FACTORS AFFECTING MATERIAL WASTE MANAGEMENT IN CONSTRUCTION PROJECTS: THE CASE OF ADDIS ABABA BOLE INTERNATIONAL AIRPORT EXPANSION PROJECT

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Factors Affecting Material Waste Management in Construction Projects: The Case of Addis Ababa Bole International Airport Expansion Project

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DECLARATION

I, Feven Hailu, declare that this thesis is my original work and has never been presented to any university or any other Institutions for the award of a degree or any other award. I have made it independently with the close advice and guidance of my advisor; and that all sources of materials used for the study have been duly acknowledged.

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CERTIFICATION

This is to certify that the thesis work entitled “Factors Affecting Material Waste Management in Construction Projects: The Case of Addis Ababa Bole International Airport Expansion Project” submitted in partial fulfillment of the requirements for the award of the degree of Masters of Project Management to the College of Business and Economics, St. Mary’s University; through the Department of Project Management, is done by Miss. Feven Hailu.

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ABSTRACT

This study investigates the factors affecting material waste management in the AABIA Expansion Project. The research employs qualitative and quantitative data collection techniques, including interviews, surveys, and document analysis. Stratified random sampling was used to sample 212 respondents, in which 151 were used for analysis. Data was collected through questionnaires and analyzed using SPSS, using frequency descriptions analysis. The findings reveal that a complex interplay of factors, including project planning, material procurement, construction practices, and waste management systems, significantly influences material waste generation. A key finding is the critical role of effective project planning in minimizing material waste. Detailed material take-offs, optimized material delivery schedules, and the implementation of lean construction principles emerged as crucial strategies to reduce excess material and minimize waste generation. Additionally, the procurement process was identified as a significant factor, with careful material selection and supplier evaluation playing a pivotal role in ensuring the acquisition of appropriate materials and minimizing waste. Practices, such as waste segregation, recycling, and reuse, were found to be essential in reducing the environmental impact of the project. The establishment of efficient waste management systems, including waste collection, transportation, and disposal, was also highlighted as a crucial component of effective waste management. However, challenges such as a lack of awareness, inadequate infrastructure, and limited financial resources hindered the implementation of optimal waste management practices. To address these challenges and promote sustainable construction practices, several recommendations are proposed. These include the development of a comprehensive waste management plan, the adoption of advanced technologies such as Building Information Modeling (BIM), the establishment of a strong material tracking system, and the implementation of strict waste reduction targets. By embracing these recommendations and fostering a culture of sustainability, the construction industry can reduce material waste.

Keywords

material waste, construction waste, construction projects, waste management, sustainable construction, AABIA, project planning, material procurement, construction practices, waste reduction, environmental impact.

ABBREVIATIONS/ACRONYMS

AABIA – Addis Ababa Bole International Airport

BIM - Building Information Modeling

C&D - Construction and Demolition

IBM - International Business Machines Corporation

LCA - Life Cycle Assessment

SPSS - Statistical Package for the Social Sciences

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CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Construction projects are more often than not plagued by poor performances such as delays, cost overrun, low productivity, construction wastes and compromised quality. Amongst the critical contributory factors of poor project performances, is the ineffectiveness of materials management occurring in the construction sites. Materials management is a very important component for construction projects. (Zairra Mat Jusoh, and Narimah Kasim, 2017)

Material waste management in the construction industry has become a pressing issue due to its significant environmental, economic, and social implications. Waste from construction projects frequently produces large volumes and includes materials such as concrete, wood, metal, and plastics. Such waste can lead to resource depletion, pollution, and congestion at landfills. The construction industry significantly contributes to global waste production, generating a substantial portion of the waste in landfills. Estimates suggest that construction and demolition activities account for approximately 40% of the total solid waste generated worldwide. This waste includes concrete, wood, metals, glass, plastics, and other debris. This waste's sheer volume and diverse nature pose significant challenges for effective disposal and management (Hoang, N. H., Ishigaki, T., Kubota, R., Yamada, M., & Kawamoto, K., 2020).

The AABIA Expansion Project is a large-scale infrastructure development that generates significant amounts of material waste. As a major construction project, it represents a typical example of the challenges faced in managing waste in the construction sector.

Previous studies on material waste management in construction projects have primarily focused on the factors influencing waste generation, such as project size, type, and construction methods. However, there is a dearth of research specifically investigating the effects of material waste management in Addis Ababa specially in large scale projects such as the airport expansion projects which generate large amount of waste. While existing studies provide valuable insights, they may not adequately address the unique challenges and opportunities presented by Addis Ababa's construction projects such as Bole airport terminal expansion project.

This study aims to fill this gap by examining the factors that affect the material waste management in this specific mega scale project within the expansion project scope by identifying and analyzing the key factors influencing material waste management. This study contends that by identifying the influential factors affecting materials management, it will help construction players to avoid the occurrence of those factors and will minimize the negative effects on the overall performance of construction projects.

1.2 Statement of the Problem

Material waste management is a critical aspect of sustainable construction and has a significant impact on project costs, environment, and overall project quality. The study will explore the factors affecting the material waste management in the construction process of the airport expansion project.

The construction industry is a significant contributor to waste generation, including material waste. This waste can have negative environmental, economic, and social impacts. To address this issue, it is crucial to understand the factors that influence material waste management in construction projects.

Construction material waste management has been a significant concern worldwide. Studies have identified various factors contributing to waste generation. For instance, Al-Tabbaa and Al-Tabbaa (2016) examined the impact of project size, construction methods, and material procurement on waste generation in the United Kingdom. Their findings revealed that larger and more complex projects tend to produce higher levels of waste. Similarly, Huang et al. (2017) investigated the role of material handling and storage practices in waste reduction. They concluded that efficient management of materials can significantly minimize waste.

In developing countries, construction material waste management faces unique challenges due to limited resources, infrastructure, and regulatory frameworks. Kumar and Rajagopalan (2018) studied the factors influencing waste generation in Indian construction projects. They found that informal construction practices, lack of awareness about sustainable practices, and economic pressures contribute to higher waste levels. Olaniyi and Oladele (2019) conducted research in

Nigeria and identified similar issues, emphasizing the need for improved waste management systems and regulations.

While specific studies on large scale projects construction material waste management in Ethiopia may be limited, several studies have been conducted regarding construction material waste in general. Ethiopia shares many characteristics with other developing nations. Based on the broader trends in developing countries, it is likely that factors such as rapid urbanization, informal construction practices, and limited infrastructure play a significant role in waste generation in the country. For instance, Asmara Seyoum (2015) provided insights into the managing and minimizing wastage of construction materials in the Addis Ababa's context. The study assessed the then current situation of wastage management and minimization and recommended that there is a need to establish a new construction waste department to develop waste management policies and develop the effective strategy to reduce construction waste, since there was a gap in policy of waste management from the government. The study also recommended contractors to assign qualified staff and workforce in construction projects and to prepare waste management plans.

This study aims to investigate the specific factors that contribute to material waste generation in the context of the Addis Ababa Bole International Airport Expansion Project. By identifying these factors, the study will provide valuable insights for improving material waste management practices in the project and potentially other construction projects in Addis Ababa and beyond.

1.3 Research Questions

1. What are the primary sources of material waste in the Addis Ababa Bole International Airport Expansion Project?
2. What are the current waste management practices and policies in place for the project, and how effective are they in reducing material waste?
3. What are the challenges and barriers to implementing effective material waste management strategies in the project?
4. What are the environmental, economic, and social effects of material waste generation in the project?

1.4 Objectives of the Study

1.4.1 General Objective of the study

The General objective of this study is to find out the factors that are affecting material waste management in the Addis Ababa Bole international airport expansion project.

1.4.2 Specific Objectives of the Study

1. To identify the factors that contribute to material waste generation in the Addis Ababa Bole International Airport Expansion Project.
2. To identify and evaluate current waste management practices in the project,
3. To identify effective strategies for reducing material waste in the project.
4. To identify the environmental, economic, and social effects of material waste in the project.

1.5 Significance of the Study

The researcher believes that this study will be of a great input to the Airport expansion project by identifying the factors that affect material waste and the waste management practices that have influence the project significantly, the effects they have on the project, its stakeholders and the environment around it. The research will be an input in the process of proposing ideas on how to improve the current material waste management issues the project has been facing.

The study on will have significant implications for both the project itself and the broader construction industry in Addis Ababa and Ethiopia. The study has identified specific factors contributing to material waste in the project, allowing for targeted interventions to reduce waste generation and improve overall waste management practices. By reducing material waste, the project can contribute to environmental sustainability by minimizing pollution, and resource depletion.

Effective waste management can lead to cost savings through reduced disposal fees, material reuse, and improved productivity. Reducing material waste can contribute to improved health and safety for workers and local communities by minimizing exposure to hazardous materials. The study will provide valuable insights for developing and implementing effective waste management policies and regulations in the construction industry. The findings of the study can be shared with other construction projects in Addis Ababa and Ethiopia to promote best practices in material waste management. The project can serve as a case study for future research on material waste management in construction projects, providing valuable data and insights for academic and industry professionals.

In summary, this study has the potential to make a significant contribution to improving material waste management practices in the Airport Expansion Project and beyond, leading to environmental, economic, and social benefits.

1.6 Delimitation/Scope of the Study

Thematic Scope

This study focused on investigating the factors that contribute to material waste generation and how waste is managed in the context of the AABIA Expansion Project. The scope of the study included identification of primary sources of material waste, assessment of factors contributing to waste, analysis of current waste management practices, identification of challenges and barriers in waste management, evaluation of environmental, economic, and social impacts, exploration of innovative solutions and development of recommendations.

Geographical Scope

The study is limited to the Addis Ababa Bole International Airport Expansion Project and did not extend to other construction projects in the city. The Project is Located at Addis Ababa city, Bole Sub city, Wereda 04.

1.6.1 Limitation of the Study

This study, while providing valuable insights into the factors affecting material waste management in the Addis Ababa Bole International Airport Expansion Project, is subject to certain limitations. The primary limitation is the scope of the study, which is confined to a single project. While the findings may be applicable to other similar projects, generalizations to a broader context should be made with caution. Additionally, the study relied on data collected through interviews, surveys, and document analysis. While these methods provide rich qualitative data, they may be subject to biases and limitations in terms of respondent recall and interpretation.

Another limitation is the time frame of the study. The construction industry is dynamic, and changes in regulations, technologies, and industry practices can impact waste management practices. Therefore, the findings of this study may not be entirely reflective of current trends and future developments in the industry. Furthermore, the study did not explore the specific costs associated with material waste generation and management. A more detailed economic analysis could provide further insights into the financial implications of waste reduction strategies.

1.7 Operational Definition of Terms

- **Project Size and Complexity:** The total budget, number of contractors involved, and the complexity of the project's design and construction phases.
- **Project Duration:** The total time elapsed from project initiation to completion, including any delays or extensions.
- **Lack of Coordination:** The frequency and severity of communication breakdowns between design, procurement, and construction teams.
- **Material Handling:** The efficiency and safety of material handling practices, including factors such as proper storage, transportation, and use of equipment.
- **Construction Methods**: The techniques and procedures used in construction, including factors such as the use of modern technologies, adherence to best practices, and efficiency of processes.
- **Site Management:** The effectiveness of overall site management, including factors such as supervision, safety measures, and adherence to environmental regulations.
- **Material Waste:** The quantity of materials that are discarded or lost during the construction process, measured in terms of weight or volume.
- **Waste Reduction:** The implementation of strategies and practices to minimize material waste, measured by the percentage reduction in waste compared to baseline levels.
- **Recycling and Reuse:** The recovery and repurposing of waste materials, measured by the quantity of materials recycled or reused.

1.8 Organization of the Study

The research paper is structured with five chapters. The first chapter begins with background of the study and general introduction to the research to problem, statement of the problem, research questions, the general and specific objectives of conducting the research, significance of the study, the scope of the research, Operational Definition of Terms and the outline of the research. In chapter two, related literature review from professional journals, magazine articles, and different research materials obtained from several sources and internet searches are dealt with, which essentially have provided a review of the factors affecting material waste management in different construction projects. The third chapter presents the research methodology including the research design, data collection methods, population and sampling and data analysis techniques used in order to achieve the objectives of the study. Chapter four will analyze and presents the research findings that will be obtained. In chapter five the research summary and conclusions and recommendations are presented based on the research findings. At the end of the document, references and a set of appendices are included.

CHAPTER TWO

2. LITRATURE REVIEW

2.1 Introduction

The construction industry, particularly large-scale projects like airport expansions, generates significant amounts of waste. This waste can have negative environmental and economic implications. This literature review will explore the factors that influence material waste management in construction projects as a theoretical and empirical reviews.

2.2 Theoretical Review

Construction material waste management has emerged as a significant global concern due to its environmental, economic, and social implications. This review explores the theoretical underpinnings of the subject, providing definitions, concepts, and theories that guide research and practice. This area explores concepts such as systems theory, waste hierarchy, and life cycle assessment. These frameworks provide guidance for sustainable waste management practices, emphasizing the importance of reducing, reusing, and recycling materials. Additionally, theories from systems theory and behavioral psychology help understand the interconnectedness of waste management systems and the factors influencing human behavior in relation to waste generation and disposal.

2.2.1 Definitions and Concepts

"Construction waste" means any substance, matter or thing which is generated as a result of construction work and abandoned whether or not it has been processed or stockpiled before being abandoned. It is a mixture of surplus materials arising from site clearance, excavation, construction, refurbishment, renovation, demolition and road works including but not limited to debris, scraps, and leftovers (Construction waste, 2020). Waste can be solid, liquid or gas, each of which have their own methods of management and disposal.

Waste Management is the systematic collection, storage, transfer, processing, and disposal of waste materials. It encompasses a wide range of activities aimed at minimizing the negative impacts of waste on the environment and public health. Put simply, waste management enables the world to look after the cleanliness of the environment. The way in which waste is managed can have a significant impact on the environment and the entire population's health, so it's vital that measures are in place to effectively manage and dispose of these materials. Failure to implement appropriate waste management techniques can lead to environmental concerns and health issues. (Recycling Bristol, 2020)

2.2.2 Theories and Frameworks

Project management literature on waste management strategies primarily focuses on construction and demolition (C&D) waste due to its significant environmental impact.

As per (Fatemi, 2012) Key strategies include the following:

- **Waste Reduction:** Minimizing waste generation through efficient design, material selection, and construction practices
- **Reuse:** Utilizing materials on-site or for other projects
- **Recycling:** Processing materials for reuse as raw materials
- **Recovery:** Extracting energy or other resources from waste
- **Disposal:** Landfilling as a last resort

Specific examples of project waste management strategies include the following:

- **Waste Management Plans:** Detailed plans outlining waste reduction, reuse, recycling, and disposal targets and procedures.
- **Material Take-Off (MTO):** Accurately estimating material quantities to minimize over-ordering and waste.
- **Waste Audits:** Assessing waste generation and identifying opportunities for improvement.
- **Recycling Programs:** Establishing systems for collecting and processing recyclable materials.
- **Waste-to-Energy Facilities:** Utilizing waste as a fuel source for energy generation.

1. **Systems Theory**: emphasizes the interconnectedness of components within a system. In the context of construction material waste management, it highlights the importance of considering the entire waste stream, from generation to disposal, as a holistic system. This theory emphasizes the interdependence of various components within the waste management process, from waste generation to disposal. By considering the entire system, rather than individual components in isolation, systems theory allows for a more holistic and effective approach to waste management. This perspective enables the identification of potential synergies and trade-offs between different elements of the system, leading to more sustainable and efficient waste management strategies. (Bertalanffy, 1968)
2. **Life Cycle Assessment (LCA):** A method for assessing the environmental impacts of a product or process throughout its entire life cycle, from cradle to grave. LCA can be used to evaluate the environmental performance of different construction materials and waste management strategies. LCA considers various stages such as resource extraction, manufacturing, transportation, use, and end-of-life disposal, assessing the environmental impacts associated with each stage. By providing a holistic perspective, LCA helps identify opportunities for reducing environmental burdens and promoting sustainability. (ISO 14040: Environmental management — Life cycle assessment — Principles and framework. ISO, 2006)
3. **Waste Hierarchy:** A framework that prioritizes waste management options based on their environmental impact. The hierarchy typically ranks waste reduction, reuse, recycling, and disposal as the preferred options. The Waste Hierarchy is a concept that outlines the options for managing waste in the most environmentally friendly manner. It establishes the preferred methods for managing waste based on sustainability and ensures as much waste as possible is reprocessed into beneficial products. (Recycling Bristol, 2020)

    - **Prevent –** Produce less waste in the first place by using less, keeping things longer, reusing products or machinery and reducing hazardous contents.
    - **Prepare for Reuse –** Check, clean, repair or refurbish waste products to be used again.

- **Recycle –** Waste materials can be recycled and converted into a new product.
- **Other Recovery –** Waste that cannot be recycled is converted into usable forms of energy, such as heat, light and electricity.
- **Dispose –** If waste can't be recovered, reused or recycled, it will be either taken to a landfill site or incinerated.

4. **Institutional Theory:** This theory examines how organizations are influenced by external pressures, such as regulations, norms, and cultural values. In the context of waste management, institutional theory helps explain why certain practices, like recycling or composting, become more widespread while others, like landfilling, may decline. Additionally, it can shed light on the role of regulatory frameworks and public opinion in driving changes in waste management behavior. (Meyer, J. W., and Rowan, B. , 1977)

Interdisciplinary Approaches

Construction material waste management is a complex issue that requires a multidisciplinary approach. Relevant theories and concepts can be drawn from fields such as:

- **Environmental Science:** To understand the environmental impacts of waste generation and disposal.
- **Engineering:** To develop innovative technologies for waste reduction, reuse, and recycling.
- **Economics:** To assess the economic costs and benefits of different waste management strategies.
- **Sociology:** To study the social factors that influence waste generation and disposal behavior.
- **Psychology:** To understand the psychological factors that motivate or hinder sustainable waste management practices.

By examining concepts such as waste hierarchy, and life cycle assessment, researchers and practitioners can develop effective strategies to minimize environmental impacts and promote sustainable practices. Furthermore, exploring theories from systems theory and behavioral psychology provides insights into the interconnectedness of waste management systems and the factors influencing human behavior in relation to waste. Overall, these theoretical frameworks offer a valuable foundation for addressing the challenges and opportunities associated with construction material waste management.

2.3 Empirical Review

Existing research on material waste management in construction projects highlights several key factors influencing its occurrence. Design errors, changes, and inadequate specifications are often cited as significant contributors. Lack of proper material handling, storage, and transportation practices can also lead to waste. Poor site management, including inadequate supervision and coordination, can exacerbate material wastage. Procurement issues, such as over-ordering or purchasing low-quality materials, can also contribute to the problem. Additionally, environmental factors, such as weather conditions and site constraints, can impact material usage and waste generation.

Al-Ghzawi, (2023), conducted a study titled Optimizing the construction planning of airport expansion projects and stated the following:

> *To address the steady increase in air travel in recent years, there is a pressing need to expand and modernize many of the existing airports in the US that serve more than three million daily passengers. Airport expansion projects often include construction of new terminals, expansion of existing terminals, and construction of new runways and taxiways. These projects often cause disruptions and delays in air traffic due to their impact on the number, length, and capacity of operational airport runways and/or taxiways…Accordingly, airport and construction planners need to carefully analyze and optimize the construction planning of airport expansion projects in order to minimize construction-related disruptions in airport operations while keeping total construction cost to a minimum.*

Cobbina *et al.* (2021), conducted a study in Ghana titled Waste Management Practices of Construction Companies at the Airport Hills and Sakumono Areas in Accra, Ghana, and concluded:

Waste generated in the construction industry is a major environmental problem but its research is rather limited. Thus, this research was conducted to assess the waste disposal practices of construction companies at the Airport Hills and Sakumono areas in Accra, Ghana. These areas were chosen because of the increasing and fast development of housing projects there. A convenience sampling technique was used in choosing the companies to achieve the research goal. Questionnaires and field observations were used to gather information about the construction companies and their waste management practices. Forty construction companies were identified in both study areas. Majority of the companies recorded a total of 60-80 cubic meters of material waste per month. Eleven companies stated amounts of between USD 250 - 350 as cost of material waste management per month. Several reusable materials were identified at construction sites. Twenty-six companies practiced sorting and recovery of waste before final disposal. It was revealed that there was no statistically significant relationship between the educational levels of waste management teams of the construction companies and their practice of proper waste management methods. A significant relationship however existed between the educational level of waste management teams and their use of waste management plans. It is recommended that waste management training programmes are developed by the Environmental Protection Agency of Ghana for construction companies to curb the problem of poor construction waste management.

Meng *et al*. (2024) stated in their research that environmental problems including the depletion of natural resources and energy have drawn a lot of attention from all sectors of society in the context of high-quality global development, and solid waste generated by the construction industry accounts for 36% of the total amount of municipal waste. The generation of large amounts of construction waste not only causes a waste of resources, but also causes great damage to the environment. Reducing the quantity of solid waste produced during a building's new construction period can be greatly aided by construction site solid waste statistics and forecasts.

Based on the statistical data of 61 public construction projects in Hainan Province, China, their study used the Random Forest algorithm to rank the importance of possible factors affecting the amount of solid waste generated, and linearly fits the data to achieve the prediction of solid waste at construction sites. Their findings indicate that, building area, building height, concrete usage, steel usage, and assembly rate are the main factors affecting solid waste in construction sites. In office buildings and exhibition buildings, an increase in ground area, building height, concrete usage, and steel usage increases the generation of each type of solid waste (inorganic non-metallic solid waste, metallic solid waste), with the exception of an increase in concrete usage, which results in a decrease in the generation of metallic solid waste. Furthermore, a higher assembly rate can substantially lower the production of all waste types. These results offer a theoretical foundation for the implementation of assembly construction to support the high-quality development of the construction industry, as well as partial design inspiration for the architectural design stage.

A research conducted by (Mohammed baqer Almusawi, Saleem Ethaib and Karim, 2022) aimed to evaluate Kuwait's construction and demolition waste (C&D waste) situation by focusing on C&D waste generation and management issues. The results showed that the average C&D waste quantities generated by construction activities were 49.5 kg/m^{2}for public/commercial building projects and35 kg/m^{2}for residential projects. At the same time, public/commercial construction, residential construction, and demolition works generated 1.480 ton/m^2, 0.0495 ton/m^2, and 0.035 ton/m^2, respectively. The average composition of C&D waste from the construction sector was 35.4% concrete waste, followed by 19.2% tiles/blocks, and 14.2% metals, with the remainder being other materials. Meanwhile, the demolition waste was composed of 70% concrete and cement waste and 20% metals. The results showed that 54% of the projects disposed of their C&D waste directly in the landfills. The leading causes of C&D waste generation were reworks due to changes in specifications, poor material quality, improper material handling, and improper site management. Strategic C&D waste management practices are necessary for sustainable natural resource management and conservation of the environment. (Mohammed baqer Almusawi, Saleem Ethaib and Karim, 2022)

The major findings from a study conducted in India by Singh *et al.* (2023) were that there has been increase in noise, air and water pollution near construction sites, issues in solid waste disposal and increased congestion and the potential Contributions to these pollution as stated by the authors are India is developing fast and there are plans of construction of metro rail in many cities in India. The findings from the study may be incorporated in the planning stage in those cities so that proactive measures may be taken to reduce the adverse impacts during the construction phases.

According to the results of the study conducted by (Shitaw Tafesse and Tamene Adugna, 2021) regarding the Critical Factors Causing Material Wastes in Building Construction Projects, they have concluded that the frequent changes made to the design, poor strategies for waste minimization, improper storage of material, poor site management, poor planning and supervision, and errors of contract document were the most critical factors causing construction wastes.

Asmara Seyoum's research findings indicate that the level of contribution of the waste sources to the generation of waste saw differences between the perceptions of the respondents (Contractors, consultants and client). The results from analysis ranked from the first to fifth position by contractors, consultants and owners that the most significant factors causing construction waste on building construction projects are site supervision factors, materials handling and storage factors, design and documentation factors, site management and practices factors and Operations factors. (Asmara, 2015)

Research Gaps

Large-scale projects, such as infrastructure developments, industrial expansions, and urban renewal initiatives, often generate significant quantities of material waste. Despite the environmental and economic implications of this waste, there remains a substantial research gap in understanding and addressing the challenges associated with its management in the Ethiopian context. Existing studies tend to focus on specific case studies or narrow aspects of waste management. This lack of systematic research limits the ability to develop effective and scalable strategies for reducing, reusing, and recycling material waste in large-scale projects.

Moreover, there is a need for more empirical researches investigating the factors that influence waste generation, composition, and management practices in large-scale projects in the Ethiopian context. These factors may include project characteristics (e.g., size, complexity, location), construction methods, regulatory frameworks, and stakeholder involvement. By gaining a deeper understanding of these factors, researchers can identify opportunities for improving waste management practices and mitigating the negative environmental and economic impacts of large-scale projects.

2.4 Chapter Summary

The literature review investigated existing researches on material waste management in construction projects, focusing on factors that contribute to its occurrence and the effects they have on the environment around them.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains how the research is conducted. It starts with a brief definition of research, the design, strategy, then will be followed by the method and procedures that are used in collecting data: the population, sampling size and sampling technique, data collection and data analysis.

3.2 Description of the Study Area

The study is conducted at the Addis Ababa Bole International Airport Expansion Project which is currently on going. The Project is Located at Addis Ababa city, Bole Sub city, Wereda 04.

3.3 Research Design

The research design for the study employ an inductive approach to explore material waste management within the context of the AABIA expansion project. This approach involves collecting and analyzing data from various sources, including project documentation, interviews with contractors, consultant and client, and on-site observations. By examining waste generation, management practices, and their associated outcomes, the researcher can identify patterns, trends, and potential areas for improvement. Ultimately, this inductive design provides a rich and detailed understanding of the factors affecting material waste management in the context of the AABIA expansion project.

3.4 Research Approach

The approach followed in this research is inductive in its nature. An inductive approach aims at developing a theory and it is more open-minded and exploratory. The research comprises of qualitative and quantitative approaches of data collection. By quantitative methods, it is to incorporate survey questionnaires, existing works, and desk studies. By qualitative methods, it is to include interviews with relevant concerned bodies from the contractor, consultant and client involved in the Airport expansion project.

The approach explores relevant factors; identification of major material waste management factors and their effects on the aforementioned construction project and its environment using questionnaires, interviews and observations.

3.5 Data Collection Method

The data collection in this research consisted of both primary and secondary sources. Questionnaires, interviews, and desk studies provided the primary data for the research while the secondary data sources included electronic sources, published articles from different sources and review of related documents.

The questions in both the questionnaire and the interviews were derived from the major findings from the desk studies and the related literature review.

3.6 Data Collecting Tools

Data was collected through a combination of the following methods:

- **Interviews:** Semi-structured interviews were conducted with key personnel in the project to gather detailed information on their experiences and perspectives related to material waste management in the project.
- **Surveys:** A questionnaire was distributed to the sample of participants to collect quantitative data.
- **Observations:** Site visits and observations were conducted by the researcher.

3.7 Population and Sampling

3.7.1 Population

The target population for this research primarily consist of individuals directly involved in the AABIA. This includes:

- **Construction workers:** workers involved in various stages of construction, including demolition, excavation, construction, and finishing works.
- **Project managers:** Individuals responsible for overseeing the overall project and making decisions related to resource allocation, scheduling, and quality control from both the Contractor and the Consulting Engineer.

- **Site Engineers:** Engineers responsible for ensuring that construction activities are carried out according to design specifications and safety standards.
- **Procurement officers:** Individuals responsible for purchasing construction materials and equipment.
- **Waste management personnel:** Individuals involved in the management and disposal of waste generated by the project.

Table 1 Population Distribution

No	Population characteristics	Total No of population
1.	Contractor	420
2.	Consultant	21
3.	Client	9
	Total	450

Source: Human resource departments of the Contractor, Consultant and Client involved in the project

3.7.2 Sampling

The samples taken for data collection shall be relevant to the study, manageable to the researcher and representative of the entire population.

Therefore, the sampling technique used for this research was a combination of both probability sampling (stratified sampling) and non-probability sampling (uncontrolled quota sampling). "This [quota] sampling design allows for the inclusion of all groups in the system researched. Thus, groups who are small in number are not neglected." (Uma Sekaran and Roger Bougie, 2016, p. 256) The researcher was able to select samples from all groups in her judgment, which she thinks will represent the entire population.

Given the target population of 450 involved staff from in the project both the Contractor and the Consulting Engineer, potential participants will include:

- **Construction workers:** Randomly selected workers from various construction teams involved in the project.
- **Project management team members:** Key personnel from the project management office, such as project managers, site engineers, and procurement officers.

- **Waste management personnel:** Employees responsible for waste collection, transportation, and disposal on the project site.

Sample Size

The optimal sample size depends on factors such as the variability of the data, the desired level of confidence, and the available resources.

Sample size refers to the number of elements selected from a given population (Zikmund, Babin, Carr & Griffin, 2010). A sample size is a section of a study population that is selected from the total population in a manner that ensures that every different possible sample of the desired size has the same chance of being selected. the purpose of this study, the (Yamane, 1967) formula is used to select the sample size for the study which brought the sample size to 212 respondents, and it is calculated using the following formula.

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

Where:

n is the sample size,

N is the total population,

1 is the constant and

e*e is the margin of error, which was for 5% for 95% confidence level.

Therefore,

$$n = \frac{450}{1 + 450(0.05 * 0.05)}$$

$$n = 211.76 \text{ ˜ } 212$$

Out of the Total number of 420 Contractor’s staff, the sample size is 192, out of the total number of Consultant staff 21, the sample size is 15 and out of the total number of the Client 9, the sample size is 5. Therefore, the sample size of 450 directly involved staff in the project is 212.

Table 2 Sample Size

No	Population characteristics	Total No of population	No of Sample population
1.	Contractor	420	192
2.	Consultant	21	15
3.	Client	9	5
	Total	450	212

Source: Survey 2024

By carefully selecting a representative from the 212-sample size and using appropriate data collection methods, the research can obtain valuable insights into the factors affecting material waste management in the AABIA Expansion Project.

3.8 Measurement of Variables

Given the research objectives, the key variables that could influence material waste management in the AABIA Expansion Project are as follows:

1. Factors that contribute to material waste generation
2. Current waste management practices in the project
3. Challenges and barriers to implementing effective material waste management strategies in the project
4. Environmental, economic, and social effects of construction material waste

The scale had 30 questions and respondents had to respond on 5 points Likert scale ranging from strongly disagree (1) to strongly agree (5).

3.9 Data Analysis Technique

The data collected from all sources and samples has been analyzed with the best accuracy possible. The researcher grouped the data collected based on variables and types of respondents, tabulate data based on variables from all respondents, presenting data for each variable to be studied, do calculations to determine the factors that affect material waste management and it's impacts on the project and its environment.

The researcher used IBM SPSS (Statistical Package for the Social Sciences) software, which is a software package used for the analysis of statistical data, for the data analysis purposes to check the reliability, validity and accuracy of the data collected. MS-Excel and MS-Word were used to present the data in chapter four of the research paper. Given the nature of the data collected (qualitative and quantitative), a combination of data analysis techniques was necessary.

Qualitative Data Analysis:

- **Thematic Analysis:** This technique involves identifying and analyzing recurring themes or patterns within the interview data. By grouping similar responses, the researcher will gain a deeper understanding of the factors affecting material waste management in the project.

- **Content Analysis:** This technique will be used to analyze the frequency of specific terms or concepts within the interview transcripts and open-end questions. By identifying commonly mentioned factors, the researcher has prioritized areas for further investigation.

Quantitative Data Analysis:

- **Descriptive Statistics:** Calculate measures such as mean, median, mode, standard deviation, and frequency distributions to summarize the quantitative data collected through surveys or observations.

By employing these data analysis techniques, the researcher has effectively analyzed the collected data and draw conclusions about the factors affecting material waste management in the construction project.

3.10 Reliability and Validity of Data Collection Tools

Ensuring the validity and reliability of data collection is crucial for the credibility of a thesis. Validity refers to the extent to which the research measures what it intends to measure. Reliability, on the other hand, refers to the consistency and reproducibility of the data. To enhance validity, the researcher has employed appropriate data collection methods, such as questionnaires, interviews, and observations, that align with the research objectives. To ensure reliability, researcher used consistent procedures for data collection and analysis.

The Cronbach Alpha test was also carried out to test the various study variables. The Cronbach's Alpha is indicated in the table below. By convention, an Alpha of 0.70 or higher is generally considered acceptable for a reliable measurement tool.

Table 3 Cronbach alpha

Cronbach's Alpha	No. of Items
0.782	30

Source: Survey 2024

3.11 Ethical Considerations

The study was conducted taking in to account all the ethical considerations of plagiarism, genuine data usage, research techniques, or data analysis, keep the rights of research subjects, mainly their rights to information confidentiality. The study included ensuring the well-being of participants, protecting their privacy and confidentiality, and obtaining informed consent. Additionally, the researcher has adhered to the ethical guidelines regarding data collection, analysis, and reporting. By addressing ethical considerations, the researcher has established a strong foundation for conducting a responsible and meaningful study.

3.12 Summary

This chapter has presented the overall research methodology of the study which comprised of the research approach, research design, the population of the study, source of data, data collection methods, and sample size to gather with sampling technique, measurement variables, and methods of data collection, data analysis, reliability and validity of data collection tools and ethical considerations were briefly stated. The next chapter presents the results and findings of the study.

CHAPTER FOUR

4. DATA PRESENTATION AND ANALYSIS

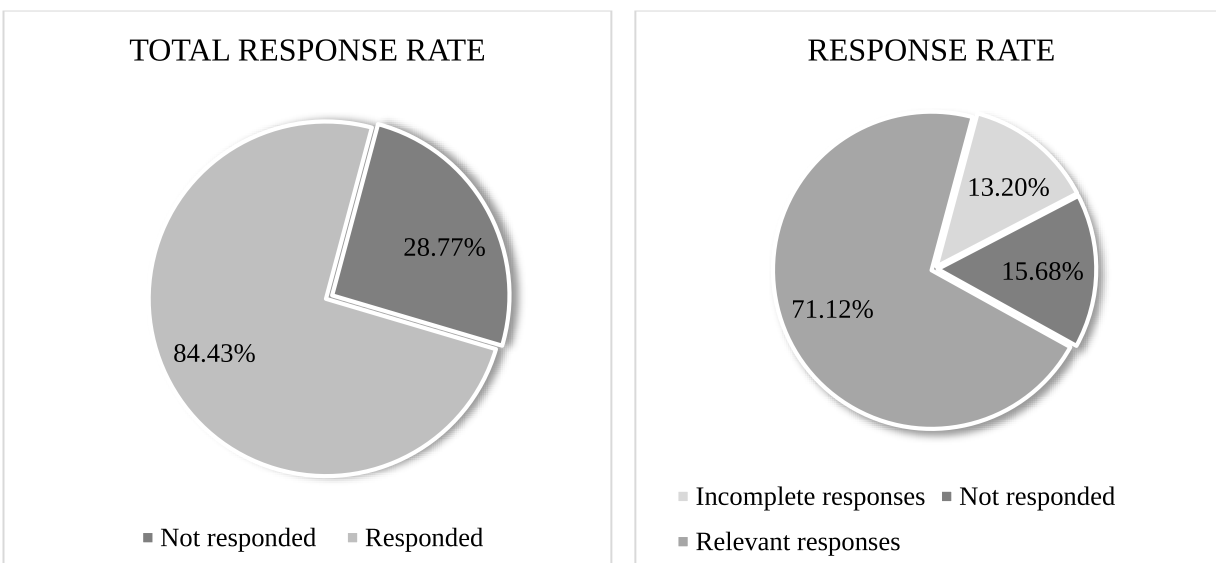
4.1 Introduction

The analysis of the research is carried out by data collected from the primary and secondary sources, information gathered through questionnaires and interview conducted.

4.2 Response and Response Rate

The researcher sent out 212 questionnaires to respondents. The researcher managed to receive 179 responses from the sample population. These results gave the study a response rate of 84%, which was above the required threshold as shown in Figure 1. From all two hundred twelve (212) of distributed questionnaires, only one hundred seventy-nine (179) of the questionnaires have been returned, which means 84% of the questioners have been returned but the respondents did not properly and completely answer twenty-eight (28) of them, which reduces the usable response rate to 71.22% with 151 responded questionnaires. According to (Morrison, 2020), a senior statistical consultant, a 50% response rate and over is sufficient for study.

Therefore, every results and analyses in this study are based on these values, which were properly answered by the respondents and observed by the researcher only.



Source: Survey 2024

Figure 1 Response Rate

4.3 Demographic Characteristics of Respondents

From all 151 respondents, 5 were of the Client's side, 15 from the Consultant's side and 131 were of the Contractors side as presented in the following table.

Table 4 Type of Organization (Respondents designation)

Type of Organization (Respondents designation)	No of Respondents	% of Distribution
Client	5	3.31
Consultant	15	9.93
Contractor	131	86.75
Total Sum	151	100

Source: Survey 2024

From all 151 respondents, 27 respondents have 0 to 5 years of experience, 96 respondents have 6 to 10 years of experience, 14 have 11 to 15 years of experience, 9 respondents have 16 to 20 years of experience and 5 respondents have more than 26 of work experience in the Construction industry as presented in the following table.

Table 5 Work experience (Years)

Experience (Years)	No of Respondents	% of Distribution
0 to 5	27	17.88
6 to 10	96	63.58
11 to 15	14	9.27
16 to 20	9	5.96
more than 26	5	3.31
Total Sum	151	100

Source: Survey 2024

From the responses used in the data analysis, 151, 1.99% of the respondents were managers, 11.92% were supervisors, 13.91% were site engineers, 15.23% were office engineers, 25.83% were Forman, 23.18% were skilled workers, 5.30% were operators and 2.65% were others (Health and safety Engineers) as presented in the following table.

Table 6 Respondent’s work position

Respondent’s work position	No of Respondents			% of Distribution
	Contractor	Consultant	Client	
Manager	1	1	1	1.99
Supervisor	1	13	4	11.92
Site Engineer	21			13.91
Office Engineer	23			15.23
Forman	39			25.83
Skilled Worker	35			23.18
Operator	8			5.30
Others	3	1		2.65
Total Sum	131	15	5	100.00

Source: Survey 2024

4.4 Descriptive Statistics Measurement of Variables

4.4.1 Factors That Contribute to Material Waste Generation in the Project

Respondents were asked to rate several factors that contribute to material waste generation in the project using the scale: 1 = strongly disagree, 2 = disagree 3 = neutral, 4 = agree, 5 = Strongly agree and their results are as shown in Table 7.

Table 7 Rating Factors that Contribute to Material Waste Generation

	N	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
Material Management Practices								
There are specific strategies in place to minimize material waste during procurement	151	8.6	15.9	16.6	50.3	8.6	3.344	1.114
There are measures in place to prevent damage or deterioration of materials during storage	151	7.3	35.8	41.1	15.9	0	2.656	0.833
There are techniques or technologies used to minimize waste during cutting and fabrication	151	0.7	51.7	47.7	0	0	2.47	0.514
Project Management and Planning								
There are tools or software used to optimize material usage during the design and planning phase	151	0.7	30.5	49	19.2	0.7	2.887	0.735
There are coordination mechanisms in place to ensure efficient material delivery and usage	151	0.7	10.6	63.6	25.2	0	3.133	0.607
Design changes or modifications are handled to minimize their impact on material waste	151	0	66.9	17.9	15.2	0	2.483	0.747
Processes are in place to review and approve design changes before they are implemented	151	32.5	17.2	35.1	15.2	0	2.331	1.088
Construction Worker Attitudes and Practices								
Construction workers are aware of the environmental impact of material waste	151	20.8	33.8	29.1	16.6	0	2.417	0.996
There are training programs in place to educate workers on waste reduction techniques	151	62.3	11.9	1.3	24.5	0	1.881	1.27
There are incentives or rewards in place to encourage workers to reduce material waste	151	40.4	24.5	19.2	15.9	0	2.106	1.108
Workers are involved in decision-making processes related to material management	151	39.1	17.9	10.6	32.5	0	2.364	1.293
There a culture of waste reduction and sustainability on the construction site	151	12.6	70.9	0	16.6	0	2.205	0.867
There are initiatives in place to promote a positive and environmentally conscious work environment	151	3.3	39.1	41.7	15.9	0	2.702	0.773
Valid N (listwise)	151							

Source: Survey 2024

1. **Material Management Practices**

According to Table 7 above, 58.9% of the respondents agree and strongly agree with the idea that "There are specific strategies in place to minimize material waste during procurement". The respondents' responses indicate that the procurement procedures consider material waste minimization.

With a response rate of 43.1% of strong disagreement and disagreement on the item "There are measures in place to prevent damage or deterioration of materials during storage", the responses indicate that the damage and deterioration of materials during storage do moderately expose materials to wastage.

Respondents were asked "There are techniques or technologies used to minimize waste during cutting and fabrication" and 52.4% of them disagree and strongly disagree and 0% of the respondents agree and strongly agree on this idea while 47.7% are neutral which shows that the waste minimization during cutting and fabrication is not well thought of in the Project.

2. Project Management and Planning

The survey results in Table 7 reveal a lack of focus on material optimization throughout the project lifecycle. Only 19.9% of respondents agreed that tools or software are used to optimize material usage during design and planning, while a larger portion (31.2%) disagreed, and nearly half (49%) remained neutral, suggesting this practice is not prioritized. Similarly, coordination mechanisms for efficient material delivery and usage appear to be lacking, with a majority (63.6%) of respondents expressing neutrality. Furthermore, minimizing material waste is not a key consideration during design changes, as 66.9% of respondents disagreed or strongly disagreed that such changes are handled with waste reduction in mind. This is further supported by the finding that 49.7% disagreed or strongly disagreed that design changes are reviewed and approved with the impact on material waste minimization in mind.

3. Construction Worker Attitudes and Practices

The survey reveals a significant lack of awareness and support for waste reduction practices among construction workers. A majority (54.6%) of respondents disagreed or strongly disagreed that workers are aware of the environmental impact of material waste, with only 16.6% agreeing.

Furthermore, 74.2% disagreed or strongly disagreed that adequate training programs on waste reduction techniques exist. Incentives to reduce waste are also lacking, with 64.9% disagreeing or strongly disagreeing that they are in place. Worker involvement in material management decisions is similarly low, with 57% disagreeing or strongly disagreeing. An overwhelming majority (83.5%) disagreed or strongly disagreed that a culture of waste reduction and sustainability exists on the construction site. Finally, while opinions were more divided regarding initiatives for an environmentally conscious work environment, a substantial portion (42.4%) still disagreed or strongly disagreed, suggesting insufficient support for such initiatives.

4.4.2. Current waste management practices in the project

Respondents were asked to rate current waste management practices in the project using the scale: 1 = strongly disagree, 2 = disagree 3 = neutral, 4 = agree, 5 = Strongly agree and their results are as shown in Table 8.

Table 8 Current Waste Management Practices

	N	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
There are specific procedures for collecting waste materials	151	9.3	53	18.5	18.5	0.7	2.483	0.923
There are project specific regulations or guidelines for waste disposal	1.3	1.3	64.2	3.3	31.1	0	2.642	0.941
There are specified time to collect waste material	151	7.3	42.4	17.9	23.8	8.6	2.841	1.132
There are challenges or limitations in accessing disposal facilities	151	0.7	19.9	9.3	46.4	23.8	3.729	1.058
Valid N (listwise)	151							

Source: Survey 2024

Respondents were asked the above-stated questions indicated in Table 8. Their response reveals significant deficiencies in waste management procedures and infrastructure. A majority (62.3%) of respondents disagreed or strongly disagreed that specific procedures for collecting waste materials exist, indicating a lack of clear protocols. Similarly, 65.5% disagreed or strongly disagreed that project-specific regulations or guidelines for waste disposal are in place. While opinions were more mixed regarding specified waste collection times, a substantial portion (49.7%) still disagreed or strongly disagreed, suggesting that waste collection is not consistently scheduled or timely. Finally, access to disposal facilities appears to be a major challenge, with 70.2% of respondents agreeing or strongly agreeing that limitations exist.

4.4.3 Challenges and Barriers to Implementing Effective Material Waste Management Strategies in The Project

Respondents were asked to rate challenges and barriers to implementing effective material waste management strategies in the project using the scale: 1 = strongly disagree, 2 = disagree 3 = neutral, 4 = agree, 5 = Strongly agree and their results are as shown in Table 9.

Table 9 Challenges and Barriers to Implementing Effective Material Waste Management Strategies in The Project

	N	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
There are physical limitations or constraints on the site that hinder effective waste management (e.g., limited space, access restrictions)	151	0	21.9	28.8	16.6	31.8	3.583	1.151
There are complex or conflicting environmental regulations or permits that need to be followed	151	7.9	48.3	9.3	10.6	23.8	2.94	1.367
There any economic factors that limit the investment in or implementation of effective waste management practices? (e.g., budget constraints, cost of disposal)	151	7.3	22.5	15.9	21.2	33.1	3.503	1.346
There are technological limitations or constraints that hinder the adoption of advanced waste management technologies	151	7.3	1.3	32.5	41.7	17.2	3.603	1.027
There are challenges in engaging and involving stakeholders (e.g., local communities, government agencies) in waste management initiatives	151	7.9	27.2	15.2	47.7	2	3.086	1.07
There are challenges or limitations in the availability or affordability of waste management equipment, materials, or services	151	7.3	2	23.8	64.2	2.6	3.53	0.886
Valid N (listwise)	151							

Source: Survey 2024

Several challenges impacting waste management effectiveness are highlighted in Table 9 above. Physical site limitations moderately hinder waste management efforts, with 48.4% of respondents agreeing or strongly agreeing that constraints like limited space or access restrictions exist. Conversely, complex or conflicting environmental regulations do not appear to be a major obstacle, as 56.2% of respondents disagreed or strongly disagreed with this statement. Economic factors, however, significantly constrain waste management practices, with 54.3% agreeing or strongly agreeing that budget constraints and disposal costs are limiting factors. Technological limitations also pose a substantial challenge, as 58.9% agreed or strongly agreed that the adoption of advanced waste management technologies is hindered by such constraints. Stakeholder engagement presents some difficulties, with 49.7% agreeing or strongly agreeing that involving stakeholders in waste management initiatives is challenging. Finally, access to affordable and available waste management equipment, materials, and services is a major impediment, with a substantial 66.8% of respondents agreeing or strongly agreeing that this is a challenge.

4.4.4 Environmental, Economic, and Social Effects of Material Waste

Respondents were asked to rate several factors that contribute to material waste generation in the Project using the scale: 1 = strongly disagree, 2 = disagree 3 = neutral, 4 = agree, 5 = Strongly agree and their results are as shown in Table 10.

Table 10 Environmental, Economic, and Social Effects of Material Waste

	N	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
Environmental Impacts								
There are potential air or water pollution risks associated with waste generation or other project activities	151	19.2	33.1	23.8	2.6	21.2	2.735	1.384
The project contributes to greenhouse gas emissions	151	14.6	23.2	46.4	1.3	14.6	2.782	1.171
There are strategies to reduce the project's carbon footprint	151	0	41.1	19.2	25.2	14.6	3.133	1.112
Economic Impacts								
There is an estimated cost of waste management for the project	151	8.6	33.8	17.2	38.4	2	2.914	1.07
There are potential negative economic impacts of waste generation or mismanagement	151	15.9	8.6	27.8	39.7	7.9	3.152	1.193
Social Impacts								
There are potential health risks associated with waste generation or mismanagement	151	14.6	25.8	43	15.2	1.3	2.629	0.956
There are measures in place to mitigate negative impacts of waste generation on quality of life	151	7.3	48.3	32.5	11.9	0	2.49	0.799
Valid N (listwise)	151							

Source: Survey 2024

1. Environmental Impact

According to table 10 above, 52.3% of the respondents strongly disagree and disagree on the idea that "There are potential air or water pollution risks associated with waste generation or other project activities" while 23.8% responded neutral and 23.8% agree and strongly agree. As per this survey results, the potential water or air pollution that might arise from the project are rare. 37.8% of the respondents strongly disagree and disagree, 46.4% responded neutral and 15.9% agree and strongly agree on the idea that "The project contributes to greenhouse gas emissions". This demonstrates that the project has less contribution to the greenhouse gas emission to the environment.

Regarding the idea that "There are strategies to reduce the project's carbon footprint", 41.1% strongly disagree and disagree, 25.2% are neutral and 39.8% of the respondents agree and strongly agree. The survey's findings indicate that the project's carbon footprint strategies are either not put forward or the staff are not aware of them, or the strategies are missing.

2. Economic Impacts

Regarding the idea that "There is an estimated cost of waste management for the project", 42.4% of the respondents disagree and strongly disagree. The results of this survey show that there is no specifically allocated waste management cost for the project. According to table 10 above, 47.6% of the respondents strongly agree and agree on the idea that "There are potential negative economic impacts of waste generation or mismanagement". As per this survey results, waste generation and mismanagement have economic impacts on the project.

3. Social Impacts

Regarding the idea that "There are potential health risks associated with waste generation or mismanagement", 40.4% of the respondents disagree and strongly disagree. The results of this survey indicate that the potential health risk associated with the waste generation of the project are less concerning. According to table 10 above, 55.6% of the respondents strongly disagree and disagree on the idea that "There are measures in place to mitigate negative impacts of waste generation on quality of life". As per this survey results, the project has mitigation plans and procedures to minimize and/or avoid the impacts of waste generation from the project on its social environment.

4.6 Interview Questions

1. What are the primary types of waste generated during the project? (e.g., construction debris, packaging, hazardous materials)

Several participants stated that the primary types of waste generated during the project are construction debris, wooden and steel pallets, scrap reinforcement, steel and aluminum, wooden materials, plastic materials, packaging materials, office wastes, electronic waste, burned oil, carbon di-oxide (from vehicle, machineries, generators, …), food waste, hazardous, steel, surplus mortar, surplus concrete, broken bricks, metallic wastes, tiles, cement, and ceramics, plastics, insulation, asbestos materials and excavated soil, papers, hazardous wastes like treated timber, glass, concrete additives, sealants, paints, varnishes, solvents, glues, fuels, asbestos and dust.

2. Approximately how much waste is generated per day or week? And has the volume of waste changed over the course of the project?

Most of the respondents stated that the quantity of waste generated in the project is unknown and there are no records to show the volume. They also stated that the volume varies over the project life cycle. However, one of the participants stated that at the beginning of the project an average of 32 m^3 of waste was disposed daily containing construction debris but from three months on since the project is in its finishing phase, most of the wastes are packaging which are on average 16 m^3 per week.

3. How is waste currently disposed of? (e.g., landfill, recycling, composting, incineration)

According to the respondents, waste is disposed in a particular disposal area as a land fill and recycling and other methods are not employed. However, for the reusable materials (mainly metallic waste) are they are dumped temporarily on unusable space provided by the Client.

4. How often is waste collected from the site?

Participants stated that the collection of waste materials depends on the volume of waste generated and the collection of waste on site is done randomly with no specific allocated duration but typically, the disposal of waste from site to land fill is about every two weeks.

Discussion

Interview Data Analysis:

The interview responses reveal a concerning gap between best practices and the project's current waste management approach. Key findings include:

- **Waste Types:** The project generates a wide variety of waste, including construction debris, packaging, hazardous materials, and other waste streams. This diversity necessitates a comprehensive waste management plan that addresses each type appropriately.
- **Waste Quantification:** A significant problem is the *lack of waste quantification*. Most respondents admitted to not knowing the amount of waste generated. Without accurate data, it's impossible to effectively manage waste, track progress, or identify areas for improvement. The single data point provided (32 m^3 daily initially, 16 m^3 weekly later) is insufficient for a comprehensive analysis.
- **Waste Disposal Methods:** The primary disposal method is landfilling, with limited recycling. This approach is unsustainable and misses opportunities for resource recovery and cost savings. The temporary storage of reusable metallic waste, while positive, is not a complete solution.
- **Waste Collection Frequency:** The random and infrequent waste collection (approximately every two weeks) further exacerbates the issues associated with landfilling and potentially contributes to environmental and health risks.

Discussion of Results

The project's current practices clearly demonstrate the negative consequences of poor waste management. The lack of waste quantification, reliance on landfilling, and infrequent collection all point to significant environmental and economic costs. The project is missing out on potential benefits like cost savings from material reuse and recycling, improved project efficiency, and a better project image.

4.7 Chapter Summary

The chapter has presented the response rate, reliability and validity tests, as well as the demographic information. The chapter has presented results for the Project’s waste management and its effects on its surroundings. Statistical measures have been used for presentations and the obtained data has been analyzed. The next chapter will present the study summery of findings, conclusion and recommendations.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The General objective of this study was to find out the factors that are affecting material waste management in the Addis Ababa Bole international airport expansion project. The key findings drawn from each of the six research questions are compiled and examined in this chapter. For each of the research objectives, it also covered the results drawn from the analysis and suggestions that could be put into practice or utilized in subsequent studies.

This chapter is divided in various sections that include introductions, summary of findings, limitation of the study, conclusions, and recommendations for improvement, and for further studies and contribution of the study.

5.2 Summary of Main Findings

1. Primary sources of material waste in the AABIA Expansion Project

Primary sources of waste generated during the project are construction debris, wooden and steel pallets, scrap reinforcement, steel and aluminum, wooden materials, plastic materials, packaging materials, office wastes, electronic waste, burned oil, carbon di-oxide (from vehicle, machineries, generators, …), food waste, hazardous, steel, surplus mortar, surplus concrete, broken bricks, metallic wastes, tiles, cement, and ceramics, plastics, insulation, asbestos materials and excavated soil, papers, hazardous wastes like treated timber, glass, concrete additives, sealants, paints, varnishes, solvents, glues, fuels, asbestos and dust.

2. Current waste management practices and policies in place for the project

Research findings indicate a lack of comprehensive waste management plans, leading to inefficient waste segregation and disposal. This often results in valuable materials (like metal and plastic) being mixed with general waste, hindering recycling efforts. Additionally, a shortage of adequate waste collection and disposal facilities within the project site contributes to improper waste management, potentially leading to environmental pollution.

The effectiveness of current waste reduction measures in the project is limited. While some recycling initiatives exist, they are often fragmented and lack proper implementation. The absence of clear guidelines and regulations for waste management further hinders the adoption of sustainable practices. Consequently, a significant portion of construction and operational waste ends up in landfills, contributing to environmental degradation and resource depletion.

3. **Challenges and barriers to implementing effective material waste management strategies in the project**

The implementation of effective material waste management strategies in the airport expansion project faces several challenges and barriers. One significant challenge is the complexity of waste streams generated during construction and operations. This diversity of waste materials requires sophisticated waste segregation and processing systems, which can be costly and resource-intensive.

Another barrier to effective waste management is the lack of awareness and understanding of sustainable practices among project stakeholders. This can lead to inconsistent waste segregation, contamination of recyclable materials, and inefficient waste disposal methods.

4. **Environmental, economic, and social effects of material waste generation in the project**

Environmental Effects

Material waste generation in construction projects, such as the Addis Ababa Bole International Airport Expansion Project, can have significant environmental consequences. Excessive waste often ends up in landfills, contributing to greenhouse gas emissions, soil pollution, and water contamination. Landfills can release methane, a potent greenhouse gas, which exacerbates climate change. Additionally, improper disposal of construction waste can lead to the release of hazardous substances into the environment, harming ecosystems and human health.

Economic Effects

Material waste generation can have substantial economic implications. The overconsumption of resources, such as raw materials and energy, increases project costs. Inefficient resource utilization can lead to higher procurement costs, increased labor hours, and potential project delays. Moreover, the disposal of waste incurs additional costs, including transportation, tipping fees, and environmental remediation. By reducing material waste, construction projects can achieve significant cost savings and improve their overall financial performance.

Social Effects

Material waste generation can have indirect social effects. Environmental degradation caused by waste disposal can impact local communities, particularly those living near construction sites or landfills. Air and water pollution can lead to health problems, such as respiratory illnesses and waterborne diseases. Additionally, the depletion of natural resources can have long-term social consequences, affecting future generations' access to essential resources. By adopting sustainable waste management practices, construction projects can contribute to a healthier and more equitable society.

This research delved into the intricate factors influencing material waste management within the context of the Addis Ababa Bole International Airport Expansion Project. The investigation revealed a complex interplay of factors, including project planning, material procurement, construction practices, and waste management systems, that significantly impact the generation of construction and demolition waste.

A key finding of this study is the critical role of effective project planning in minimizing material waste. Detailed material take-offs, optimized material delivery schedules, and the implementation of lean construction principles emerged as crucial strategies to reduce excess material and minimize waste generation. Additionally, the procurement process was identified as a significant factor, with careful material selection and supplier evaluation playing a pivotal role in ensuring the acquisition of appropriate materials and minimizing waste.

Construction practices, such as waste segregation, recycling, and reuse, were found to be essential in reducing the environmental impact of the project. The establishment of efficient waste management systems, including waste collection, transportation, and disposal, was also highlighted as a crucial component of effective waste management. However, challenges such as a lack of awareness, inadequate infrastructure, and limited financial resources hindered the implementation of optimal waste management practices.

To address these challenges and promote sustainable construction practices, several recommendations were proposed. These include the development of a comprehensive waste management plan, the adoption of advanced technologies such as Building Information Modeling (BIM), the establishment of a robust material tracking system, and the implementation of strict waste reduction targets. By embracing these recommendations and fostering a culture of sustainability, the construction industry can significantly reduce material waste and contribute to a more environmentally friendly future.

5.3 Recommendations

1. Enhanced Project Planning and Design

Effective project planning is crucial for minimizing material waste. This involves meticulous detailed material take-offs to accurately estimate material quantities, preventing over-ordering and subsequent waste. Optimized material delivery schedules ensure timely material arrival, minimizing storage requirements and potential spoilage. Furthermore, implementing lean construction principles streamlines processes, reduces rework, and minimizes waste by focusing on eliminating non-value-added activities. Finally, Building Information Modeling (BIM) technology can significantly enhance project planning and material coordination through virtual simulations and real-time monitoring, enabling proactive identification and mitigation of potential waste sources.

2. Improved Material Procurement and Supply Chain Management

Sustainable procurement practices are essential for minimizing environmental impact. Prioritizing environmentally friendly materials and selecting sustainable suppliers can significantly reduce the project's ecological footprint. Fostering strong relationships with suppliers facilitates efficient material delivery, minimizes delays, and improves communication, thereby reducing the risk of material waste. Rigorous quality control measures throughout the procurement and construction phases are critical to ensure material quality and minimize the need for replacements or rework due to defects, which can significantly contribute to material waste.

3. Effective Construction Practices and Waste Management

Implementing effective construction practices is paramount for minimizing waste generation. Proper waste segregation systems are crucial for facilitating recycling and reducing the volume of waste sent to landfills. Encouraging recycling and reuse of materials whenever possible conserves resources and minimizes the environmental impact of the project. Employing waste minimization techniques such as material substitution, modular construction, and prefabrication can significantly reduce waste generation during the construction process. Finally, providing comprehensive training and awareness programs to construction workers is vital to promote sustainable practices and encourage their active participation in waste reduction efforts.

4. Strong Policy and Regulatory Framework

A robust policy and regulatory framework is essential to ensure the successful implementation of waste reduction strategies. Clear waste management guidelines and regulations provide a consistent framework for all stakeholders, ensuring effective implementation of waste reduction measures. Establishing incentives for waste reduction and penalties for non-compliance can motivate stakeholders to prioritize sustainable practices. Finally, regular monitoring and evaluation systems are crucial to track progress, identify areas for improvement, and ensure the effectiveness of waste management initiatives. By continuously assessing and adapting strategies based on these evaluations, the project can maximize its environmental and economic sustainability.

5.4 Contribution of the Study

This study contributes significantly to the understanding of material waste management challenges in construction projects, particularly within the context of large-scale infrastructure developments like the Addis Ababa Bole International Airport Expansion Project. The research has shed light on the complex interplay of factors influencing material waste generation, including project planning, material procurement, construction practices, and waste management systems. By identifying these factors, the study provides valuable insights for policymakers, practitioners, and researchers to develop effective strategies for material waste reduction.

Furthermore, the study highlights the potential of sustainable construction practices, such as lean construction, modular construction, and waste minimization techniques, in mitigating the environmental impact of construction projects. By emphasizing the importance of a comprehensive approach to material waste management, this research aims to promote a more sustainable and resource-efficient construction industry.

5.5 Directions for Future Research

Future research in this area could explore the following directions:

- Quantitative Analysis of Waste Reduction Strategies: A quantitative analysis of the cost-benefit implications of various waste reduction strategies could provide empirical evidence to support their implementation.
- Comparative Analysis of International Best Practices: A comparative analysis of international best practices in material waste management could identify innovative approaches and lessons learned from other countries.
- Life Cycle Assessment (LCA): Conducting a life cycle assessment of construction materials can help identify the environmental impacts associated with different materials and construction processes, enabling more informed decision-making.
- Social and Economic Impacts of Waste Reduction: Exploring the social and economic benefits of material waste reduction, such as job creation, community development, and reduced healthcare costs, can highlight the broader societal implications of sustainable construction.

By addressing these research directions, future studies can further advance the understanding of material waste management in construction projects and contribute to the development of more sustainable and resilient infrastructure.

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ANNEX 1: QUESTIONNAIRE SURVEY

St. Mary's University

School of Graduate Studies

College of Business and Economics

Department of Project Management

Questionnaire Survey

Thesis paper on: Factors Affecting Material Waste Management in Construction Projects: The Case of Addis Ababa Bole International Airport Expansion Project

Dear Respondent,

I am presently pursing a Master of Arts Degree in Project Management at St. Mary's University, School of Graduate Studies.

The aim of this questionnaire is to study the factors that affect construction material waste management, the factors that contribute to material waste generation, environmental, economic, and social effects of material waste, current waste management practices, challenges and barriers to implementing effective material waste management strategies in the project at Addis Ababa Bole International Airport Expansion Project.

Please answer all questions. All the information gathered will be kept strictly confidential and will only be for academic research and analysis.

Thank you in advancing for your time and kind cooperation

For any of your inquiries or in need of additional information I can be reached via email at: fevenhailu14@gmail.com or telephone +251921584770

With Kind Regards,

Feven Hailu

Supervised by: Dr. Alazar Amare

Part 1: General Information

Please use the (X) symbol on the spaces in front of the response options.

1. Type of Organization (Respondents designation)

Owner ☐	Consultant ☐	Contractor ☐

2. Work experience **(**Years**)**:

0 – 5 ☐	6 – 10 ☐	21 – 25 ☐
11 – 15 ☐	16 – 20 ☐	More than 26 ☐

3. Respondent's work position

Manager ☐ Supervisor ☐ Site Engineer ☐ Office Engineer ☐ Forman ☐

Skilled worker ☐ Operator ☐ Others ____________________

Part 2: Factors That Contribute to Material Waste Generation

Put (X) mark on the level you agree on according to the following grades.

1: Strongly Disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly Agree

	1	2	3	4	5
Material Management Practices					
There are specific strategies in place to minimize material waste during procurement					
There are measures in place to prevent damage or deterioration of materials during storage					
There are techniques or technologies used to minimize waste during cutting and fabrication					
Project Management and Planning					
There are tools or software used to optimize material usage during the design and planning phase					
There are coordination mechanisms in place to ensure efficient material delivery and usage					

Design changes or modifications are handled to minimize their impact on material waste					
Processes are in place to review and approve design changes before they are implemented					
Construction Worker Attitudes and Practices					
Construction workers are aware of the environmental impact of material waste					
There are training programs in place to educate workers on waste reduction techniques					
There are incentives or rewards in place to encourage workers to reduce material waste					
Workers are involved in decision-making processes related to material management					
There a culture of waste reduction and sustainability on the construction site					
There are initiatives in place to promote a positive and environmentally conscious work environment					

Part 3: Current waste management practices in the project

	1	2	3	4	5
There are specific procedures for collecting waste materials					
There are project specific regulations or guidelines for waste disposal					
There are specified time to collect waste material					
There are challenges or limitations in accessing disposal facilities					

Part 4: Challenges and Barriers to Implementing Effective Material Waste Management Strategies in The Project

	1	2	3	4	5
There are physical limitations or constraints on the site that hinder effective waste management (e.g., limited space, access restrictions)					
There are complex or conflicting environmental regulations or permits that need to be followed					

There any economic factors that limit the investment in or implementation of effective waste management practices? (e.g., budget constraints, cost of disposal)					
There are technological limitations or constraints that hinder the adoption of advanced waste management technologies					
There are challenges in engaging and involving stakeholders (e.g., local communities, government agencies) in waste management initiatives					
There are challenges or limitations in the availability or affordability of waste management equipment, materials, or services					

Part 5: Environmental, Economic, and Social Effects of Material Waste

	1	2	3	4	5
Environmental Impacts					
There are potential air or water pollution risks associated with waste generation or other project activities					
The project contributes to greenhouse gas emissions					
There are strategies to reduce the project's carbon footprint					
Economic Impacts					
There is an estimated cost of waste management for the project					
There are potential negative economic impacts of waste generation or mismanagement					
Social Impacts					
There are potential health risks associated with waste generation or mismanagement					
There are measures in place to mitigate negative impacts of waste generation on quality of life					

ANNEX 2: INTERVIEW QUESTIONS

Questions

1. What are the primary types of waste generated during the project? (e.g., construction debris, packaging, hazardous materials)
2. Approximately how much waste is generated per day or week? And has the volume of waste changed over the course of the project?
3. How is waste currently disposed of? (e.g., landfill, recycling, composting, incineration)
4. How often is waste collected from the site?