collectors (MSEs) by trucks and skip loaders (Bekele, 2017).

The municipality transports the waste from the depot area to the landfill site in two ways. One is by the use of dump trucks and the second is using skip loaders. The dump trucks are loaded manually at the depot and transported the waste to the dump at the landfill site. The skip loaders pick the waste stored in the skip container (7 m^3 and $8m^3$ volume) located at different depots. Skip loaders pick a container at every trip and transport it to the landfill site where the skips are empty. The skip containers were transported back empty and replaced at the depot site for the next collection. Some skip containers empty every day and others may empty every two or three days based on the volume of waste collected at respective depot sites. There are also Five MSEs (secondary collectors) with dump track capacity to transport waste to landfills (Bekele, 2017).

The final waste disposal site of Adama city that was selected as an alternative to the old site in the year 2004 masterplan is located southwest of the city 9.8 km away from the city center on the road leading from Adama to Addis Ababa commonly known as Jogo Goaded. This site has been in service since 2002 being officially administered by the city municipality covering the land with an area of about 14,000 square meters. But due to the complaints of the neighboring communities the site was changed to an extracted quarrying site which is against the structure plan of the city. This site is near the previous landfill site in the Gorge. It is also near the Aba Geda Conference Hall and in between the Toll Road which connects Adama with Addis Ababa which is also the main road that connects Addis Ababa with Djibouti passing through Adama city (Alemayehu, 2021). Based on the city's municipality office out of more than 200 tons of waste generated 70 % of the waste is collected while the rest 30 % is disposed of indiscriminately on the roadside, drainages, on streets around Communal Containers, and open spaces ("Solid Waste Generation Rate and Characterization Study for Adama City", 2019).

The city has a temporary Controlled open dumping site in Melka Adama Kebele at an average distance of 7 km from the center of the city. At this site about $500m^3$ of waste is disposed of per day, there are activities like spreading and compacting of waste daily by using loader and excavator, Soil was covered once per four months in order to prevent bad smell and litters blowing. The site has two site controllers and six guards that register the daily disposed waste and control unnecessary waste disposal. The dumpsite is located near the main road at the entrance of the city from Addis ("Solid Waste Generation Rate and Characterization Study for Adama City", 2019).

2.7.3. Ethiopia's Urban Waste Nationally Appropriate Mitigation Action (NAMA)

"The Ethiopian NAMA: providing municipalities with the opportunity to create and implement solid waste transformation" is called the Nationally Appropriate Mitigation Action (NAMA). The Nationally Appropriate Mitigation Action (NAMA) compost project is a GEF-funded initiative run by the Ministry of Urban Development and Construction (MUDC), with financial and technical assistance from UNDP Ethiopia (Mengistu et al, 2019).

In order to shift integrated solid waste management and promote alternative treatment technologies among the country's public and commercial partners, Ethiopia proposes that the Urban Waste NAMA be implemented (UNEP, 2015). There are 6 main target cities and towns (Adama, Bahir Dar, Bishoftu, Dire Dawa, Hawassa, and Mekelle) in which the compost project is aimed to be implemented (UNDP, 2019).

In 2010, the Ethiopian government submitted its NAMA Actions to the UNFCCC through the Ministry of Environment and Forest. The NAMAs include mitigation goals for seven different industries. The GTP selected these action plans, which are in line with the GTP's overarching goal of supporting economic growth and eliminating poverty. These broad objectives are in line with achieving co-benefits while lowering GHG emissions. The overall goal of this NAMA program is to make it easier for municipalities to execute various measures to reduce GHG emissions from the solid waste industry (UNEP, 2015).

The project aims to improve the regulatory and administrative frameworks for integrating Integrated Solid Waste Management (ISWM) and Urban Green Infrastructure (UGI) into urban systems. Through a market-based structure involving micro and small businesses, it ensures the financial sustainability of compost production and use (MSEs). Reducing emissions, boosting urban areas' resilience to drought and flooding, improving urban quality of life, and providing employment opportunities for low-income households in urban and peri-urban areas are all goals of the project (UNDP,2019).

The project was designed in order to achieve the following goals (UNDP,2020):

The enabling framework was created and enforced to support ISWM and UGI; the Private sector value chain for compost was created and professionalism promoted to support sustainable production and utilization of compost; Architecture for Nationally Appropriate Mitigation Action (NAMA) was developed and implemented; Integration of UGI and ISWM in urban systems, including design and implementation in 6 cities and towns (Adama, Bahir Dar, Bishoftu, Dire Dawa, Hawassa and Mekelle); The specific objectives of the proposed NAMA are (UNEP, 2015); and Reduction of waste going to landfills (source reduction): reuse/recycling of waste; and energy recovery.

2.8. Policy and Laws of Solid Waste Management in Adama City

2.8.1. Reuse/Recycling and Minimizing Solid Wastes at Source (Article 9) (Council of Adama City Administration, 2017)

1. Any person shall have an obligation to minimize the size of things used for covering/sealing items he produces, reuse byproducts, or convert them into other items that can be used and minimize the number of wastes.
2. Any person who produces, imports, or distributes plastic or similar products for covering/sealing/carrying goods shall make sure that such things are durable and can be used repeatedly for a long time or biodegradable/suitable to the environment.
3. Producers or importers of plastic products shall devise a mechanism by which those products are reused or recycled after their expiry date in accordance with the regulation/guideline to be issued by the competent authority.
4. Slaughtering houses shall have and strictly follow procedures that enable them to reuse products.
5. The city administration and its lower administrative units support and encourage entities that are engaged in the task of reusing/recycling solid wastes. A guideline shall be used to govern the details.
6. Any person who is engaged in the collection and disposal of solid wastes shall segregate wastes and put them at a specially designated place and handover, for consideration or otherwise, to another person who wishes to reuse/recycle them. A guideline shall be used to govern the details

Empirical Literature

2.9. Case Study

2.9.1. Local Case Study

2.9.1.1. Reppi/ Koshe Solid Waste Disposal Site, Addis Ababa, Ethiopia

Figure 1: Location Reppi

Source: (“Overview of Addis Ababa City Solid Waste Management System”, 2010)

Addis Ababa is home to Ethiopia's largest and oldest waste dumpsite or landfill site (Community Development Research, 2011). Koshe Reppi is home to the city's only open dumpsite, which was constructed in 1964 (“Invitation for a Consultancy Service, Terms of Reference”, 2015). Reppi Solid Waste Disposal Site (SWDS) is located in the Kolfe-Keranyo Sub City area, which is located 13 kilometers south-west of Addis Ababa City Center by which Addis Ababa’s City Administration (AACA), through its Solid Waste Recycling and Disposal Project Office (SWRDPO), is responsible for its current operation. The location of the site is on the north-eastern side of the new Addis Ababa Ring Road, which leads to the city's western areas. Latitude 8° 58' 29.6754" N (or 8.9749° N) and longitude 38° 42' 43.6314" E (or 38.7121° E) are the geographical coordinates of the Landfill with a total area of about 364,000 m2 or 36.4 hectares (CDM – Executive Board, 2012).

Every day, the site gets about 750 tons of waste (“Ethiopia Solid Waste & Landfill”, 2011). The amount of waste brought to this location each year, according to the Addis Ababa City Administration (AACA), is 3,467,500 m3 which the present capacity of the site has been exceeded (“Invitation for a Consultancy Service, Terms of Reference”, 2015).

Since 1968, Reppi SWDS has been used as an unmanaged open dump. The waste from Reppi contains a high amount of organic and biodegradable components. Because the landfill lacks basic provision for collecting, treating, destroying, or utilizing the method for the gas methane, large amounts of this gas is released into the atmosphere uncontrollably, as a result causing bad environmental conditions in the surrounding area (CDM – Executive Board, 2012).

Figure 2: Location of Case Site

Source: (CDM – Executive Board, 2012)

Solid waste from both industrial and domestic sources are the main types of waste disposed of at the landfill. The waste delivered to the land fill site is placed on flat land by which a layer of waste is spread and compacted on the surface of the ground which means there is no need of requirement for the excavation of trenches. Because the landfill site lacks a basic fence structure around its area it has become open for different animals like goats, cats, sheep, dogs, and so on which have become possible disease transmitters in the community (Community Development Research, 2011).

At about 40m deep Reppi open dumpsite stands as considerably the biggest waste storage in the city of Addis Ababa in which the site contains an enclosed region for the purpose of the plan to convert waste to energy. This enclosed region has an area of about 19 hectares which houses both physical and biological preservation works including terracing and plantation of a variety of vegetation respectively. The different plantation activities exist in a nursery area where they are taken care of. The plantation process involves the use of compost that is produced from the dump on the site (Gelan, 2021).

Figure 3: Waste to Energy Plant, Dump Site, and Closed Part of Reppi

Source: (Gelan, 2021) & Google earth

Figure 4: Reppi Waste to Energy facility boilers and Waste to Energy Plant of Reppi

Source: Google earth

The building of the Reppi waste-to-energy plant began in 2014, thanks to a partnership between Cambridge Industries in the United Kingdom and the Ethiopian government. Cambridge Industries Ltd. and its partner China National Electric Engineering Company are working together on the project, which is being developed, designed, and built under the supervision of Ethiopian Electric Power, the state power generator. Every year, the Reppi factory has the capacity to recycle 3.6 million kg of metals from burned garbage. Residue ash might potentially be utilized to make 27,000 bricks every day, according to estimates. The plant's initial design called for a 50MW generating capacity (Alemu, 2019).

In the employment sector, the Reppi dumpsite has provided about 1500 waste pickers with jobs. For almost most of these workers, the site has become their livelihood because their lives mainly depend on resources the site provides to them from the solid waste they pick. Composting and seedling making processes are some of the works these pickers are involved in at the site.

The dumpsite is reported to produce a thermal energy output of about 50MWh every hour but due to some mechanical and technical issues faced by the site, it is currently producing 15.7MWh of energy every hour (Gelan, 2021).

Figure 5: Nursery of Plantation

Source: (CDM – Executive Board, 2012)

The current system of waste disposal at the site includes open dumping which is achieved by transporting the waste by trucks and then flattening and bounding the waste by bulldozers and compactors. The site lacks day-to-day coverage of waste with soil, treatment, and containment of leachate, rain water drain off and control for odor or vector. This has caused various problems on the site which include different health risks and inconveniences to the nearby habitants. The problems are also associated because the site is surrounded by residential areas and different public organizations and the fact that the dumpsite is about to fill its allotted space (Annepu, 2018).

2.9.2. International Case Study

2.9.2.1. 27th Avenue Solid Waste Transfer and Recycling Center

The 27th Avenue Solid Garbage Transfer and Recycling Center is one of the country's largest and most creative waste management facilities that also incorporates both art and public participation. For the past 20 years, the recycling plant, which is located in the downtown area, has served the city of Phoenix. It is a dynamic waste transfer and recycling plant that has made significant progress in promoting industrial transparency and public participation. In industrial facilities, this center successfully mixes public participation with landscape planning, structure, and architectural design (Chen, 2017).

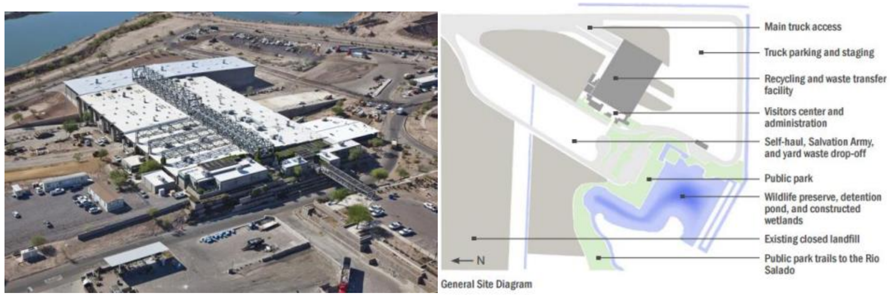

Figure 6: 27th Avenue Solid Waste Transfer and Recycling Center and General Site Plan
Source: (Chen, 2017)

The 27th Avenue Solid Waste Transfer and Recycling Center is a 25-acre facility in Phoenix, Arizona. It was built between 1989 and 1993 and was planned in 1989, and functions as a solid waste transfer and recycling center that is open to the general public (Chen, 2017).

Solid waste transfer, recyclable material sorting, composting, and solid waste division are the key functions of the facility in which its main objective is to temporarily store solid waste. Solid trash transfer and recycling share the first level of the station to prevent dust and noise pollution (Chen, 2017).

The region can be separated into solid waste transfer and recycling stations, a self-haul area, and an organic composting and solid waste division station. 4Residential trash, green organic materials, and recyclable materials like paper, glass, metals, and plastics are all accepted. The 27th Avenue Solid Waste Transfer and Recycling Center is one of Phoenix's two primary transfer stations which serves more than 350,000 households and processes 60% of the city's residential waste (Chen, 2017).

Design Strategies

The design strategies of this site applied a series of approaches to enhance public engagement and create experiential learning spaces at the operating waste sites. These design approaches included: increasing industrial transparency and visibility (through exclusive public access builds easier connections between the public and the waste sites, as well as bringing natural lighting, show casing the waste management process for visitors), emphasizing public access (through an elevated public pedestrian pathway to lower risk by separating waste and the public) and circulation division (through attractive and safe public access and separates traffic streams from visitors and employees to lower traffic conflicts), building elevated observation pathways and providing many types of outdoor learning spaces (through planned exterior amphitheater space for accommodation gathering, communication, and educational events) (Chen, 2017).

Figure 7: Elevated Public Pedestrian Pathway and Industrial Transparency: Large Windows, Sky Lights, and Glass Blocks

Source: (Chen, 2017)

Figure 8: Public Access and Circulation Division and Amphitheater and Garden

Source: (Chen, 2017)

2.10. Summery and Literature Gap

According to the research provided by Eshetu Bekele, Teshome Geremew, and Lema Assfaw in the year 2017, Adama is facing a problem of increased waste generation due to the city's strategic location being a transit point for neighboring cities, and being the seat for different governmental and non-governmental organizations resulting in an increased number of habitants in the city. Due to the increase in waste generated the municipality of the city is facing problems regarding the proper management of the solid wastes including their inability to provide a suitable and proper center for the further reuse and recycling of the recyclable wastes generated.

Throughout the review of available literature, it was observed that centers of recycling are not available in Ethiopia, with the only existing processing center being the landfill site incineration center of Reppi. There is however a composting movement undertaken in the country which is the NAMA project that works in 6 cities of the country one of them being the city of Adama.

The project is in its infancy stage by which composting is done through the processing of organic waste generated from the cities. The project in the city of Adama was observed to lack basic infrastructures, services, and requirements.

The researcher has drawn conclusions from both local and international case studies that there is a dire need for the implementation of waste management through recycling and composting. The solid waste management of our country will be best managed if recycling and composting becomes incorporated into the other management systems employed by the country.

The research through investigation was done on the conditions of the NAMA compost project in terms of its management system and conditions of services and infrastructure requirements for the purpose of proving a planning and design solutions of a designated solid waste recycling center in order to create an enhanced view and awareness towards waste reducing, reusing and recycling practices of an integrated solid waste management system.

Throughout the research making process of reviewing the different literature reviews, the researcher has faced a great gap which was the lack of documents and data that are solely provided for the recycling center's planning and design. Even though there are data that describe recycling as a whole the standard requirements for architecturally planning and designing a recycling center, in the research concerning solid waste recycling center, is lacking. This deficiency of information regarding architecture's role, landscaping role, and urban planning's role in the general waste management in different cities has been somewhat of a hindrance to the researchers' journey through this research. The researcher, therefore, has also learned that the integration of architecture, urban planning, and waste is an important input for better waste management systems. It is also important to integrate these fields with the community in order to create a community-based and community-oriented system of waste management as all the waste is generated by the community itself.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the Study Area, Adama

Adama city was established in 1916 in the introduction of the Addis Ababa-Djibouti railway line. In 1946, it became the seat of the then Yarer and Kereyu Awraja and later in 1988, it became the seat for the East Shoa Administrative Region. At present, it is serving as the second seat of Oromia National Regional State/Chaffe Oromia, and as a center for industry, trade, culture, and conference center (Oromia Environment, Forest and Climate Change Authority, 2011EC).

The city is spatially positioned at a crossroad in the southeast of Addis Ababa at a distance of 99 km and 84.7 kilometers via old and express roads respectively along the all-weather road that leads from Addis Ababa to the seaport of Djibouti. Adama is situated at 8^{o} 25'-8^{o} 37'N Longitude and 39^{o}12'-39^{o}22' E Latitude ("Socio-Economic Profile of Adama", 2018). According to a data source obtained by the city Socio-economic profile, 1996 EC/2004, the total size area of the city was 13,666.5 hectares. From the recent Master Plan, the total size of land area under the jurisdiction of the city administration is about 31,100 hectares (Disaster Risk Management Team, UIIDP, 2011).

Adama city was built on flat and undulating fertile ground that ranges from a completely low-lying center to hilly peaks overlooking the city, each with its unique landscape sceneries. The altitude steadily drops/declines from all of the city's outskirts to the city's core, where the slopes become mild in the heart of the city, which contains significant swaths of the city. According to the city's current master plan, the city is located between 1500 and 1900 meters above mean sea level with an average elevation/altitude of 1700 meters above sea level. The climate is tropical, with plenty of rain in the summer and relatively little in the winter. The average annual temperature of Adama is 20.50°C, with an annual rainfall of 808 mm. There are six sub-cities and 18 administrative kebeles in the city (the lowest admiration level) ("Socio-Economic Profile of Adama", 2019).

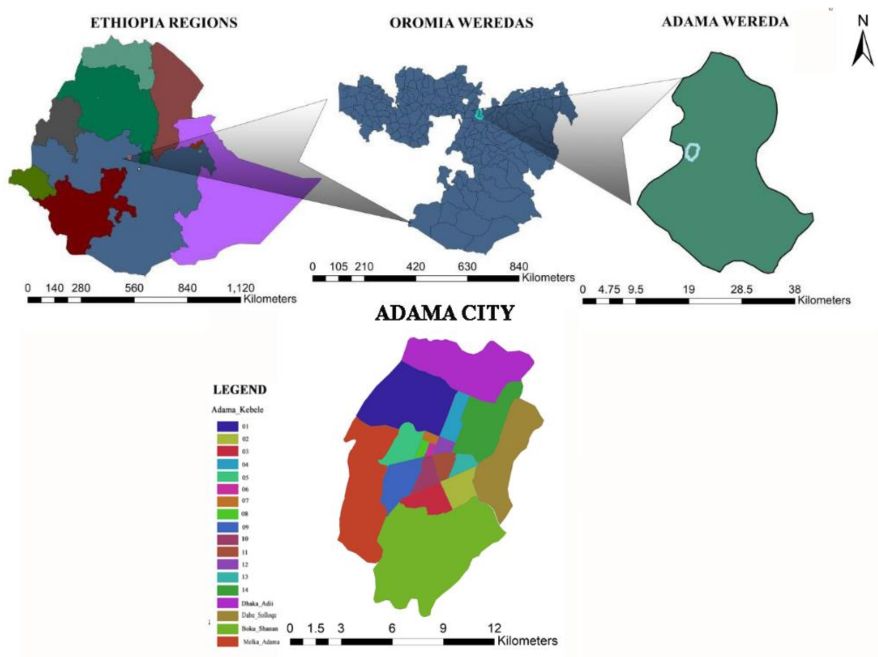

Figure 9: Location of Adama City

Source: Own Computation

3.2. Case Site Description

The study is conducted on the NAMA compost project of the city of Adama. The project is one of the NAMA projects among the 6 projects located in 6 different cities overseen by the UNDP and UNEP in collaboration with the country of Ethiopia. The NAMA compost project of Adama city is located at 8º32'25''N 39º14'42''E at an elevation of 1651 meters in kebele 05(Dagaga) near Unity University on 8000 square meter area. The station constructed 2000 square meter area shades for composting the waste and for economic purposes.

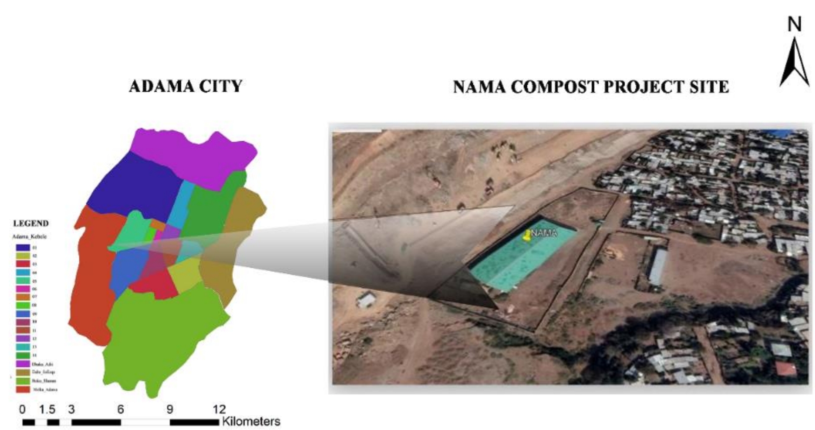

Figure 10: Location of Case Site

Source: Own Computation

3.2.1. Case Site Selection Criteria

It has become a great difficulty to manage the waste generated by the population of the city of Adama. The city has been experiencing an ever-increasing population number because the city is a conference center, a city of transportation which is recognized by its Ethio-Djibouti railway line, a city that holds the transportation route that connected the capital city of Addis Ababa with Dire Dawa and further leading to Djibouti. Different people come from different cities of the country to hold their meetings which has made the city a center of commerce and marketing as different international hotels are built for the purpose of accommodating these people. All these factors have been leading towards a generation of a significant amount of waste that is observed to not be properly managed by the city and its citizens.

The city, therefore, needs to better understand its waste content and work on methods of properly managing its waste. Currently, the city is working on simple recycling measures that include simple groups acknowledged by the municipality of the city but the main project the city is working on is the NAMA compost project which is working on recycling the organic waste generated by the city. Because the organic waste of the city holds the lion's share of the waste generated in the city this project is more than fit to be studied further in order to enhance the management system of the waste of the city.

3.2.2. Legalization Of the Case Site

The case site is legally recognized and provided for composting by the municipality of the city. The site was provided for the members of the project in order to overlook the production of compost from the collected waste.

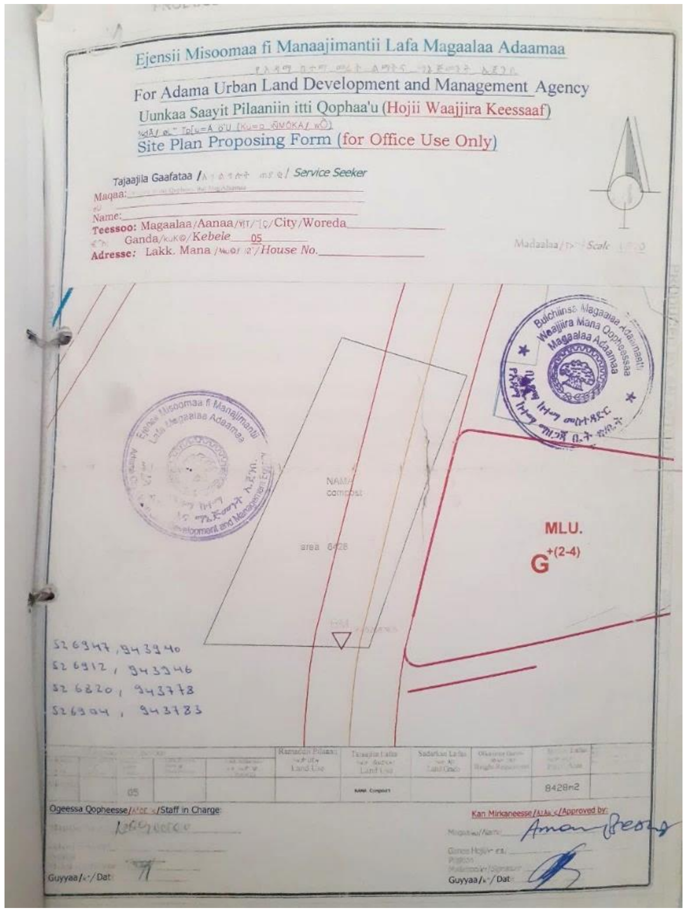

Figure 11: Site plan of case site

Source: Adama Municipality office

3.3. Research Approach and Design

Both qualitative and quantitative data were collected through narrative analysis and descriptive approach respectively regarding the organic waste management system of the NAMA compost project of Adama city with respect to the solid waste management system of the city. Qualitative research is a form of research used in order to acquire knowledge of the human "behavior, experience, attitudes, intentions, and motivations" based on different examinations and explanations of how they think and feel. This type of research gives more emphasis on the participant's outlooks (Ahmad et al, 2019).

In the qualitative data (as it is made up of words, observations, images, and even symbols) we used Narrative analysis method because we are analyzing data from sources such as questionnaires of respondents, and field studies by using the stories and experiences shared by people to answer the research questions and in-depth interviews that were conducted on the different officials of the city including the Adama municipality offices of the city including the members of the project and their leaders all which was an input for understanding the general perception of the respondents concerning the study.

Quantitative research also known as empirical research is another form of research that is reliant on providing numerical information and data which are hard facts in order to create a cause-and-effect connection on both variables by employing “mathematical computational and statistical methods” which can be measured with accuracy and precision (Ahmad et al, 2019). In quantitative data (as it is a clear distinction between the data preparation and data analysis stage,) the researcher used the descriptive statistics of data analysis because the exact number of the sample is known and no inference needs to be made.

For the Quantitative data, the researcher was involved in studying the general waste generation of the kebeles the NAMA compost project was involved in the collected waste form. By doing so the researcher quantitively distinguished the amount of organic waste reduced by the project and the amount of waste to be reduced from the whole city by quantitively collecting the required data of the kebeles of the project and the whole of the city respectively.

3.4. Source of Data

The research has employed data collected from both primary and secondary sources in order to fulfill the objective of the research. The data collected from the primary sources were from the direct contact with the involved parties achieved through the self-administered questionnaires and field studies and in-depth interviews. Through the data acquired from the primary sources, the researcher was able to understand and look into the practical conditions of the NAMA compost project concerning its general management systems by taking the city’s management as a reference point.

The data are collected from the secondary sources were from a thorough desk review of available journals, articles, books, and published research in order to get an insight into our countries and her cities and other countries and their cities' experiences regarding the current study which is concerned with solid waste management systems and their trends of recycling and composting. These secondary data were also from different city administration agencies such as the Adama municipality office, the Adama land administration agency, and other published articles and journals.

3.5. Data Collection Methods

This study was conducted through data obtained from both primary and secondary sources as mentioned above. The primary data collection method was involved in collecting data through self-administered questionnaires with the aid of trained data collectors, in-depth interviews, and field studies done through site observation. The site observation was done through the self-administered involvement of the researcher in the daily activities of the members of the association. The site observation involved the activities from the collection of the waste from household to sorting to transportation and then composting. The secondary data collection was involved in collecting data from desk review (available document and literature analysis) which was done through a thorough analysis of the required articles, journals, and documents acquired both from online sources and from the governmental organizations of the city.

3.5.1. Self-Administered Questionnaires

The questionnaire was prepared and organized in a relevant and understandable manner in the language of the local communities and the respondents, primarily being prepared in English and then translated to Amharic and Affan Oromo. The questionnaires included both open-ended and close-ended questions which were supplied to the different respondents, which included the leaders and the employees of the associations working on the project and they were charged with filling the questions with the direct help of the researcher. The questionnaire was mainly concerned with understanding and acquiring the general perception of the respondents in order to fulfill the objectives provided. The questionnaire was then analyzed and presented by the use verbatisms method concerning the open-ended questionnaires. When questions cover more than a single topic and each topic is mentioned by respondents the form of verbatism methods by which it is presented from Appendix III, IV, V, and VI with a full set of verbatism responses.

3.5.2. Field Study

The field study was conducted in the form of site observation of the NAMA compost project. During the site observation, the general work situation of the members of the associations working together in the station was thoroughly observed and recorded. The site observation was able to view and understand the type of waste and its management system in the project and the existing infrastructural conditions in terms of services provided at the site. The researcher was able to observe the general organic waste management at the project site from the collection of the waste to the final output of the waste.

3.5.3. In-Depth Interviews

The in-depth interview was held face to face with the higher-ranking officials and stakeholders of Adama municipality administrative bodies and other organizations involved being directly interviewed. An in-depth interview was also done with the leaders of each association to acquire better insight on the concerning matter. Both the in-depth interview and the field survey were shown in an integrated manner in order to better elaborate on the general conditions of the site. The in-depth interview mainly focused on getting insight into the general conditions of the NAMA compost project by taking into consideration the general waste management system of the city and its trend toward recycling and recovering waste.

3.5.4. Desk Review

A desk review was carried out on the existing information regarding the NAMA compost project. The review was done on any available data on the NAMA compost project to identify its overall system of waste management and infrastructural conditions. Similar studies were also conducted on relevant secondary sources on current trends of solid waste recycling programs in the city and other sources with the best experience of a solid waste recycling center. From the data acquired from the different documents, the current management of the city was also addressed in order to acquire data on the general waste generation, waste disposal, and recycling of the city. Data including the sources of waste, types of waste and the population of Adama city were also addressed for the further analysis of the research.

3.6. Sampling Methods

For the study, non-probability sampling techniques have been employed Convenience sampling and purposive sampling. Convenience sampling is a non-probability sampling technique where samples are selected from the population only because they are conveniently available to the researcher. And because in the case of this research, the researcher was only concerned with the employees and the leaders of the associations working in the NAMA compost project which are readily available for the research. Purposive sampling techniques were used for the selection of higher-ranking officials, and stakeholders of Adama municipality administrative bodies and involved organizations of Adama city in the project

3.6.1. Sampling Techniques and Sampling Sizes

In the research the researcher was involved in selecting samples for conducting and collecting data from the members of the NAMA compost project, For the qualitative approach, the researcher chose participants for questionnaires (Appendix I) as the sample population conveniently available was 52 in number. The sample size of the project area is relatively small and readily available to conduct the research. Therefore, for the questionaries survey the researcher used a sample size equal to its population size with a total number of 52 respondents, the variance is equal to zero. In this case, there is no uncertainty about a population proportion. Sample size for the total questionnaire can be achieved through:

In a census, when data are collected on the entire population, hence their sample size is equal to the population size.

Population Sample Size for Questionnaire

$$n = N * \{(z^2*p*(1-p))/e^2)/[N-1+(z^2*p*(1-p)/e^2)]\}$$

Whereas, N – Population size = 52

z – critical value (99.9% confidence level) = 3.3

e – Margin of error = 0.001

p – (a) sample proportion (uncertain) = 0.5

p – (b) sample proportion = 0.05

Hence, n – sample size = 52

In addition to the questionnaire provided for all the members of the project, high-ranking officials, and stakeholders of the city Administration Municipality office were provided the in-depth interview (Appendix II) selectively because each selected participant had direct involvement with the project and the city's conditions of waste. These high-ranking officials and stakeholders are chosen based on their place and individual set of skills in the community which enables them to forward more detailed information on issues that are happening around them.

Sample Size for the In-depth Interview

The selection criteria were based on (Creswell, 1998) recommendation that allowed 5-25 individuals selected for qualitative research. Therefore, from the Adama municipality office 3 people and 3 leaders of the NAMA compost project associations, and 1 person involved in the NAMA project. The in-depth interview was conducted to get information on the current trends of recycling in the city concerning the general management of waste in the city and the NAMA compost project. The organizations of the land administration and central statistics agency of the city were also used as a primary source of information as they were used to find and gather documents and data regarding different information required for the research.

The Field survey involved the direct engagement of the researcher in the site visits and site observations of the general waste management of NAMA compost project in addition to the handing out of questionnaires, in-depth interviews, and secondary data from different institutions. Hence, the in-depth interview and the field survey have been provided in combination for a better information.

Concerning the quantitative approach, the data sample size was used for taking into consideration of the 2 kebeles (Kebele 13 and Kebele 14) which were sites from which the NAMA compost Project waste collection occurs. In order to compute the current NAMA compost Project capacity, the data was taken from the 2 kebeles. After the selection of the kebeles, the researcher was involved in taking data on the total population of the 2 kebeles and the total waste generation of the city in order to calculate the waste generation of the 2 kebeles and their amount of the organic waste to find out how much organic waste is currently recovered by the project. The researcher has also computed the population estimation and waste generation estimation for the future 15 years of the city in order to provide conclusive evidence for the increase in waste generation through population growth.

Population Estimation for the future 15 Years (2011-2025) EC of Adama City

The following formula is generated in order to compute an estimation of the population number and the waste generation of the city for the future 15 years. The formula was generation form exponential growth population model (Hathout, 2013)

$$p_{(t)} = p_o ekt \qquad \text{(Equation 1)}$$

whereas, p(t) – population in target year

Po – population in base year

k – growth rate

t – number of years

The growth rate used for Adama city is about 4.8% per annum and the population projection initial data was the population of the year 2010EC

Waste Generation for the future 15 Years (2011-2025) EC of the Adama City

$$Sw_g = ((Pn * Sw_{gr}) * 365)/1000 \qquad \text{(Equation 2)}$$

Whereas, Sw_g – solid waste generation amount of Adama city based on the number of populations

Pn – each year population number

Sw_{gr} – solid waste generation rate of population/capita/day

The generation rate of waste used is 0.4 kg/capita/day

Waste Generation from Two Kebeles (Kebele 13 and Kebele 14)

The current population of kebele 13 and kebele 14 for the past years from 2010 to 2013 is presented as follows:

Table 1: Population of the two Kebeles

Year	Population	
	Kebele 13	Kebele 14
2010	18,448	35,152
2011	19,352	36,874
2012	20,300	38,681
2013	21,295	40,576

Source: Kebele 13 and 14 offices

The following formula is generated in order to compute the current NAMA compost project capacity in waste reduction of the organic waste generated by the kebeles by taking the years 2012, and 2013 as the project did not start work until then. Hence the waste generation of the kebeles can be computed by the following formulas:

$$Ksw = (kp * Aw)/Ap \qquad \text{(Equation 3)}$$

Whereas, Kw – kebele solid waste generation

kp – kebele population number

Aw – Adama waste generation

Ap – Adama population

3.7. Data Processing and Analyzing

For the purpose of the field study, in order to acquire the primary data required for the purpose of the research, the researcher employed the use of materials and instruments such as Audio and Video recording Camera phones, measuring tapes, and notebooks.

The data from both the primary sources and secondary sources such as the self-administered questionnaires, in-depth interviews, and desk reviews were analyzed by the use of SPSS, MS Excel 2016, and ArcGIS 10.3, Revit architecture software version 2020, Lumion, Adobe Illustrator cc 2019 and Adobe Photoshop 2019, and finally MS word 2016.

Table 2: Materials and Instruments

Materials and Instruments	Purpose of the Materials and instruments
Camera phones	To take photographs, to record audio and video recordings from interviews
Measuring tapes	To measure some features of the NAMA buildings conditions
Note Books	To jot down and document any important information on the field survey of the researcher
SPSS software	For the analysis of the result acquired from the self-administered questionnaire
MS Excel 2016	Was used for the analysis of data
ArcGIS 10.3	Were used to properly identify the case site To generate location maps For site analysis of the case site
Revit architecture version 2020	To design the current condition of the NAMA compost project site and infrastructure
Lumion	Was used for aesthetical rendering of the designed center
Adobe Illustrator cc 2019	Were used to further integrate and present the different outcomes achieved by the above software's
Adobe Photoshop 2019	
MS word 2016	Was used to forward the final document report.

Source: Own Computation

3.8. Ethical consideration

Letters were written to the different organizations for their willingness to share information required by the researcher. The official letters were provided by the institute of Adama Science and Technology University which asks for the respectful compliance of Adama city municipality and other organizations that the researcher might deem important for the gathering of information.

CHAPTER FOUR

4. RESULT AND DISCUSSION

The main chapter of the research is the result and discussion of a study that works to fulfill the objective proposed by the researcher. In this research, both primary and secondary data were analyzed and reported qualitatively and quantitatively through the evaluation of the self-administered questionnaires, in-depth interviews, and field study. This chapter is also concerned with providing major findings regarding the case site and its current management systems and related issues such as its infrastructural conditions and its waste-reducing abilities as viewed from the two kebeles it is currently engaged in collecting waste from. The result also provides insight into a newly designed recycling center and its potential for waste reduction and recycling through the quantification of the city's waste and its population.

4.1. The Population of Adama City

As the population of the city of Adama increased by a significant amount, the amount of waste generated has also increased. According to projected demographic figures from 2010 EC, the population of the shining city of Adama was 413,236 people with a growth rate of 4.8%.

Table 3: Population of Adama city

Year	Population Number
2001	237,266
2002	281,279
2003	295,006
2004	308,224
2005	324,068
2006	339,329
2007	356,344
2008	373,661
2009	391,597
2010	413,236

Source: Disaster and Risk management team and Adama city Municipality

4.2. Amount of Solid Waste Generation of Adama City from 2011-2025EC

From the annual growth rate and population of the Adama city the researcher has computed estimation of the total population of the city for the future 15 years using the year 2010 as a base year (Equation 1) for population estimation and (Equation 2) for waste generation estimation) in order to estimate the future waste generation of the city.

Table 4: Population and Waste generation estimation

Year (Ec)	Population	Solid waste generation (ton)
2011	433,484	63,289
2012	454,725	66,390
2013	477,006	69,643
2014	500,379	73,055
2015	524,897	76,635
2016	550,617	80,390
2017	557,597	81,409
2018	605,899	88,461
2019	635,588	92,796
2020	666,732	97,343
2021	699,402	102,113
2022	733,673	107,116
2023	769,623	112,365
2024	807,334	117,871
2025	846,893	123,646

Source: own computation

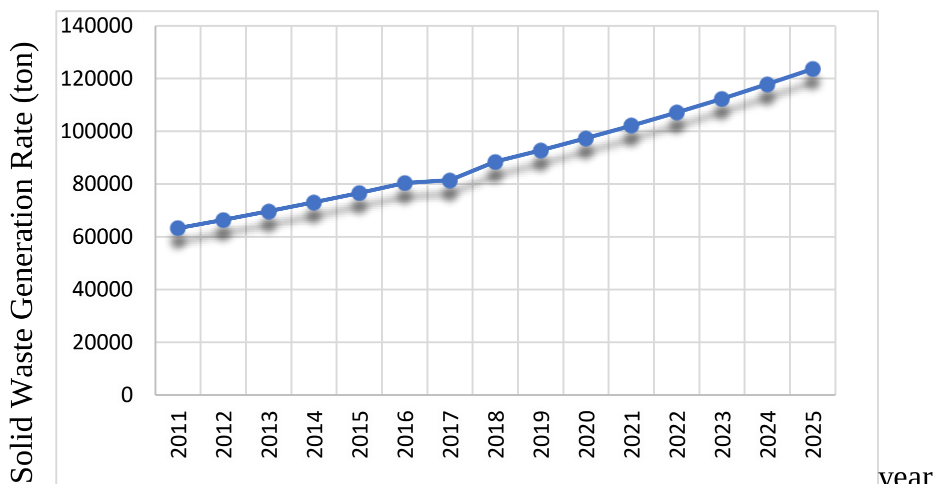

Figure 12: Solid waste estimation graph from (2011-2025)

Source: own computation

In this study the researcher was first able to estimate the amount of waste that is going to be generated and the number of populations in the city of Adama in the coming years (15 years) to further indicate and prove that the management of solid waste in the city of Adama needs serious looing in to. Hence, as the population of Adama city increases through the years the generation of solid waste also increases in the city showing a directly proportional relationship between these two features. This means that as solid waste generated increases there will be a dire need for a more organized solid waste management system for the city.

The general increase in the solid waste of the city will put pressure on the management system of solid waste in the city in such areas of collection, sorting, transferring, transporting and disposing of the waste generation. This will be put pressure on the cost needed for the management processes and the environments safety and the societies wellbeing.

4.3. Waste Generation of Adama City

Based on the Adama municipality office, information provided regarding the generated amount of waste that originates from different sources in the year 2016 (2008Ec) by which waste generation rate is 0.4 kg/capita/day (Bekele, 2017). According to the research done by Kitila Alemayehu Mijena, Jianfu Zhao, Sha Lu, Tao Wang, and Kitila Gizachew Mijena in the year 2021 on, the Assessment of Integrated Solid Waste Management Practices in Adama City, Oromia Region, Ethiopia, the average waste generation in the city is 0.42kg/day/capita which is beyond the national average level of 0.33kg/day/capita (Alemayehu, 2021).

Nearly half of this solid trash (49 percent) came from households. Hotel, restaurant, café, and bar waste accounted for 16 percent, commercial enterprises such as market places, stores, garages, and so on accounted for 13 percent, industrial and agricultural solid waste accounted for 9 percent, and construction and demolition waste accounted for 6%. The other waste types account for less than 10% of total waste (Bekele, 2017).

Table 5: Waste Generated from each source

Source of waste	Waste generated (%)
Households	49
Hotels	16
Commercials	13
Industrial and agricultural	9
Construction and demolition	6
Other	10
Total	100

Source: Own Computation

4.4. Types Of Waste in Adama City

As shown in the table below the lion's share of the waste generated is taken by the organic biodegradable waste which is followed by plastic waste. The existence of plastic and paper waste with the above percentage indicated that there is an existence of potentially recyclable material in Adama City. Therefore, Plastic wastes are widely collected for recycling purposes daily, about 330 m3 of plastic wastes are collected daily in addition to this there is an organic waste composting project that used about 30 tons of waste in a time interval of three months ("Solid Waste Generation Rate and Characterization Study for Adama City", 2019).

Table 6: Amount of type of Waste generated

Type of waste	Waste generated (%)
Organic waste	70
Plastic waste	10
Fine matters (ash and dust)	6
Paper	6
Other	8
Total	100

Source: own computation

4.5. Nationally Appropriate Mitigation Action (NAMA) Compost Project, Adama City Solid Waste Management System

As acquired from different desk reviews the amount of organic waste generated in the city of Adama is about 70% which shows that it is the city's dominant waste type. This also shows that the city has a great potential for the employment of organic waste recycling and composting.
The original project proposal of the NAMA project was the recycling of plastic both highland water bottles and polystyrene, organic waste composting and paper but the project is currently involved in organic waste composting. The three associations are Green Ethiopia, Hojene Yagudenu, and Tedecha Arara. The onsite leaders of the three associations include Ato Bedelu, Ato Gemechu, and Ato Mulugeta respectively.

The association of Green Ethiopia works on house-to-house sanitation and composting; the association of Hojene Yagudenu works on house-to-house sanitation, composting and high land grinding and recycling; the Tedecha Arara works on composting and house-to-house sanitation. The project members were organized in the year 2008 and started their first work in kebele 13 (Kela sefer) after relocation to kebele 05. The compost project has been in work for about 2 years and 6 months from 2012 and 2013 still working on to the year 2014. Each association has work sectors such as Manager, Product quality and operation manager, Casher, Public relations, Head of material supply and market study, and Awareness creator. The NAMA compost project in Adama city employs the composting system of Aerobic windrowing.

Table 7: NAMA Compost General Information

Association names	Number of members	Location (Kebele)	Male	Female
Tedecha Arara	22	Kebele Boku Shenan	20	2
Hojene Yagudenu	15	Kebele Germ	12	3
Green Ethiopia	15	Kebele 04 and bole	13	2

Source: Field Survey data, 2021

As mentioned above the NAMA compost project is a company working on the composting process of organic waste that is collected from two distinct kebeles (kebele 13 and kebele 14).

4.5.1. Location of the Kebele 13

Kebele 13 is commonly known as chafe with a total area coverage of 132.9387Ha. The site is located in the south eastern part of the city from its center known as Posta Bet.

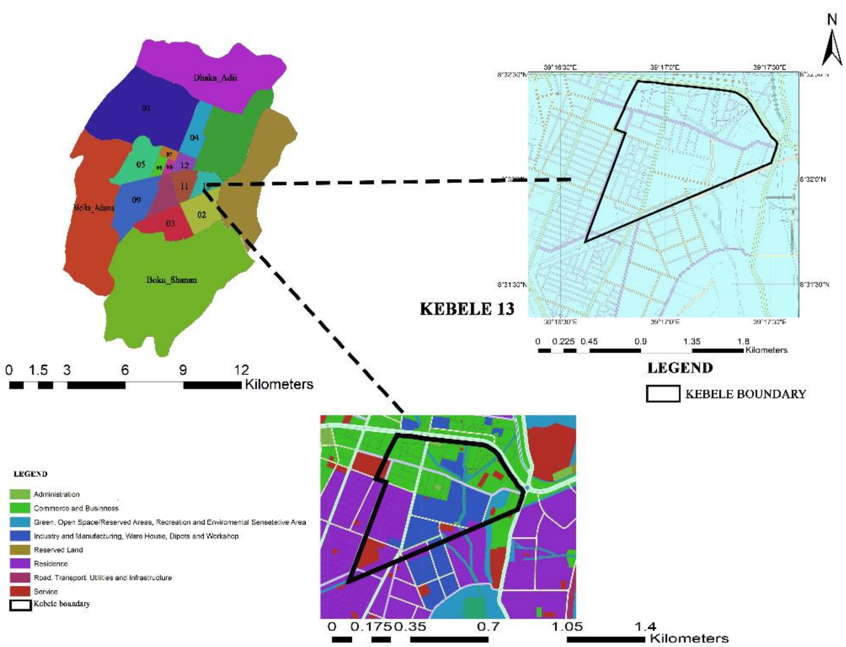

Figure 13: Location of Kebele 13

Source: own computation

Table 8: Solid and household waste generation of Kebele 13

Kebele 13		
Year	Solid Waste generation (ton)	Household Solid waste generation (ton)
2012	2964	1453
2013	3019	1523

Source: own computation

Based on the population number and solid waste generation rate (Equation 3), kebele 13 has generated the above amount of waste. Because the NAMA compost project takes waste from households the amount of waste generated by households in the two consecutive years has been computed through the 49% of solid waste from household generation.

4.5.2. Location of the Kebele 14

Kebele 14 is commonly known as Angatu with a total area coverage of 956.7814 ha. The site is located north east of the center of the city Posta Bet.

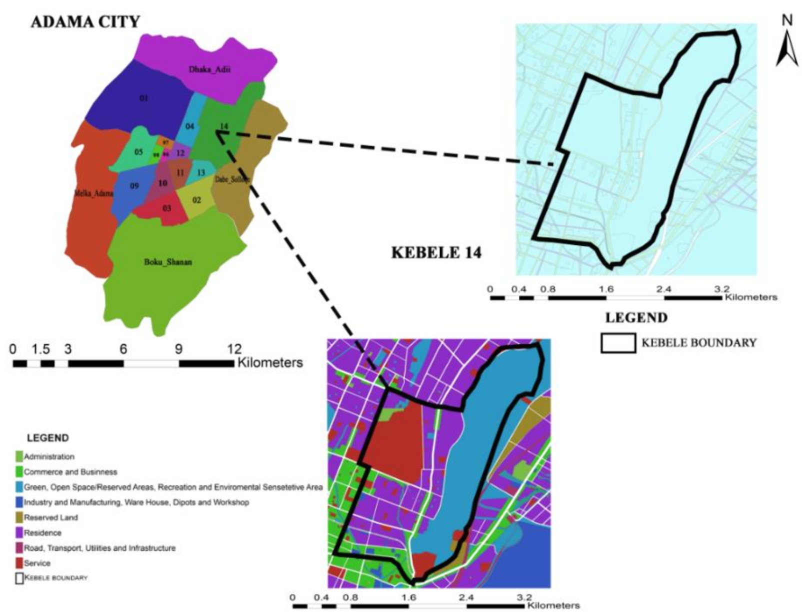

Figure 14: Location of Kebele 14

Source: own computation

Table 9: Solid and household waste generation

Kebele 14		
Year	Solid Waste generation (ton)	Household waste generation (ton)
2012	5647	2767
2013	5924	2903

Source: own computation

Based on the population number and solid waste generation rate (Equation 3), kebele 14 has generated the above amount of waste. The waste generated from households each consecutive year is about the 49% of solid waste from households. NAMA compost project then collects waste from the above two kebeles in order to produce compost from the organic waste collected from households of each kebeles.

Collection of Waste: The members formerly gathered solid waste starting from 250 households to 500 households to currently 780 households. The associations were first involved in the creation of awareness and promotion of household participation in waste source sorting. The collection of waste was done once every week. The waste is collected utilizing a manually operated hand Cart (Gari)

Figure 15: Collection of Waste

Source: Field Survey Data, 2022

Sorting of Waste: The collected waste was further sorted because the households after some time did not sort the waste the way the associations needed it to be. Therefore, the association now has another sorting site known as the Transfer Station located in kebele 13. The collected waste is taken to the Transfer Station and then sorted there. The members of the association sort the organic waste from the highlands, plastics, papers, metals, glasses, ceramics, and other waste types. Then the organic wastes are then taken to the NAMA compost project site while the other waste types are moved to the land fill site.

Figure 16: Waste Segregation

Source: Field Survey Data, 2022

Transportation: The sorted waste from the Transfer Station is transported to the NAMA compost project site located in kebele 05 (Dagaga) employing tractors. The NAMA compost project collects a total of 1760 tons of waste each year from 780 households about 36.666 tons (36,666 cubic meters) of waste is collected every week. This totals about 916 Medeb (Patch) of waste from the Transfer Station.

Figure 17: Waste Transportation to Transfer Station

Source: Field Survey Data, 2022

Composting: Composting will be done on the sorted waste that is received from the Transfer station. The waste goes through an intensive mixing process with water and required temperature it is turned into compost. The waste is turned into compost after a maximum time-lapse of two and a half to three months. The output compost is then sold to markets and companies. The whole composting process takes place after the waste collected from each house holds is sorted which distinguishes the organic waste from the other types of waste. After sorting is finished all the wastes except the organic ones are transferred to the landfill site. From the sorted organic waste, there exists a process that further separates the dry organic waste from the wet organic waste.

The composting system employed in the NAMA compost project of Adama city is known as the windrow composting system which is the most commonly implemented composting method of organic wastes and is done by piling up different raw materials and biodegradable wastes one on top of the other creating a long narrow pile and then mixing them continuously in a regular basis.

The system of the aerobic windrow composting employed in the NAMA compost project is done by first placing the dry organic waste at the bottom of the layer which includes wastes such as plant leaves, grass, and others. Above the dry waste water is added in a certain amount because water is the main ingredient that aids the mixing process. Above the water wastes such as potatoes, onions, and others are placed. Food kinds that are easily perishable are layered above these wastes such as bananas, avocados, and so on. Water is again applied and layered above these perishable foods. Then materials that are good heat absorbers and materials that have good wind movement tendencies are layered above the water which includes materials such as straw and cotton (feedstock). Above them, animal manure is placed from chickens and cows, and others. Finally, the above layer will consist of left-over compost from the previous compost production batch that has some unprocessed particles such as hard avocado seeds. Each layer is about 10cm. The pile will be 1.5m in height, 50m in length, and 5m in depth.

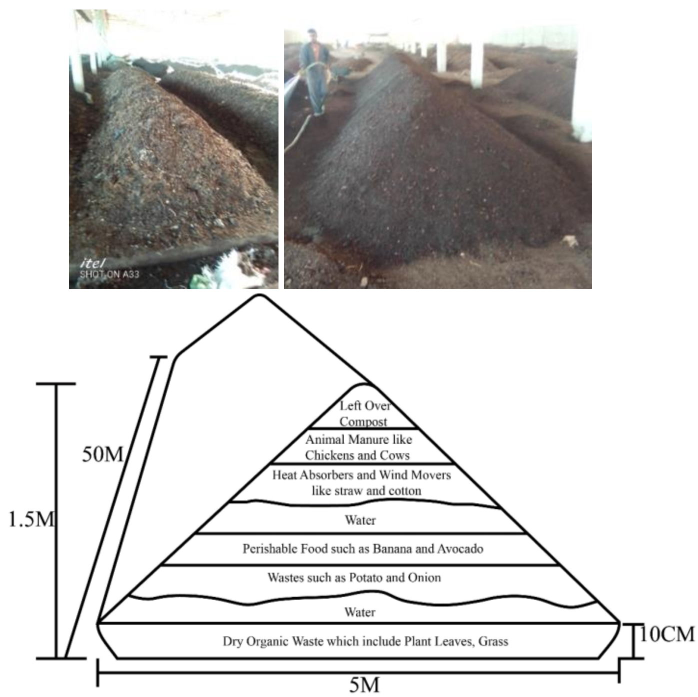

Figure 18: Mixing of The Layered Compost

Source: Field Survey Data, 2021

After the layering is finished the pile is mixed regularly every 15 days by applying a certain amount of water. After mixing the pile is continuously covered with cloth materials known as Phills, which are good absorbers of heat and reducers of evaporation of water from the pile. When the temperature of the pile reaches 55c^{o} and above it is the maximum temperature limit they require for mixing the pile because a higher temperature is required to decay the pile of organic waste. If the temperature becomes very low it is a sign that they need to mix quickly as a cold temperature doesn't allow the pile to disintegrate and rote.

The mixing stage will continue until the pile is turned into compost which takes about 2 and a half months to three months. After this period the pile turns to neutral compost and is then further sifting is done on the product to pick out products that are not turned to compost such as hard avocado seeds. These will be used again and recycled in the next pile to be composted. The NAMA compost project finally produce compost of about 880 tons. The process of composting has been done manually but recently there has been a provision of a turner machine that helps in the mixing process of the products.

Figure 19: Mixing of the Layered Compost and Ingredients in the Composting Process Such as Straw, Cotton

Source: Field Survey Data, 2022

The NAMA compost project is also involved in the collection and sorting of plastic waste to further transport that waste to the city of Addis Ababa. The plastic waste collected by the members of the project is dumped in a transfer station located in Kebele 11(Amede). The plastic waste is collected and then crushed and transported to Addis Ababa.

Figure 20: Plastic Waste Sorting area of the city

Source: Field Survey Data, 2021

4.5.3. Current NAMA Compost Project Capacity of Waste Reduction

From the waste generation in the two kebeles (kebele 13 and kebele 14) in the year 2012 and 2013, household waste accounts for 49% of the total waste generated while organic waste accounts for 70% of the household waste.

Table 10: Household and organic waste generation of the two kebeles

years	Kebeles 13		Kebeles 14	
	House hold	Organic waste	House hold	Organic waste
2012	1,453 ton	1017 ton	2,767 ton	1937 ton
2013	1523 ton	1,066 ton	2903 ton	2,032 ton

Source: Field Survey Data, 2021

The total organic waste generated by the two kebeles accounts for about 2,954 tons in the year 2012. While the amount of organic waste generated in the year 2013 from the two consecutive kebeles accounts for about 3098 tons.

NAMA compost project could collect 36,600 cubic meters (36.666 tons) of waste each week from 780 households which are 146,666 cubic meters (146 tons) per month and 1,760,000 cubic meters (1,760 tons) per year. Therefore, from the total organic waste generated from kebele 13 and kebele 14 in the year 2012, the amount of waste NAMA collects is currently limited by its capacity to 1,760 tons of waste which leaves (2,954 tons -1,760 tons) 1,194 tons of waste uncollected.

The same goes for the waste generated from kebele 13 and kebele 14 in the year 2013. The same bounded amount of waste is collected by the NAMA compost project which is 1,760 tons leaving (3,098 tons -1,760 tons) and 1338 tons of waste uncollected by the project. NAMA compost project then finally produces about 880 tons of compost from the 1,760 of organic waste it collects.

4.6. Perception Of Respondents

4.6.1. Sex Distribution of The Respondents

From the acquired results the dominating sex of the respondents was found to be the *Males*. The *Males* held an 86.5% while the *females* were only about 13.5% of a total of the members of the associations.

Table 11: Sex of the Respondents

Sex	Frequency	Percent
Male	45	86.5
Female	7	13.5
Total	52	100

Source: own computation

4.6.2. Work Station's Service Provisions

Respondents were given a question concerning the supply of services for their workstation of the NAMA compost project compound. The question aimed at getting information on whether they were content enough with the amenities and facilities provided related to their work.

According to the data obtained about 85% of the respondents were dissatisfied with the conditions of their workstation concerning service provisions. The rest of the respondents who accounted for 15% of respondents were not that affected by the service lack as they were not fully engaged in the work and used shifts.

Table 12: The Respondent Satisfaction Level

	Frequency	Percent
Satisfied	7	15
Dissatisfied	45	85
Total	52	100

Source: own computation

Concerning the open-ended question provided for respondents for the better elaboration of their reply to the above question, the section of respondents that were not dissatisfied were so because of their work habits. They were the portion of the respondents who were not that engaged in their work and those who come with shifts and sometimes were absent to work as well. Because they used shifts, they did not need much from their workplace as they already came after they used what they needed in their homes.

Those who had the higher percentage and dissatisfaction level were highly affected in their work station and mentioned various reasons which the researcher categorized as lack of basic facilities and services, lack and insufficiency of infrastructures, and insufficiency of space each with a total percentage of 30.7%, 33.8% and 35.4 respectively.

- proper and well sanitary Toilets,
- Stores for their raw materials and final finished product,
- Offices for purposes of the general management of the whole compound
- Proper water supply as water is not present as it needs to be because their entire work is highly dependent on surplus water supply
- Space for placing their compost rows properly, for placing the organic waste that is being sorted and arranged, and space for movement in and around the work space.
- Proper Drainage because the water that is drained from the compost raw materials in the process of turning needs a proper way to exit their work station as it brings foul smells that are unsafe for the health of the workers
- Proper Sewage system and path as the existing toilet is less maintained and used with disregard which is also risky for the health and well-being of the workers.

Table 13: Problems of the NAMA Compost Project Station

Problem	Frequency	Percent
Insufficiency of space	45	35.4
Lack of infrastructure	43	33.8
Lack of services	39	30.7
Total	127	100

Source: own computation

4.6.3. Work Performance due to the Case Site Conditions

The researcher provided an open-ended question to the respondents that requested them to provide their general performance in their work due to the NAMA compost project conditions on the site. The portion of respondents that accounted for 87.3% of them were set on proving their work performance was highly lacking due to the current condition of the NAMA compost project site. They also pointed out that the insufficiency of space in combination with the lack of basic services has resulted in a total disruption of their work performance as they are sure if the above problems, they have mentioned are dealt with they will be able to work even better than they are now.

The rest of the respondents that accounted for 12.7% of the total percent described that they were not as much bothered by their work performance because they hadn’t thought about it enough and that they are not that engaged in their work. This portion of respondents were those who were not that bothered by the service provisions of the case site.

Table 14: Respondent's Work Performance

	Frequency	Percent
Yes	47	87.3
No	7	12.7
Total	52	100

Source: own computation

4.6.4. Architectural Design Solutions

On the questionnaires supplied by the researcher, this particular question inquired the respondents to share their view on whether or not the problems they had would be better adhered to by the employment of architectural design. They were asked this question in order to gain information on the knowledge they had on the general relationship architecture and building design had with waste and its management and what position each element had in the city.

The respondents responded concerning the architectural solutions that they believed would be provided for them and their company in order to mitigate the problems they have faced, as such the provision of basic infrastructures such as well-organized, proper, and well maintained toilets, Offices for the better administration of the case site, canteens for having meals while they rest, proper drainage for their wellbeing and smooth running of composting process, treatment of the waste leftovers, and storage for their materials such as feed stocks and finished compost products should be well taken care of, these respondents accounted for 79% of the total sample. About 21% of respondents were worrisome about how these solutions could be provided as the case site is not enough by itself to hold such services in place in addition to the fact that the site is located in a residential zone that will disrupt the residences if it were to be developed further.

Table 15: Architectural design solution

	Frequency	Percent
In favor	41	79%
Less favored	11	21%
Total	52	100

Source: own computation

4.6.5. The Enhancement of the Case Site to a Solid Waste Recycling Center

After the researcher had information on what the respondents thought of architecture as a source of solution, she further requested them to provide their apprehension on enhancing their case site into a broader project of a solid waste recycling center. About 81% of the total respondents were in favor of the idea because they believed that the solid waste recycling center will not only upgrade their work field and increase their productivity to further include paper and plastic recycling but also help provide the Adama with a better solid waste management strategy. After all, the city will gain benefits in economy, environment, health, and so on from recycling and reducing the waste it generates.

The portion of respondents that accounted for 15% of the total respondents, On the other hand, was hesitant about how this enhancement could be achieved as they believed the site lacks basic criteria that would allow it to be further improved and that the site was small and located surrounded by residences that can be disturbed and harmed by such decision. The rest of the respondents were utterly unaware of what the whole idea of enhancement meant and were not that interested in such manners.

Table 16: Respondents on Recycling Center

	Frequency	Percent
Yes	42.12	81
No	7.8	15
Un aware	2.08	4

Source: own computation

4.6.6. Marketing of Product

In order to get additional information on how the research can benefit in creating awareness and recognition towards recycling, the research added one question on the marketing conditions of the by-product or the finished product of compost. Respondents were asked to share their views regarding the marking potential their project has been provided with and about 77.4% of the respondents were not satisfied with the current marking they are receiving as they have been in work for 2 years now.

About 14.7% of respondents were quick to answer they were alright with the marketing they have had so far and hoped to get more market because they are working hard and their project is just starting and it is in its infancy state. The rest of the respondents that accounted for 7.9 % of the whole sample were unaffected by their marketing status as a whole as they were unaware of the problems that less marketing will have to their work as they focused on getting paid.

Table 17: Marketing of Products

	Frequency	Percent
Satisfied	7.64	14.7
Un Satisfied	38.16	73.4
Don’t Understand	4	7.9

Source: own computation

4.6.7. Physical Characteristics of the Building

The building of the NAMA compost project in Adama city lies on a 10,000sqm area site provided by the municipality of the city. The project is done on a single shade standing in a 2000sqm area inside the site. The shade has a length of 100m and a width of 40m and is a ground-level building. The shade is constructed with HCB blocks with a concert as a mortar. The columns and beams are precast and the building's plaster is made from concrete and the roof of the building is a corrugated iron sheet roofing. The building is empty with no partitions in side it. The shade is completely open 3m above the ground level with no designated windows on its four sides of walls. The building lies 55m away from the northern end of the compound and 31m away from the southern end of the compound and 6m away from the western end of the compound.

The site and the building lack basic infrastructures and services required for any production area, such as offices, raw material (organic waste) storage area, finished compost storage area, equipment storage area, Administration area, employee canteen, warehouse, research center, and other because it is just one building in a compound.

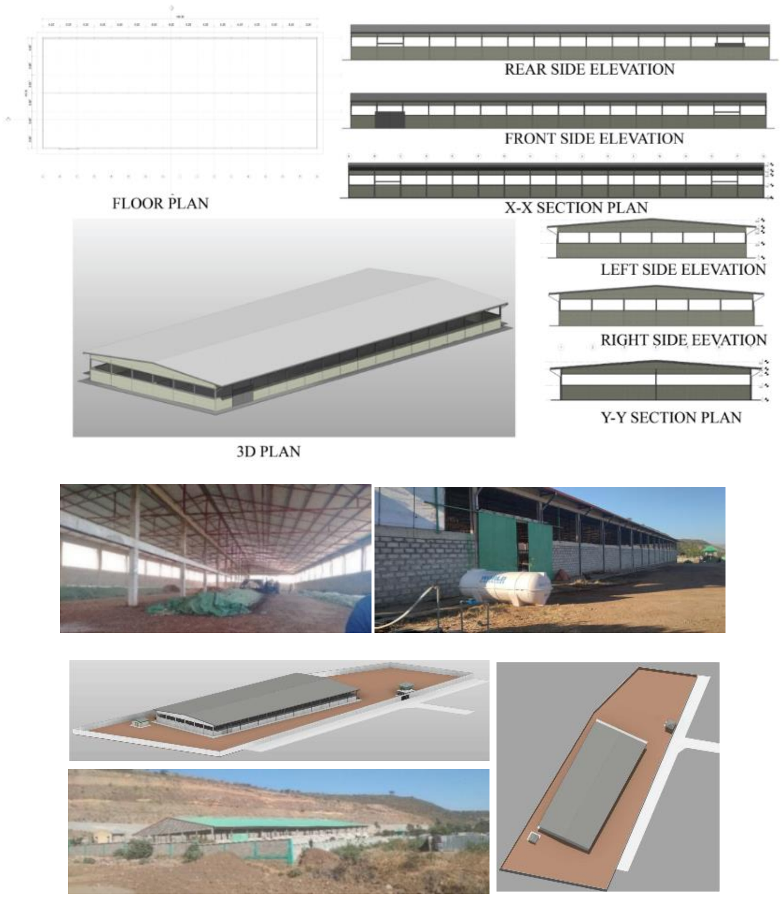

Figure 21: Left Side Elevation, Right Side Elevation, X-X Section, Y-Y Section

Source: own computation

The site has only two facilities including the shade which are the toilet and the guard house. The site has one toilet on the southwestern part of the site, which is located about 5 m away from the shade. It has a length and width of 4.4m and a height of 3m with both a female and male toilet provision. The building is made of HCB and precast columns and beams.

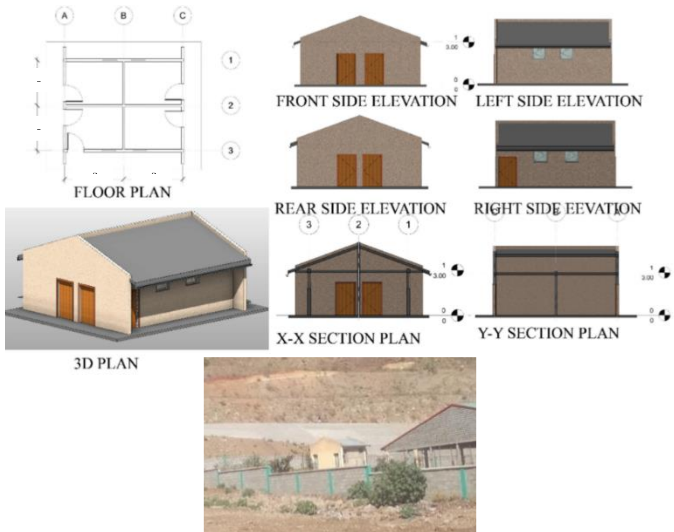

Figure 22: 3D view of the NAMA Compost Project Site

Source: own computation

The guard house is a single G+1 house located directly next to the main entrance of the site. It is made of HCB building block with columns and beams made of precast concrete. The length and width of the building are 2.5m with a height of 5.6m.

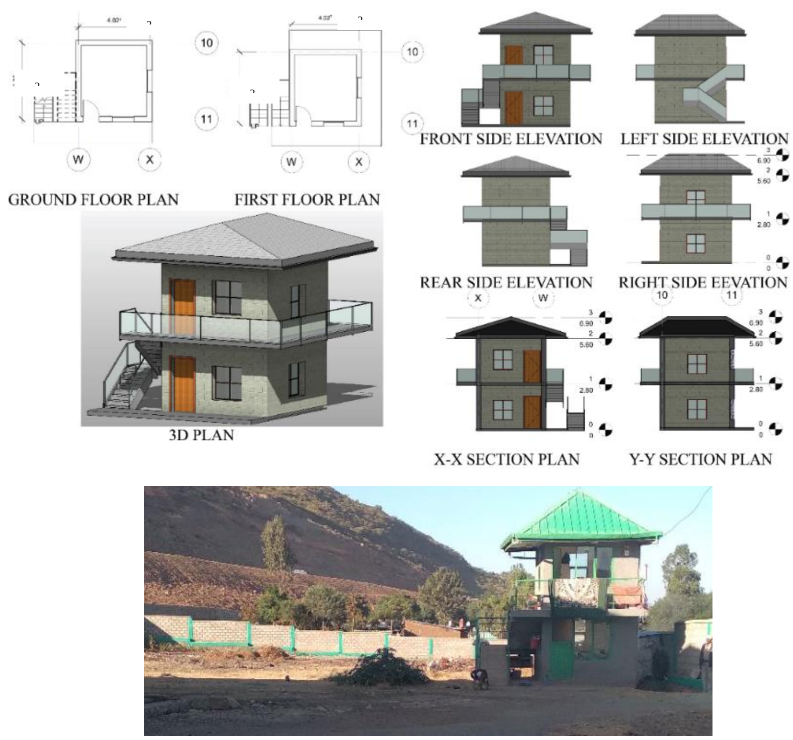

Figure 23: Guard House of the NAMA Compost Project Site

Source: Field Survey Data, 2022

4.7. Major Findings of Current Organic Waste Management System of the NAMA Compost Project concerning The Building's Sustainability and Functionality

Concerning the problems of the current organic waste management of the NAMA compost project and its building characteristics, the following lists have been provided as major findings:

Based on Services Provisions

- There is a guard house that is G+1
- There is provision of toilet.
- There is shade for production purpose.

Major Finding

- Unsanitary toilet
- Shade is insufficient for three associations production wise.
- No offices, administration area, canteen, changing room for employees, clinic.
- Production space is generally lacking from the above conclusions that are not enough for the three associations and the space is not segregated.

Based on Infrastructure Provisions

- There is electricity from the area
- There is water supply
- There is a provision of local roads leading to the site and the inside of the site is also available with local roads

Major Finding

- The availability of electricity and water to the site is insufficient
- The site lacks electric poles both outside and inside the site which is hindrance towards security and lighting.
- The roads provided are local foot path roads both inside the site and outside the site that lack basic standard material as they are mud and rocks, and it is not following standard width.
- There is lack of parking both inside and outside the site.

Based on Aesthetics

Major Finding

- The site doesn't have any greenery provisions except for grasses that are dried and unnoticeable
- There are no trees for purposes such as buffering and shading
- There is no defined open space
- There is no landscaping and landscape features in the site.

Based on Building Design Quality in Terms of Architecture

- The site is having a single shade, one toilet and one G^{+1} guard house.

Major Finding

- The shade, the toilet and the guard house are all made of HCB walls and concrete mortars.
- They basic architectural elements such as color, texture, form…
- The shade is an empty building covered with four walls and lacks basic partitions for the production area for segregation of work.
- The site lacks basic services such as offices, Administration areas, storage spaces, work shop areas, warehouses and so on.
- There is a significant lack of storage space for raw materials, finished materials equipment's of composting, and for piling the waste for purpose of turning.
- The project lacks space for inputs such as feed stocks, cotton, straws, and other raw materials required for the composting process.

Based on Building Design Quality in Terms of Health, Economy, and Social Affairs

- The project is the only existing center that can be considered as a small-scale organic waste recycling center for Adama city.
- The center works in producing and promoting compost for the city.

Major Finding

- The project lacks health care centers for the employees.
- The drainage system for the water left over in the process of composting is lacking as the water curdles and settles on the floor inside the production area (shade) creating foul smells and difficulty of movement.

- The toilet in the site is not well sanitary and not well treated and managed.

Based on the Three Challenges of Sustainable Solid Waste Management System

Major Findings on the recycling materials' marketing restrictions,

- There is a marketing problem in the project because of two reasons which include less awareness of society and sufficiency of space to conduct the composting process.
- The project is labor-intensive
- The collection of the waste that is done by the NAMA compost project members from the two kebeles (kebele 13 and kebele 14), it can be seen that the project's capacity of the collection is very small and only collects 59.6% in 2012 and 56.8% which shows that the capacity of NAMA has not changed and with the rising amount of waste the compost project is collecting less and less waste compared to the former year.

Major Findings on the widespread belief that recycling is an expensive system,

- The compost project lacks a supply of input raw materials for composting as these materials are in short supply the needed by the project.
- In addition to lack of infrastructure they also lack proper equipment and materials.
- The cost of materials such as Phills is high.
- An initiative of employees for their line of work.

Major Findings on the requirement for more storage space

- As mentioned in the above criteria's the project lacks storage for different purposes such as for equipment, for raw materials, for finished materials, for organic waste, inputs, composting process and so on.

Therefore, the research has provided information on the general conditions of the NAMA compost project seeing that it is the only project engaged in the organic waste recycling process in Adama city. It works in such a way that the members of the project collect waste every week from two kebeles and then turn it into compost by segregating the organic waste from the other types of waste. The products have been observed to be good composts packaged and labeled for marketing purposes. The NAMA compost project also works in gathering plastic waste and segregating the cap from the bottle and transporting them to Addis Ababa for further processing. The project is working but it doesn't have enough recognition from the city's community and governmental offices even though the idea of the project is embedded in the municipality offices of Adama city. due to these factors, the project lacks basic requirements to further its work in not only recycling organic waste of 2 kebeles but also the entire cities. The capacity of the NAMA compost project can be well supported if there was a supply of basic services required for the running of the work.

4.8. Proposed Design Process

Adama city is among one of the cities of Ethiopia that are facing evermore growing problems of waste management due to the increased generation of waste with the growing population of the city. The management of the waste in the city begins with the generation of the waste and ends with disposal but the city lacks waste recycling facilities except for the new project of NAMA compost that works in the sector of organic waste recycling. The NAMA compost project has been in existence for about 2 years and 6 months. It works in recycling organic waste from the houses of residences into a compost project that is useful as a fertilizer. But the compost project lacks the basic infrastructures and services that are required for any product processing and production center.

By basing its foundation on the result acquired through the research study, the proposed plan is concerned with the creation of a standard solid waste recycling center for the city of Adama. The design proposal is provided to show a system that can improve the solid waste management of the city of Adama in a design-based system. The proposal aids in creating awareness by enhancing the knowledge people have about recycling by creating a standard solid waste recycling center with the proper infrastructure provisions in a sustainable manner to make recycling an appealing feature of the world rather than mis regarded system.

4.8.1. Site Study (Location and Land Size)

The site is located in the city of Adama commonly known as kebele 05 (Dagaga) or commonly known as Meskid Sefer in the North western part of the city. The area was provided by the municipality office for The NAMA project in the city. Currently, the size of the site is about 8000 hectares. The researcher has further expanded the site to about 40,000 sqm for the development of the design. For this research, the researcher has deemed it fit to expand to the surrounding landscape for the design of the solid waste recycling center.

The researcher has directly inquired upon the members of the association on what their thoughts were on expanding their current territory and they were in favor of that inquiry as the municipality office has been willing to support their thoughts if they had ideas of further expansion of the site because the site is an open or environmental space on the proposed structural map of the city.

Figure 24: Site Location of the NAMA Compost Project

Source: own computation

4.8.1.1. Structural Plan of Adama City

Ethiopia and its cities have different plans and maps in place for the country's development. the structural plan is a plan that is valid for about 10 years and guided by the national and regional development plan of the country.

Land Use Around the Site

The structural plan of the city of Adama has land-use class categories which include: commerce and business(centers and market areas); Mixed-use (mixed land use and buildable area); Green/Park; service (Social, Cultural, general, Utility, Municipal, and public squares); Urban Agriculture (farm land, horticulture and Ground Water Protection); MSC (manufacturing and Storages); Administration (special Administration centers and Government Offices); Housing Expansion area; Transport Terminals and Roads.

The project site is allocated as a Mixed residential land use area by the proposed structural plan of the city. The NAMA compost project site was given by the municipality of the city but the area is not the standard area as this site is a manufacturing project in a mixed residential zone. The site is located close to the monument of the city known as the Aba Geda conference hall and the martyr's monument which are clear indicators that you have entered the city of Adama.

The Existing Land Use and Road of the Site

The existing land use of the area shows that the site is surrounded by residential areas to the north and east of the site, and monuments to the south of the site, while to the west there is a road in construction at a relatively higher altitude than the sites' location and the site is close to the main road.

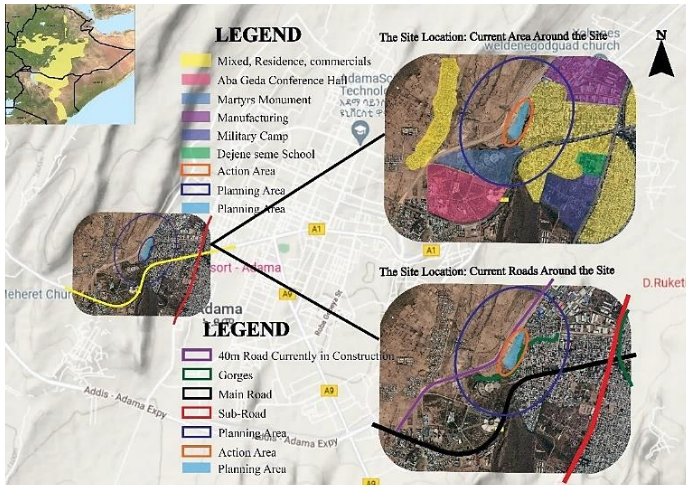

Figure 25: The Existing Land Use and Road around the NAMA Compost Project Site

Source: Own Computation

The Land Use around the Site from the Proposed Structural Plan

From the structural plan of the city, the site is located in a mixed residence zone. To the south of the site, there is a greenery zone and west of the site is a service zone. The expanded area for the 40,000 m^2 design site is designated as open space or environmental space.

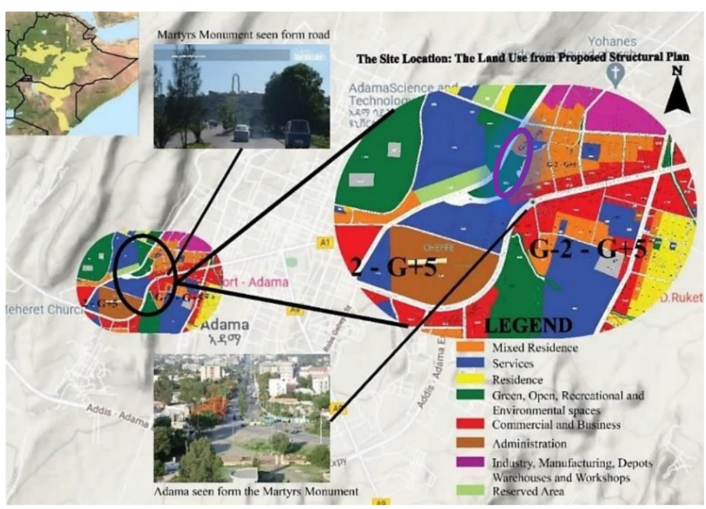

Figure 26: Land Use around the Site from The Structural Map of The City

Source: Own Computation

Road Network around the Site from the Proposed Structural Plan

From the structural plan of the city, the case site is located 0.37 km away from the main road square (Aba Geda Square) that crosses through the city and which is the road that leads from Addis Ababa to dire Dawa as the main transit road. The site is also adjacent to the new 40-meter road that is currently in construction which is a clear distinction that the site is accessible. The site is located near the main entrance of the city.

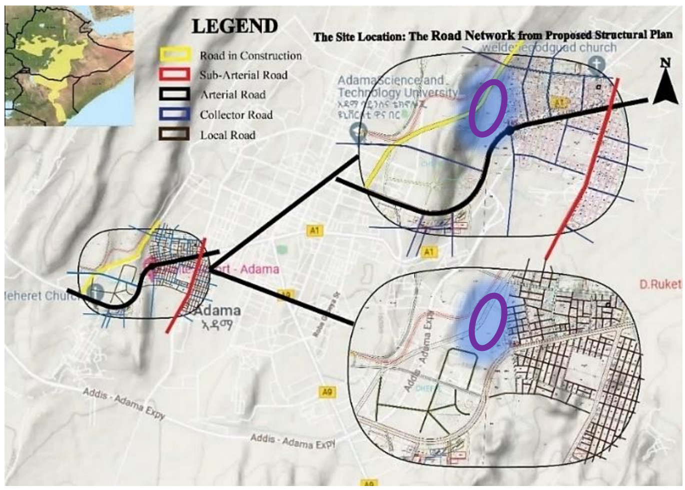

Figure 27: Land Use and Road Network around the Site from the Structural Map of the City

Source: Own Computation

4.8.1.2. Site Selection

The site is the area where the NAMA compost project of Adama city is located. The site was provided by the Adama city municipality office to the mentioned three associations. Based on the structural map of the city the project site is located in a mixed residential zone surrounded by Residences, Environmentally Reserved areas, and Manufacturing zones. The site is located about 500m away from the main road of the city that crosses the city coming from Addis Ababa going to Dire Dawa. The site is also located adjacent to the new 40-meter road currently in construction. Near the site about 500m away the Martyrs Monument is located next to the Aba Geda conference hall. A small gorge is located next to the site which can be fixed by simple engineering solutions.

4.8.1.3. Site Analysis

From the site analysis done on the case site, the wind direction goes from north to the easterly while the noise reaching the site comes from all directions surrounding the site.

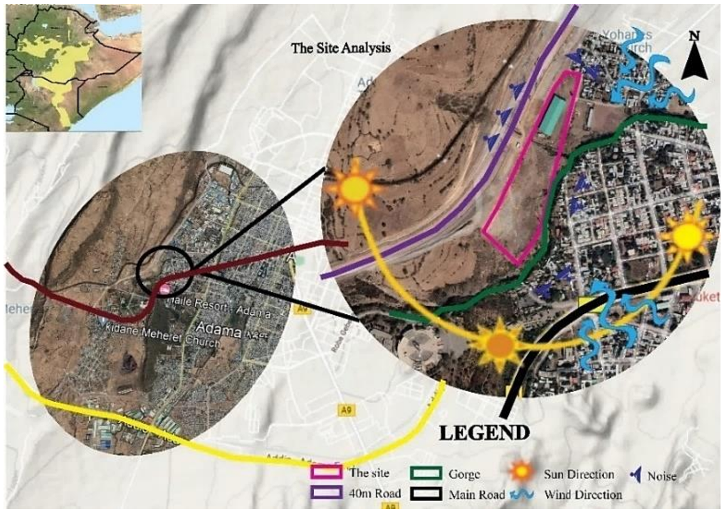

Figure 28: The Site Analysis

Source: Own Computation

4.8.1.4. Case Site Natural Condition

Contour Line Analysis

A map that represents an imaginary line on the land surface drawn by connecting points of equivalent height and elevation. When the lines are drawn closely shows the slope is steep such as in a mountainous area and lines drawn far apart show the slope is suitable such as areas of leveled and flattened surfaces.

Site Elevation Analysis

The NAMA compost site exists at an elevation ranging between 1642-1679 meters. It originally has work done on it for the purpose of the construction of the station of the project. It also lies relatively lower than its adjacent area located on the northwestern side of the city.

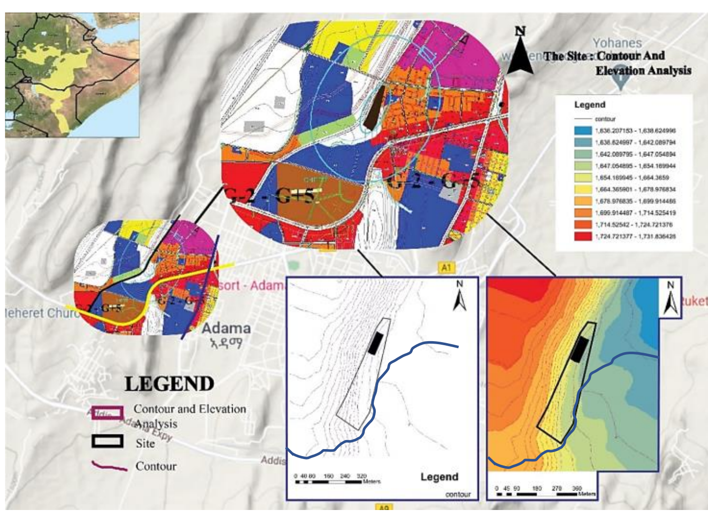

Figure 29: The Site Contour and Elevation Analysis

Source: Own Computation

Site Slope Analysis

According to Environmental Systems Research Institute (ESRI, 2008), the slope function calculates the maximum rate of change between each cell and its neighbors. A slope value is given to every cell in the output raster. The lower the slope value, the flatter the terrain feature, and the steeper the terrain, the higher the slope value. The output slope raster can be calculated as the percent of slope or degree of slope.

The site is originally at a level where it is acceptable for an urban setting but difficult to implement in such a setting. The existing site has been exposed to some engineering adjustments to make way for the construction of the shade of the NAMA compost project.

The slope levels with

- 0-2 - Flat site, favorable for an urban setting, subjected to flood and cost for the drainage system.

- 2.000000001-5 - Favorable for an urban setting and no requirement of cost for drainage set.

- 5.000000001-8 - Promote urbanization with different infrastructural elements.

- 8.000000001-15 - Acceptable for an urban setting, expensive drainage and retaining wall, subjected to gully formation.

- 15.000000001-100 - Difficult for an urban setting.

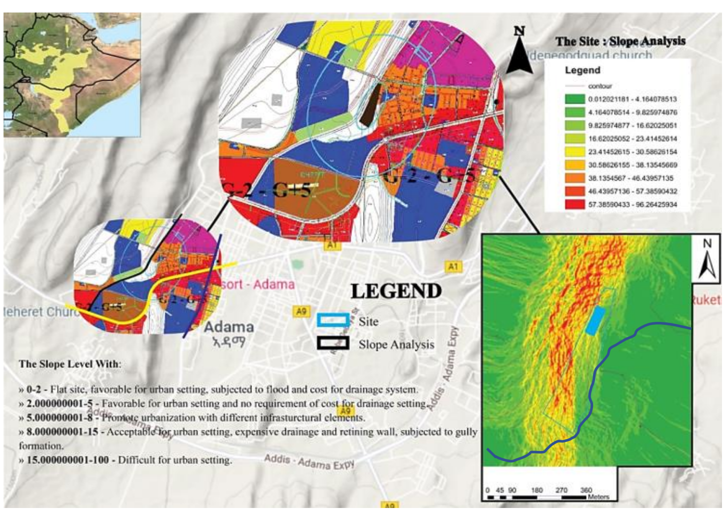

Figure 30: Slope Analysis

Source: Own Computation

Site Morphology analysis

The site morphology analysis shows the settlements around the site in a figure-ground map. This figure-ground shows that the site is surrounded by residences that are compacted in their existence. The morphology analysis also shows that the site is just adjacent to the 40-meter road in construction and that the site is surrounded by local roads that were created by the residence's existence

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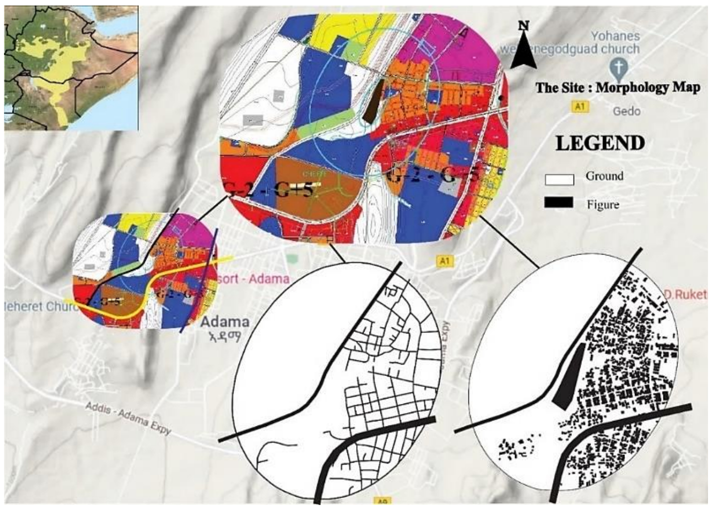

Figure 31: Morphology

Source: Own Computation

4.8.1.5. Site Inventory

Topography

According to topographical information obtained from satellite images and aerial photos, the topography of the city is invariably mosaic and divided into the low-lying center and hill slopes, as Adama city was established in a flat and undulating fertile land that ranges from a completely low-lying center of the city to hilly ridges with an altitude that gradually drops from the peripheries of the city to the center of the city and is between 1500-1900 meters above mean sea level with an average altitude of about 1700 meters.

The NAMA compost site's surrounding area exists in an elevation ranging from about 1600-1800 meters and the NAMA compost site exists in an elevation ranging between 1642-1679 meters. The site lies relatively in a lower plane than the adjacent surrounding area in the North-Western part of the city. In the North-Eastern part of the city next to the site exists a gorge.

Figure 32: The Site Inventory

Source: Own Computation

Vegetation

The surrounding areas that lie adjacent to the site of the NAMA compost project in the North-Eastern part of the city are covered with residential areas which are vegetated. Different plant types and fruits exist in the residences such as mangos, avocados, papayas, and other types of tresses locally known as Miliya, Moringa, and so on. The site of the project area is not vegetated and lacks significant vegetation city.

Geology

Adama city is grouped as the highest seismic area in the outstanding Rift Valley area where severe tremors and earthquakes are located at some distance below the surface of the earth. The likelihood of the occurrence of unpredictable seismic activity and disruption risks that could slam the Rift Valley and ruin property and change everything into a flat in a blink of an eye is high in the Rift Valley where the city of Adama is situated. Different building materials like stone, red ash, sand, and pumice which are the results of the geological formation of the city are abundant resources around Adama and have great economic significance to the development of the city. The case site's soil type is sandy soil with a light brown color. The site also has gravel mixed with the soil of the site.

4.8.1.6. Infrastructure and Services

Roads

The site of The NAMA compost site is located about 500 meters away from the main road of the city that passes through the city from Addis Ababa towards Dire Dawa and goes on to Djibouti. There is currently a road in construction directly adjacent to the site in the North-Western part of the city called 40 Meter Road which when finished will serve as an alternative route for the transportation coming from Addis Ababa ("Socio-Economic Profile of Adama", 2019).

Drainage

The topography, nature of the soil, and vegetation cover of the city often dictate the natural drainage of the city that has a bowl shape. The city is overwhelmed by hills and hillcrests stretch out foot in the direction of the low-lying area of the city ("Socio-Economic Profile of Adama", 2019).

Electricity

The site has proper availability of infrastructures such as electricity, and clean water supply ("Socio-Economic Profile of Adama", 2019). The case site is in short supply of this infrastructure as it received insufficient services from them.

4.8.1.7. Weather And Climate

Climate

The regions of the country are divided into three climatic regions that comprise Dega (Cold 2500 3200 meters), Woina Dega (semi-arid 1500-2500 meters), and Kola (desert below 500 meters above mean sea level) based on the elevation and climate condition of the country. Dega, Woina Dega, and Kola encompass 10%, 30%, and 60% of the total area of the country respectively. As the city rests in the Rift valley and crosses the country from north to south, Adama city falls into Kola which is a hot and dry climate throughout much of the year with sparse rainfall in the winter and milder condition in the summer ("Socio-Economic Profile of Adama", 2019).

Temperature

The mean maximum temperature is the height from March to May and the mean minimum temperature is lowest from October to November ("Socio-Economic Profile of Adama", 2019).

Rainfall

The city experiences bi-modal rainfall. The city receives the highest mean maximum rainfall from July to September ("Socio-Economic Profile of Adama", 2019).

4.8.2. Design Proposal

The proposed design of the solid waste recycling center of the NAMA compost project of Adama city is designed as a recommendation for the recycling of the solid waste collected from residences, commercials, markets, hotels, stores, and so on. The design of this project was done on a site that was already given by the municipality of Adama city for the members of the project. The area is surrounded by residences and a new road in construction is located adjacent to it. The site is separated into two sections based on the importance of the space's arrangements. The design of the buildings on the site will be in a linear manner in the direction from North to South. The design will be able to showcase a solid waste recycling center through the knowledge acquired from the literature reviews and case studies done throughout this research. This design is to serve as a baseline for future development in the city and the country for the better promotion of recycling and reusing of waste.

4.8.2.1. Design Goals and Objectives

The goal of the design is to recommend a solid waste recycling center for the NAMA compost project in Adama city. The design of the recycling center is mainly concerned with the creation of awareness in the community of the city of Adama and encouraging the integrated solid waste management system of the 3Rs (reduce, reuse and recycle) and providing an initial motivation for their implementation.

The design of this recycling center is a community-oriented design process that promotes the community's involvement and engagement. Community engagement is highly important for recycling, based to the US Environmental Protection Agency (EPA) The act of creating relationships with tribal members, stakeholders, residents, and interest groups is known as community engagement in order to work together as long-term partners to establish a combination of support for a variety of integrated waste management policies, initiatives, and services, with the ultimate objective of conserving the environment and making the community a better place to live. (Jia Jiunn, 2017).

Community Oriented-Recycling Center

Community oriented-recycling centers will help install the recycling culture and recycling practices in the communities and their behaviors especially their social norms to have a powerful effect on their human environmental behavior which will reduce the amount of waste that goes to the landfill areas (Jia Jiunn, 2017). There are three major components of spatial design that can be considered a design principle.

Spatial Requirements

This includes a list of required spaces and the area of accommodation schedule that defines the function of a space. This can be archived by providing more recycling facilities and providing **structured recycling programs** (Jia Jiunn, 2017).

Spatial Planning

This includes spatial organization and circulation. How space might relate to one another in terms of their proximity and the paths that people may choose or be forced to take through a building to access the facilities it provides. This can be achieved by being **convenient to users, having easy access** to recycling bins, and recycling bins located with signage (Jia Jiunn, 2017).

Spatial Compositions

Refers to the design making that brings the space to life. Creating a space that meets the emotional needs as well as **engages and delights the users**. This can be achieved by the creation of an atmosphere of sustainability (Jia Jiunn, 2017).

4.8.2.2. Design Description

The design has put into consideration several factors related to the community of the city of Adama. The community of Adama city is highly social and interactive with each other, they are cultural and are a combination of different nations and nationalities of Ethiopia, and they are people who plant different types of plants, fruits, and trees. This shows that the community is interactive, and cultural and promotes sustainability. Community oriented-recycling centers will take advantage of all the above features of the community of the city as its core is the community as a whole. The design of the recycling center will be mainly concerned with providing communal spaces, recycling areas, and plants. The design of the project will be divided into two main categories: The Public zone and the non-Public zones. The public zones will accommodate the communal spaces. The non-public zones will zone will accommodate the recycling plant.

4.8.2.3. Spatial Allocation

Spatial Allocation and Program

The different spatial requirements and programs for the design of the recycling center were based on the researcher's review of the primary sources of data such as literature reviews on published researchers and documents.

Table 18: Space Allocation of the Recycling Center, Public Zone

Public Zone				
Social and communal areas				
Residences	**Exhibition halls**	**Services**	Shops and stores	Cafes and restaurants
	Resting areas	Locker rooms		
	Offices	Security		
	Exhibition	Electrical and Mechanical		
		Storage		

Source: Own Computation

Table 19: Space Allocation of the Recycling Center, Non-Public Zone

Non-Public Zone		
Administration	**Research Labs**	**Industrial**
Recreation	Office	Recycling plant
Office	Lab	Plant Administration
Services	Services	Service
Lobby		

Source: Own Computation, 2022

Table 20: Space Allocation of the Recycling Center, Administration

Administration			
Recreation	**Office**	**Service**	**Lobby**
Shop	General Manager	Security	Reception
Cafeteria	Secretary	Electrical and Mechanical	Entrance
Open spaces	Marketing Manager	Storage	Waiting area
	Personnel Manager	Locker room	
	Research general	Employee rest room	
		Rest room	
		Kitchenette	

Source: Own Computation

Table 21: Space Allocation of the Recycling Center, Industry Zone

Industry Zone				
Recycling Plant			**Plant Administration**	**Services**
Loading	**Processing building**		Break room	Store
Un-loading building	Machine zone	Storage building	Electrical Network	Clinic
	Maintenance and Service area		Security	Changing room
	Electrical compressor		Manager room	Wcs
	Fire pump room		Supervisor room	
			Occupation Safety room	

Source: Own Computation

Program Development

From the structural plan of the city, the site is located in a mixed residence zone. To the south of the site, there is a greenery zone and west of the site is a service zone.

Table 22: Public Zone Program

Public Zone			**Area (m2)**	**Qty**	**N per**	**(m2) /per**
Social And Communal Areas						
Residences			200	2		
Shops and stores			50	2		
Canteens (Cafes)	Eating area	Indoor	60	1	15	4
		Outdoor	80		20	4

	Kitchenette		40	1	8	5
	Store		20	1		
	Changing room	Male	10	1	5	2
		Female	10		5	2
	Office		10	1	2	4.6
	Wc	Male	10.5	1	3	3.5
		Female	10.5		3	3.5
Exhibitions	Resting area		200	2	50	4
	Office		50	2	2	4.6
	Show room		200		6	5
	Wcs	Male	35		10	3.5
		Female	35		10	3.5
Services	Changing room	Male	20	1	5	3.5
		Female	20	1	5	3.5
	Security		15			
	Electrical and mechanical room		30			
	Store		20			
Ancillary Facility	Customers Parking		225			
Total			**1351m²**			

Source: Own Computation, 2022

Table 23: Non-Public Zone Program

Non-Public Zone				**Area. (m²)**	**Qty**	**N. per**	**(m²) /per**
Recycling Plant							
Administration	Recreation	Shops		40	3		
		Cafeteria		50			
	Office	General Manager		35		1	4.6
		Secretary		20			
		Marketing Manager		20			
		Personnel Manager		20			
		General Research Office		30		4	6
	Services	Security		15			
		Electrical and Mechanical		30			
		Storage		50	2		
		Employee Rest Room		30			
		Rest Room		22	2		
		Kitchenette		25			
	Lobby	Reception		20	1		
		Entrance		15	1		
		Waiting Area		30	1	15	2.4
		Wcs	Male	24	1	5	3.5
			Female	24	1	5	3.5
Total				**500**			

Research lab	Office	Security Office				30	2		
		Fire Control Room				30			
	Lab	Dry Lab				150	2		
		Wet Lab				200	2		
		Lab storage				100	2		
	Service	Rest Room				40	2	5	3.5
		Changing Room	Male			20	1	5	3.5
			Female			20	1	5	3.5
		Electrical room				50	2		
		Service				45	2		
Total						**685**			
Industrial	Recycling plant	Production blocks	Loading			250			
			Unloading			200			
			Production floor			900			
			Warehouse			400			
			Raw Material Storage			880			
			Packaging			800			
			Quality Control Manager Office			75	2		
			Production Manager Office			50			
		Processing Building	Machine Zone			200			
			Maintenance and Service Area	Workshop		100			
				Store		50	2		
				Engineers' office		50	2	4	4.6
				Changing Room	Male	20	1	5	3.5
					Female	20	1	5	3.5
			Electrical Compressor			100			
			Fire Pump Room			40			
		Storage Building				80			
	Plant Administration	Break Room				25			
		Electrical Network room				50			
		Security				25			
		Manager Room				20	2	2	4.6
		Supervisors Room				20	1	4	4.6
		Occupation Safety Specialist				30	2	4	3.5
	Services	Store				50			
		Clinic	Changing Room	Male		25	1	5	3.5
				Female		25		5	3.5
			Recovery Area			40	2		
			Treatment Area			45	2		
			Sanitary			20			
			Laundry			25			

			Lounge	40			
			Nurses Station	25	2	3	3.5
			Waiting Area	20			
			Consulting Room	20	2		
		Changing Room	Male	20	1	5	3.5
			Female	20		5	3.5
		Wcs	Male	20	2	5	3.5
			Female	20	2	5	3.5
Total				**4800*2 Quantity**			
Ancillary Facilities	Services	Security Post		25	2		
		Water Treatment		200			
		Powerhouse		150			
		Customer Parking and Staff parking		750			
		Truck parking		450			
Total				**1575**			
Sum Total				**23,303m^2**			

Source: Own Computation, 2022

4.8.2.4. Design Conceptual Development

The concept of the design is based on the notion of growth and shows the transition from the initial stage towards bigger stages for instance in the cases of the production system of the center. It also centers on the relationship of each system with each other and how these systems grow and change from one form to another.

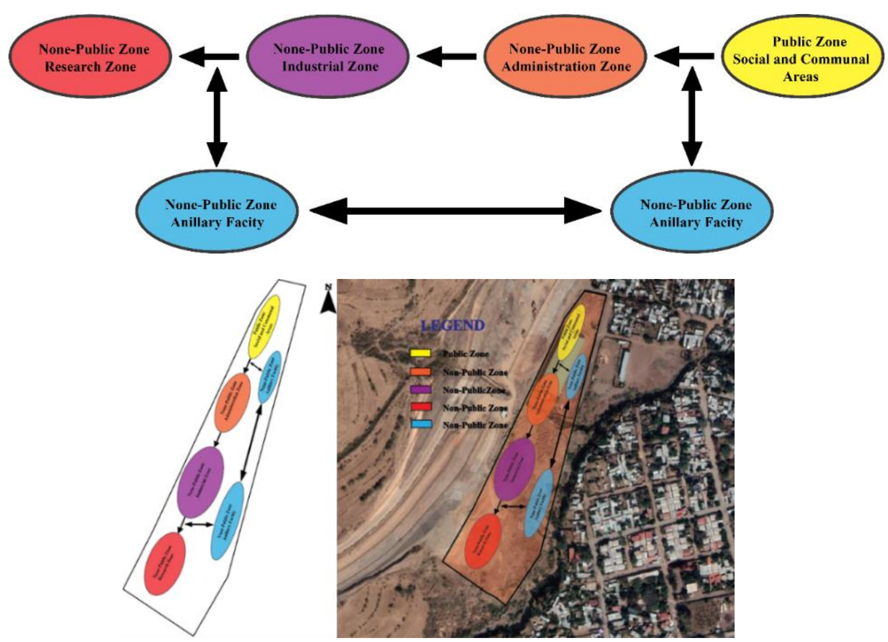

Figure 33: The Bubble Diagram, and Conceptual Zoning of Site

Source: Own Computation

Form Development

A form of anything is created by the 4 main primary elements that grow and gradually change one another. Primary elements include point, line, plane, and volume. A point extended becomes a line, a line extended becomes a plane, and a plane extended becomes a volume (Ching, 2007).

Point – Indicates a position in space. Extended becomes a line.

Line – Has length, shows direction and position. Extended produces a plain.

Plain – Has length and width, show shape, surface, orientation, and position. Extended becomes a volume.

Volume – Has length, width, depth, shows surface, orientation, and position, and also indicates form and space.

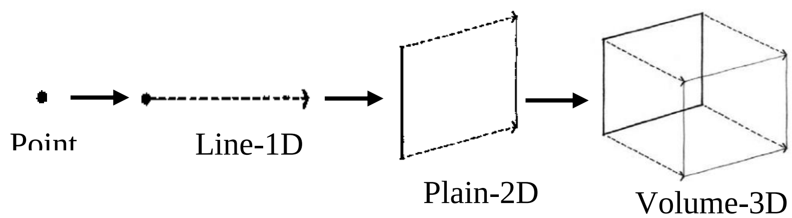

Figure 34: Primary Elements

Source: (Ching, 2007)

The form can be regular or irregular in shape and can be transformed by many different which include Dimensional transformations (modifying one or more of its dimensions while maintaining its identity as a member of a family of forms), subtractive transformations (removing a portion of its volume), and additive transformation (adding a portion of its volume). In addition, transformation groups can be identified by their capability to grow and to grow and merge with other forms.

Additive forms can be categorized as the relationship among the component forms as well as their overall configurations into centralized forms (A prominent, central parent-form surrounded by several subordinate forms.), linear forms (A row of forms ordered in a certain order), radial forms (A radial composition of linear forms spreading outward from a core form), clustered form (A collection of forms grouped by proximity or the sharing of a common visual trait), grid form (A three-dimensional grid connects and regulates a collection of modular structures) (Ching, 2007).

Form Development and Concept Implementation

A linear form can result from a proportional change in a form's dimensions or the arrangement of a series of discrete forms along a line either repetitive or dissimilar in nature. A linear form can describe movement and processions. The Repetition of Forms is one way to express linear growth.

The design of the solid waste recycling center is centered and oriented on the provision of community participation through the creation of space that has structured recycling programs, spaces that are convenient to users, spaces that have easy access, and a system that engages and delights the users. For the design linear arrangement of forms in space will show community involvement gradually to increase and progress their views and habits of recycling.

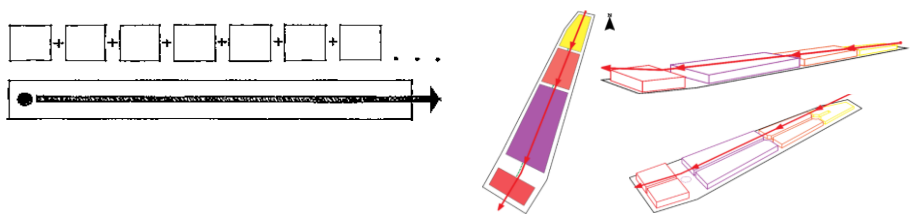

Figure 35: Linear Growth Through the Repetition of Forms

Source: Own Computation

4.8.3. Site Plan

4.8.3.1. Land use of the Site

The proposed design has two categories of land uses which are the Public and Non-Public zones in which there are 7 land-use types altogether that including the Residences (Public Zone), Services (Public Zone), Restaurants (Public Zone), Exhibition Hall (Public Zone), Administration area (Non-Public Zone), Industry Area (Non-Public Zone), Research area (Non-Public Zone), Parking area, Road, Expansion area, Service area (Treatment plant), and Greeneries.

Figure 36: Zoning and land use of the Site

Source: Own Computation

4.8.3.2. Road Network of the Site

The site has road networks that are the main road, the collector roads, and Pedestrian roads. The main road has a distance of 20m, the collector roads range between 10mm, 8m, and 6m. The pedestrian road has a distance ranging between 3m and 2m. The main road and the collector roads are made of asphalt material while the pedestrian roads are made of cobblestones.

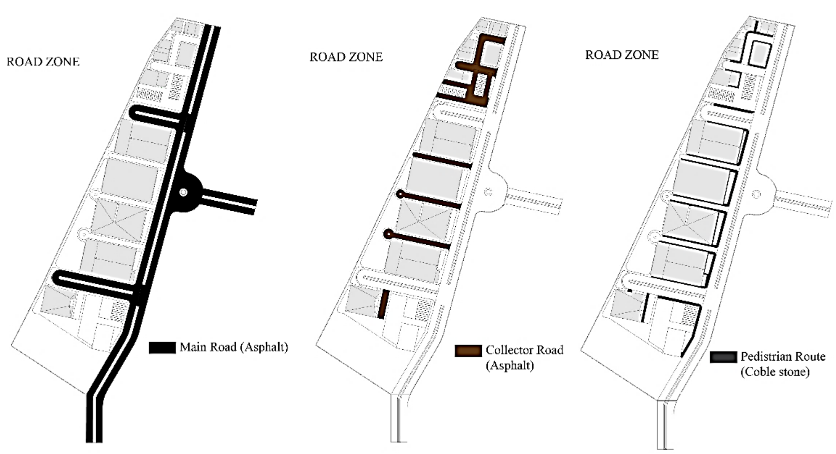

Figure 37: Zoning and Road Network of the Site

Source: Own Computation

4.8.3.3. Greeneries of the Site

The sites greeneries include; farm areas where fruits, vegetables, and flowers are grown using the compost that the proposed project makes to showcase the strength and benefits of using natural compost; and other greens such as trees and plants both serve as buffers and natural air cleaners for the smell the site might release, the vegetation also provide noise insulation as well.

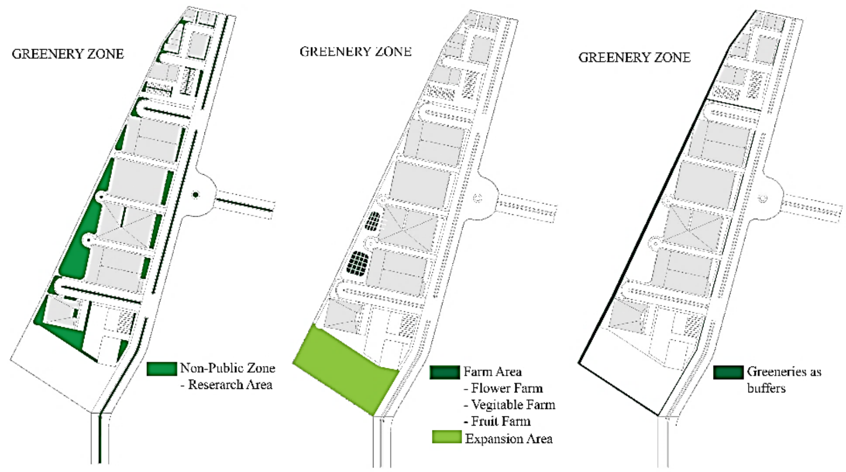

Figure 38: Zoning and Greenery of the Site

Source: Own Computation

4.8.4. The Design

The success of any industry is highly dependent on its ability to carry out its production process without interruption and with unity. There needs to be a smooth flow of the recycling starting from the raw material to the end material packaged and put for use again, in the case of the solid waste recycling center. Residential areas, service areas, production areas, and parking areas are the areas in mention which are under the recycling plant.

4.8.4.1. The Infrastructure Services Plan and Designs

The different facilities and components planned and designed in the recycling center have categories that emphasize their main functions and interrelations. In the design, there are two main categories which are:

Public Zones – these zones include areas that are directly available not only for the staff of the facility but also for different customers and community members. These facilities include the canteen, and the exhibition halls and parking areas which are under the social and communal zone.

Non-Public Zones – these zones include areas that are mainly accessed by the staff members of the facility. They are directly available only for the staff while the involvement of other members such as the community members and customers are accepted under certain conditions.

4.8.4.2. Access To the Site

The site is given one main access because of the site's current existing condition which allows access to be in one path leading to the main road of the city. The site main road gives access to the main gate of the site in which the access towards the public zone is through the right side of the main gate while the non-public zone is accessed on the left side of the center. Therefore, to access the public and non-public zone both staff and customers are forced to turn right and left respectively after they pass the main gate and square next to the gate.

There is one main access road connected to intermediate roads inside the site. These are roads inside the site that are provided adjacent to the facilities to provide easy access in all directions. There is also the provision of pedestrian walkways for more access to the facilities and connection to the intermediate roads. The width of the road's ranges from 20m, 10m, 8m, 6m, and 3m

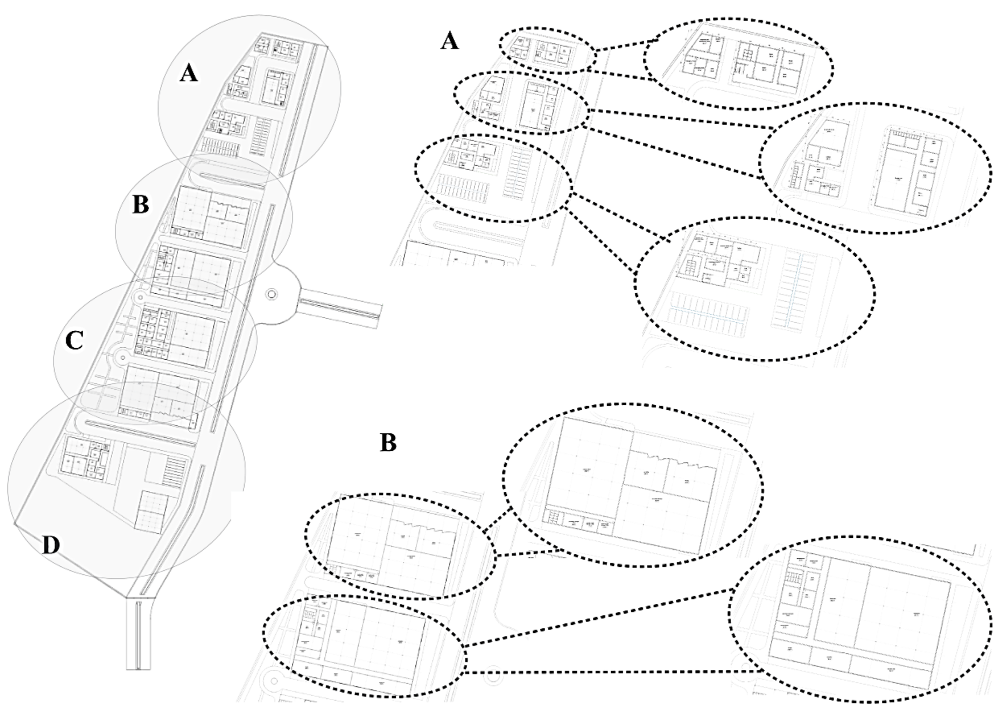

Figure 39: Ground Floor Plan Public and Non-Public zone

Source: Own Computation

Figure 40: Administration, cafeteria, residence, and exhibition hall

Source: Own Computation

Building Structure

The buildings are arranged in the growing flow of their importance in the production process ranging from the public areas to the non-public areas. The public areas are accessible to the public and the non-public areas are accessible for the production process by selected people employees and employers and others for visiting the general process of the company. The residence is a G+2 building while the exhibition hall is a G+1 building. All the other buildings are on the ground level. The administration building is the next building that is above the Ground level having an extra new floor being G+1.

Public Zone: Social and Communal Zone

These zones include the residential area, the canteen (cafeteria), the exhibition hall, service areas, and shops. The zone is located to the north of the site. The residences are provided for visitors to the site while the cafeteria and the exhibition hall are accessed by both the public and staff. In the exhibition hall, there is a display of the different materials from the raw materials to the finished products for the education of the public community.

Non-Public Zone: Recycling Plant

It is an area where the recycling process is carried out in an ordered manner and includes the administration area, the industrial zone, and the research lab.

The Administration Zone

The administration area is a very important area that assures the smooth, speedy, and efficient flow of activities on the site. In the design of the site, the administration zone is provided between the public and non-public zone which emphasizes the zone's central role in the control and administration of movement and workflow of the site. Parking areas are also placed inside these zones in which both staff and customer parking are provided in the northern and western parts of the administration zone respectively.

The Industry Zone

The industrial zone is located next to the administration zone in the southern part of the site. The industrial zone has three main zones which include the recycling plant, the plant administration, and the service area.

The recycling plant includes zones of the production floor and the processing building where the recycling process is addressed. The plant administration is the area where the industrial zone is administered and monitored. The service area is an area that provides services to the industrial zone it being mainly clinical services. All these areas are provided with a shade

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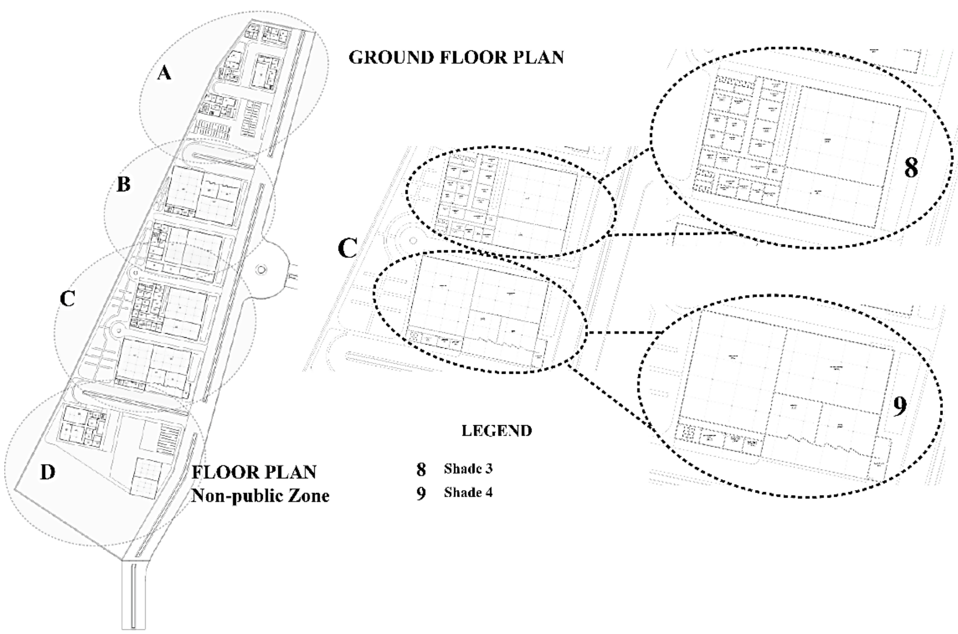

Figure 41: Ground Floor Plan of Non-Public Zone, Shade

Source: Own Computation

Figure 42:Administration, Industry Zone, Shades

Source: Own Computation

The Research Lab

The research lab is located away from the general processing area because the area is a place where different chemical reactions are carried out which means the area should be separated to some extent. It is located in the southwestern part of the site and includes areas where different laboratory examinations and experiments are done.

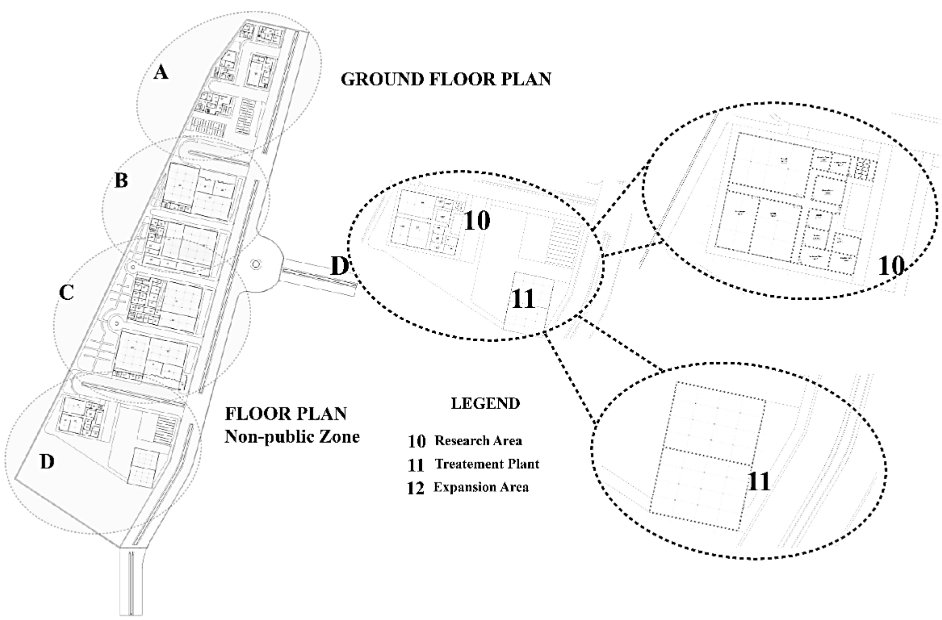

Figure 43: Ground Floor Plan of Non-Public Zone, a Research zone

Source: Own Computation

Figure 44: Industry Zone, Research lab, Shades

Source: Own Computation

Services

Basic services such as electricity, telephone, internet, and clean water are readily available in the site as the site is located in the residential area where these services have been provided before the site's provision for composting purposes by the city's administration

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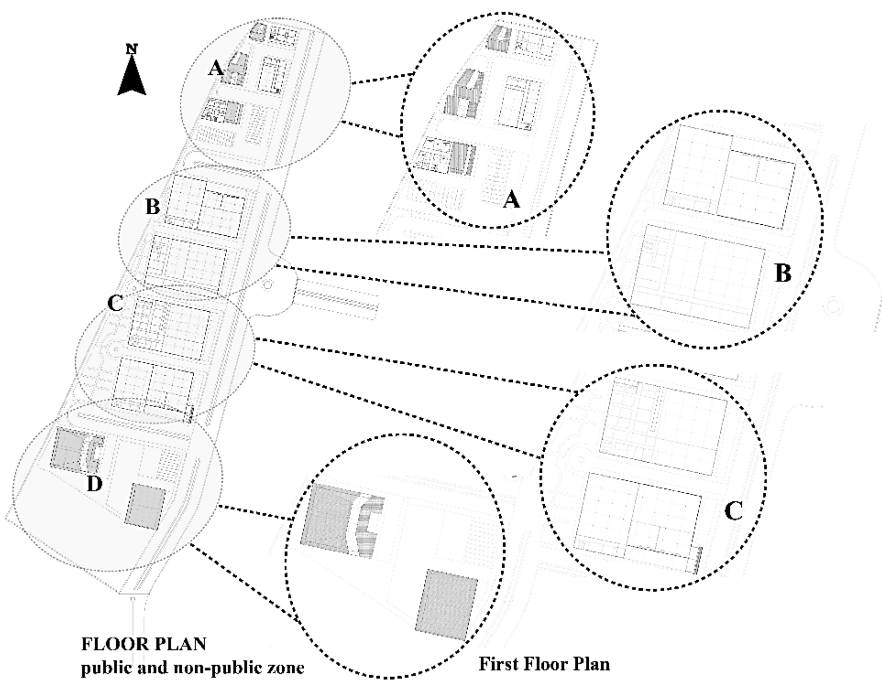

Figure 45: First floor plan

Source: Own Computation

Landscaping

The site has the provision areas for greenery and other designated open areas and different native trees are planted on the site to create an area for shading and a microclimate for the site as the city is characterized by a hot climate.

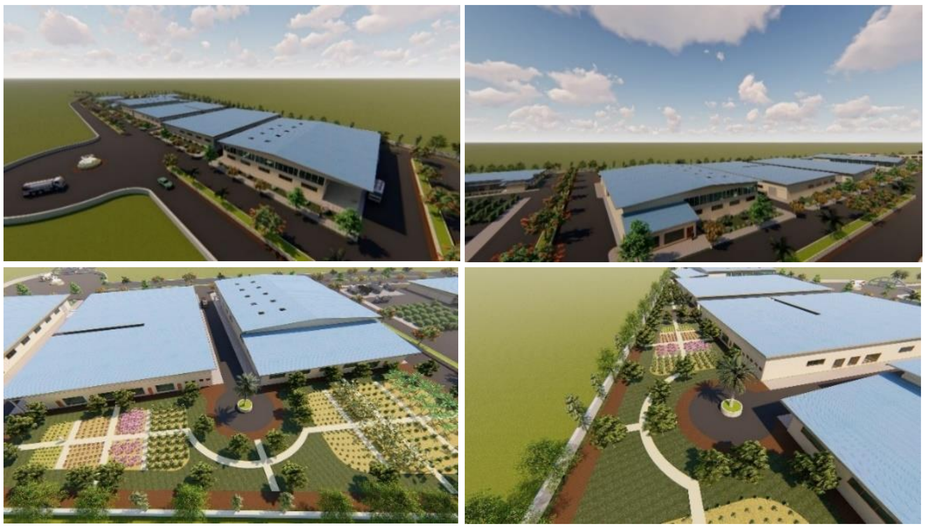

Figure 46: Site view, Shades, Agricultural area

Source: Own Computation

General Condition of Design Proposal

In general, the design is aimed at aiding the already existing recycling process of organic waste into a compost product. The design also aims in paving a way for further investigation into the recycling sector for the city and the country itself. It works in the integration of the community with the facility in order to increase awareness of recycling and cooperation between the city administration's waste management system and the community from which the waste is generated.

The residential area is created to house those that have come for visiting purposes and other meeting purposes. Employees are provided with buses for transporting them from their homes to their workplaces as the area is a residential area.

The service area is provided to overlook the general conditions of the industry by controlling and overlooking every process on the site. An exhibition hall is a place where the different recycled and composted materials are showcased for visitors in order to educate and emphasize the importance of recycling and reusing materials and wastes.

The administration zone is a zone categorized under the Non-Public area where the overall administration of the site is managed. A restaurant is a place where both employees and visitors can access it. Different visitors coming from the exhibitions halls and employees can access this restaurant which has an open space for eating as well.

The shades are categorized under the Non-Public zones of the industrial zone. In the design proposal, the first and last shade serve more or less the same purposes by which the waste coming to the center is loaded and unloaded processed, and stored. The other two shades house different facilities including clinics, warehouses, and other facilities

The research center is placed away from the other facilities and is categorized under the Non-Public zone. Their location is strategical as this is a zone where chemical processes are held in different laboratories. The treatment plant is placed in this section of the site while the piece of land left is for further expansion purposes

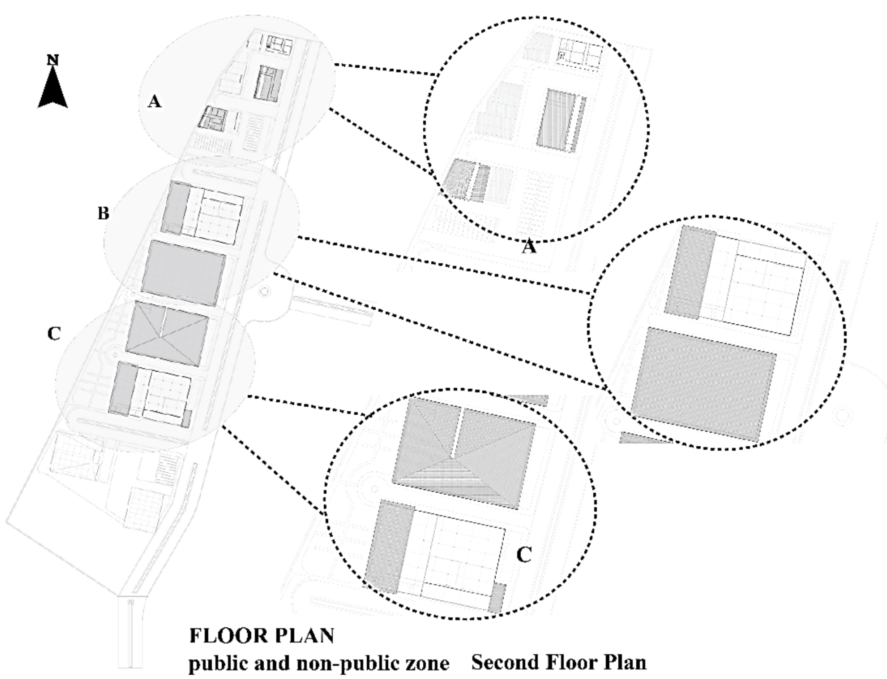

Figure 47: Second Floor Plan

Source: Own Computation

The Agricultural areas are placed in order to create an enhanced community involvement to educate the use of compost through the use of the compost as a growing medium for different fruits and vegetation.

Figure 48: Cafeteria and Agricultural land

Source: Own Computation

The solid waste selling and buying area is a place where the community can engage in the recycling center through the selling of solid waste to the center and buying of solid waste from the center which will enhance the community's involvement in solid waste management through home sorting, reusing, and recycling of solid waste

Figure 49: Shade for buying and selling solid waste

Source: Own Computation

Buffer zones are provided as green areas that will help shield the shade visually from the surroundings and reduce the noise pollution both ways from outside to inside and inside to the outside of the site in addition to separating the residential zone from the potential industrial zone it also serves a barrier for odor and smells that might arise from the site.

An expansion site exists in case the center requires a further expansion in the future in order to incorporate other materials recycling such as plastic and paper. The site can also act as a temporary transfer station for the design.

Figure 50: Buffers of the site, Road features

Source: Own Computation

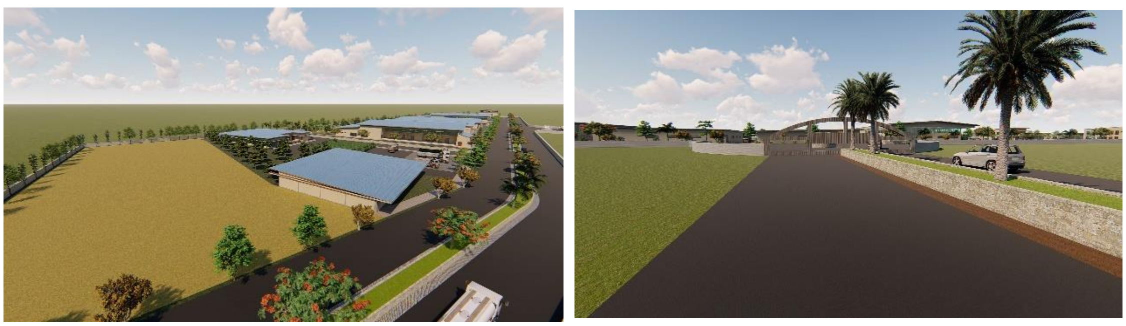

Figure 51: Expansion site, Road features

Source: Own Computation

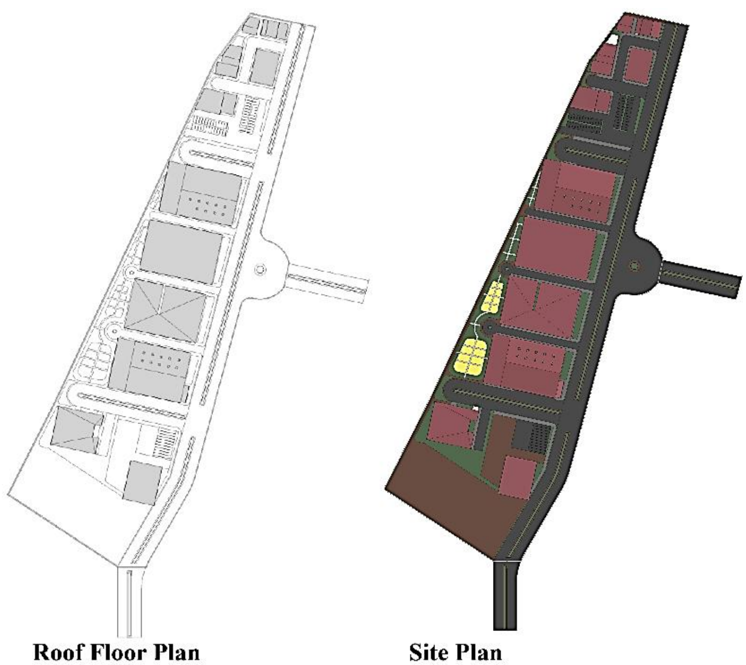

Figure 52: Roof and Site plan

Source: Own Computation

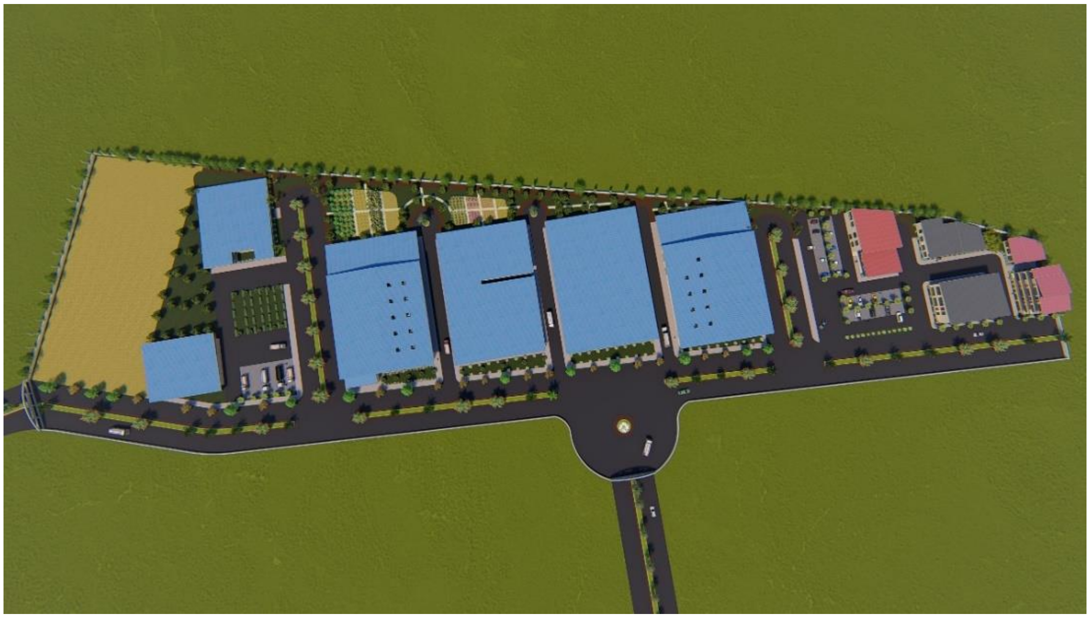

Figure 53: 3D Development of the Site

Source: Own Computation

4.8.4.3. Proposed Design Summery

In conclusion, this research is concerned with providing systems by which waste is connected with the city, its inhabitants, and the planning and design of a city through the integration of form in space. This research provides a plan design of a project in the city of Adama that is concerned with the recycling of solid waste generated in the city. The design tries to first look at the NAMA compost project in the city in order to provide an enhancing proposal for the project through the design works in solving many problems that the current management of the project and city have been facing. The design shows provisions of basic infrastructures and services required by any industry like a center that works in the production process. These infrastructures lacking in the current system provided in the design include administration centers, industrial centers, research centers, recreation areas, and farm areas for showcasing products produced in the center. The research aims in finding methods of encouraging people to further look into proper waste management and understand the significance of waste reducing, reusing, and recycling to benefit themselves, their cities, and the natural environment. The design also provides an expansion area and site that can be utilized for further enhancement of the site if deemed necessary. It is also a mandatory fact that production purpose facilities require provisions of expansion due to the existence of different activities and the need for flexibility.

4.8.4.4. Waste Recovered from The Solid Waste Recycling Center of The NAMA Compost Project

New Solid Waste Recycling Center Capacity of Waste Reduction

The newly designed solid waste recycling center seats in an area of 40,000m^2 by which the total production area is that of a lightweight industry plant. The lightweight industry plant is segregated into 4 shades by which the areas for the production include the loading and unloading areas, production floor, raw material storage, warehouse, and packaging.

The current NAMA compost project's total production area is about 2000 m^2 and its total capacity of waste collected accounted for about 1760 tons of organic waste in a year from the two kebeles of the city with a total of 880 tons of compost being produced. This means that only half of the organic waste collected is composted and the left half is either used as another bi-product for further composting or is sent to the landfill.

The newly designed Solid waste recycling center can collect organic waste of about 8,800 tons from the two kebeles in a year which is more than triple the organic waste collected in the current condition of 1760 tons of organic waste. The amount of organic waste processed and composted in the newly designed solid waste recycling center is about 4000 tons of waste per year which is about quadrupled the current composting potential.

Sustainable Solid Waste Management

The newly designed solid waste recycling center is able to break through the three main challenges of sustainable solid waste management through the implementation of the 5 main incentives of sustainability.

1. Waste is full of useful resources.
    - By working in composting and recycling of the waste.
    - By collecting different types of waste for recycling and then repurposing.
    - By recycling the waste, the city will be able to market the products both domestically and outside the city.
    - The increased marketing potential of the recycled materials will create economic advantage for the city.
    - The solid waste recycling center has facilities provided for buying and selling of the waste and the finished product respectively from the community.

2. Waste diversion can be less expensive than landfilling
    - By collecting the waste from different areas of the city and reducing the amount of waste sent to landfill.
    - As less and less waste is sent to landfill the cost of transportation is reduced.
    - The cost of man power, equipment and transportation facilities required for sending waste to the land fill is reduced.
3. The increased public awareness of the impacts of waste on the environment
    - The designed solid waste recycling center is community-oriented recycling center that involves the community and integrates itself with its surrounding residences.
    - Different facilities are provided for the further integration of the public and the center. Such facilities include
        - Public zones: cafeterias, exhibition halls, residences, agricultural area which area accessible for the general public so that they can look at the different recycled materials, for instance: organic wastes recycling to the compost, and see the benefits of compost through the agricultural areas and exhibition areas.
        - Other zones such as buying and selling of waste and processed products respectively gives opportunity for public engagement in giving notice that waste is a resource, the waste can harm the environment if not managed, waste can be important economic factor and so on.
4. Waste regulation is becoming more rigid
5. Incentives towards taxes, permitting bonds, plan reviews, inspections, and others
    - The solid waste recycling center will further give opportunity for the municipality of the city to engage in solid waste management that is both environmentally sustainable and economically feasible. This can be achieved through enforced rules, regulations and incentives that will further contribute to solid waste recycling trend and movements.

Summery

The research employed the use of qualitative data and quantitative data through the self-administered questionnaires, in-depth interviews, field surveys (primary sources of data), and desk reviews of documents (secondary sources of data) to accomplish the objectives set for the research. The research conducted estimation of the population and solid waste generation of the city by the use of initial population and growth rate of both the population and solid waste by which the result revealed that Adama city will keep on increasing her general solid waste generation in the future. This implies that the city will require a solid waste management system that is well organized to deal with the rising waste.

The whole result showed that the NAMA compost project is insufficient and lacking in the sectors of both management of the organic waste that it processes and the required facilities that are lacking for the management system of the project. The respondents pointed out that they were in dire need of basic services and infrastructural support to accommodate a smooth running of their work process. The site observation and in-depth interview were provided in combination to show the general condition of the solid waste management of the compost project to better understand the project and provide conclusive evidence on its shortcomings.

Hence the research puts forward a design solution with proper planning which project provided can be used as a baseline in further research and projects throughout the cities of Ethiopia, it will also work in providing awareness for people on waste recycling potential to create a symbiotic relationship between the city, its people and their waste with proper allocation of space through Architecture.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

- Waste generation is directly proportional with population increase and each of them go hand in hand because of the consumption increase of the population that will result in general waste increase.
- From the conducted questionnaires the researcher was able to conclude that the city of Adama is currently engaged in a composting and recycling process which means the city is in the movement toward waste reuse and recycling. Even though this movement exists there is a lack of awareness among the community and a lack of dedication from the municipality of the city. The municipality is giving less attention than the project deserves therefore the project needs to be well recognized both by the communities and the municipality of the city because their involvement in the project will help the associations achieve their goals of educating and providing well-prepared compost to different organizations. And that if the compost project can be aided with the creation of a solid waste recycling center it will further increase their achievements.

- Currently, the city’s current practice in the composting system is working in creating natural compost that is showing great promise through the National Appropriate Mitigation Action compost project located in the city.
- NAMA is currently in movement towards organic waste recycling yet it faces sustainable waste management challenges which include marketing insufficiency, lack of storage space and community awareness.
- NAMA compost project lacks basic infrastructure and service provisions.
- The recycling potential of the NAMA compost project is still the same while the waste generation of the city is increasing.
- The newly designed NAMA recycling center fulfills the three incentives of sustainable solid waste management through community involvement and standardized provision of infrastructure and services.

5.2. Recommendation

Through the aid of questionnaires and field studies, the solid waste management system of the city of Adama was assessed as the information acquired was from secondary sources of information. Further studies were also conducted on the city's National Appropriate Mitigation Action compost project in which direct observation and field studies provided information on its current condition and management system. This information has further shed light on the recycling practices of the city of Adama to provide a primary baseline for the research's main aim of providing a design of a solid waste recycling center.

Therefore, the following recommendations are provided to aid in future developments related to the research for better implementation of the two basic incentives concerning the sustainable solid waste management

- The city of Adama should develop better strategies for controlling and monitoring its solid waste management system to properly execute its duties of managing the solid waste generated by the habitants of the city.
- The city with the aid of different governmental (city administration and municipality) and non-governmental (institutions and organizations) should work on paving the way to the recycling and reusing systems of management by providing rules and regulations that support the implementation of centers (recycling centers) dedicated for such purposes.

- The city is working on an integrated solid waste management system that is on the right track but also needs to be further studied and implemented for increased results.
- The planning and design of a solid waste recycling center for the National Appropriate Mitigation Action compost project of the city will better increase the output and productivity of the project's system of management as it will pave the way for further recycling of material such as plastic and paper and other recyclable solid wastes which will aid in the cities economic benefit towards the economic sector.
- As understood from the research the solid waste generation of Adama city is increasing with the rise of the population. The newly designed proposal of solid waste recycling center has recovered a combination of organic waste more than the two kebeles total organic waste generation this means the Adama city will benefit greatly if there are such sites provided in numbers with the proper site, infrastructure, and service provisions.
- The newly designed solid waste recycling center will also give opportunity for the further recycling of liquid wastes, for instance urine has high nitrogen content which makes it favorable in the decomposition process for the compost production.

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APPENDIX

Appendix I

Sample no: -----------------

Date: -------/-------/--------

Questionnaires were prepared for National Appropriate Mitigation Action (NAMA) composting project members.

In order to gather initial insight and information regarding the assessment and analysis of the existing National Appropriate Mitigation Action (NAMA) composting project of Adama city, this simple questionnaire was provided to the members working at that company. The questions are centered on identifying the general insight these members have regarding their work sector as it is necessary to view the condition in the eyes of its attendants and to acquire the understanding these people have towards the enhancement of the project into a standard solid waste recycling center. The study will be a baseline for the further study of solid waste management and co-operative to decide on appropriate Technology for solid waste management and reuse in order to profit environmental, economic, and social aspects of the city of Adama and her other sister cities. Thus, your genuine responses are extremely important for the success of this research.

The respondents are respectfully inquired to respond freely, confidently and as honestly as possible as the information requested is purely for Academy. Thank you for accepting the questionnaire.

General information

Please put √ in the appropriate box/ boxes for your answer

1. Sex
    1. Male ☐
    2. Female ☐
2. What is your insight on your work area regarding the services provision?
    1. Satisfied ☐
    2. Dissatisfied ☐

3. Could you please elaborate on the reasons for your answer for question number 2?

____

____

4. Could you be kind enough to elaborate on your work performance due to the case site conditions?

____

____

5. Do you think the problems on the case site can be solved through Architectural design, If so? What areas should be addressed in the design?

____

____

6. Do you agree on enhancing National Appropriate Mitigation Action (NAMA) station in to solid waste recycle center?
   1. Yes ☐
   2. No ☐

   What is the reason for your answer?

____

____

7. What is the NAMA compost projects Marketing potential and how is it going?

____

____

Appendix II

Interview for National Appropriate Mitigation Action (NAMA) composting project stakeholders with selected municipal administrative bodies and involved organizations.

1. What is the solid waste management system of Adama city?
2. What are the current movements that exist in the solid management system of the city?
3. What is the National Appropriate Mitigation Action (NAMA) compost project? When and how was it coined?
4. What is the purpose and goal of the National Appropriate Mitigation Action (NAMA) compost project? And how many of its goals were accomplished during its existence?

5. What are the management system of the project and the available workspaces of the project? And is the existing workspace of the project fulfilling standard architectural requirements and building regulations? Please explain your answer?
6. What is your suggestion for the future of the project?
7. What do you think about enhancing the NAMA compost project located in Adama city into a solid waste recycling center?

Appendix III

Verbatim Responses Question # 5

- There was a section of respondents that were unaffected by the general condition of the site because of shifts for work and absences.
- Lack of standard production area
- Insufficiency of space in the production area concerning storage area for raw materials (Organic waste), inputs such as feedstocks, equipment, and finished material.
- Insufficiency of production space for three associations in row placing.
- Lack of proper provisions concerning toilets, offices, and cafeterias.
- Lack of sufficient water supply
- Lack of proper drainage for waste water of organic waste
- Unsanitary sewerage system
- proper and well sanitary Toilets

Appendix IV

Verbatim Responses Question # 7

- Work performance is hindered as a result of a lack of basic services and infrastructures such as storage space for equipment and materials.
- Work performance is affected by the insufficiency of space for the composting process primarily turning of organic waste.
- Because of dissatisfaction in the work area, employees lack the initiative to work and produce more.
- Even if workers finish products lack of marketing hinders their production as the finished products are not sold.

- Some respondents as mentioned in the "**# 5**" response was not that bothered by the situation.

Appendix V

Verbatim Responses Question # 8 and #9

- Respondent's response was separated into two one believing that architecture is the solution while the other was against the idea.
- Respondents in favor of architectural solutions believed that the integration of architecture with their compost project will promote more productivity and more output.
- They believed that architecture meant that basic services and infrastructures will be provided as such. They, therefore, believed that offices, organized production spaces, cafeterias, proper drainage systems, and stores can be provided by architecture implementation.
- These respondents were in favor of enhancing the current NAMA compost project into a well-organized solid waste recycling center.
- Respondents against the proposed solution believed the area is not fit because of its location in residential areas, the site's lack of space, and the general position of the site. They were as such against the enhancement of the area as they believed it need more modification to consider this solution

Appendix VI

Verbatim Responses Question # 10

- The marketing potential of the NAMA compost project is very lacking and most of the time finished products are left in the shade for longer periods.
- Lack of awareness among the community at large, and among both governmental and non-governmental organizations.
- Even if there is recognition in the municipality office of Adama city, there is disregard for the issue to make it a larger project.
- Because of this disregard members are less motivated in their work and only do it for pay and not for the importance of the general project for the city

Figure 54: Site Inventory
Source: Field survey

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