



School of Commerce

**ADDIS ABABA UNIVERSITY
COLLEGE OF BUSINESS AND ECONOMICS
SCHOOL OF COMMERCE**

**Exploring the Relationship between Environmental Management Tools
and Sustainability Performance in Construction Projects**

**BY:
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**A RESEARCH WORK SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT
FOR THE AWARD OF A MASTER OF ARTS DEGREE IN PROJECT MANAGEMENT**

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DECLARATION

I declared that this work entitled “Exploring the Relationship between Environmental Management Tools and Sustainability Performance in Construction Projects” is a result of my own effort and study and all sources of materials used for this study have been referenced and acknowledged. This research was produced independently with the guidance and suggestions of my research advisor. This research has also not been submitted for any degree or master’s program in this and/or other universities.

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STATEMENT OF CERTIFICATION

This is to certify that, NETSANET WUBESHET has carried out this project work on the topic titled “Exploring the Relationship between Environmental Management Tools and Sustainability Performance in Construction Projects”. Accordingly, I hereby assure you that her work is appropriate and standard enough to be submitted for the award of the Degree of Master of art in project management.

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June 2024

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GRADUATE STUDIES

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LIST OF ACRONYMS

(EMTs)- Environmental Management Tools

(EIA)- Environmental Impact Assessment

(LCA)- Life Cycle Assessment

(EMS)- Environmental Management System

(BIM) - Building Information Modeling

(GMS)-Green materials selection

(WMP)Waste management plans

(ECP)-Energy-efficient construction practices

(BC)Building commissioning

(EMS2)-Energy monitoring systems

(WCS)-Water conservation strategies

(Res_Con) Resource Consumption

(poll) Pollution

(Was_Gen) Waste Generation

(QOL) Quality of Life

(JC) Job Creation

(H_S) Health and Safety

(CS) Cost Saving

(MD) Market Demand

(FN) Financial Returns

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ABSTRACT

This study explores the relationship between environmental management tools (EMTs) and sustainability performance of construction projects focusing on environmental, social, and economic dimensions. The study utilized a mixed methods approach. Data were obtained through the administration of questionnaires to project management professionals that work in construction. The study also analyses the case of the the Sawla-Maji Road Upgrading Project to offer a real-world perspective on the topic. Descriptive Statistics and correlation analysis were used to analyze the quantitative data whereas thematic analysis was used to analyze the documents and interview conducted to assess the case study. The research established that there are positive associations between EMT implementation and all three sustainability areas. The correlation analysis shows that there is a negative relation between EMTs and environmental performance indicators such as waste generation, resource consumption and pollution. The analysis also suggested a possible relationship between EMTs and social outcome. This connection was further solidified by the case study which provided evidence of a positive link with workers health and safety. Economically, EMTs seem to have a positive relationship with financial return and cost savings, though challenges like upfront costs require consideration. Overall, the paper adds to the current body of knowledge on the contribution of EMTs in sustainable construction. This research provides significant insights for practitioners, policy makers and researchers to utilize EMTs and its environmental, social, and economic sustainability benefits. Future research could explore EMT effectiveness across a wider range of project types and geographical contexts.

Keywords: *Environmental Management Tools (EMTs), Sustainability, Construction Projects, Environmental Performance, Sustainable Construction*

Chapter 1

1. Introduction

1.1 Background of the Study

The Construction industry has long played an important role in advancing the progress of society and contributes positively for the growth of its nation. It has contributed to improved infrastructure, revitalization and urban renewal, community development, and other factors that have helped improve the day-to-day life of the people (Fei et al., 2021). Besides its positive contribution, construction has had an astronomical negative impact on the environment. It has been linked with resource depletion, pollution, habitat destruction, and excessive energy consumption. (Moshood, 2024). This has led the construction industry to evaluate its practices and come up with a solution that would lessen the negative impacts. In response to this, the industry has looked towards sustainability. It has been able to embrace sustainable practices as a way to manage and mitigate the negative impact of the construction industry on the environment. (The United Nations Environment Programme.2022).

Achieving sustainability means relaying heavily on project management practices. Project management in construction, involves the planning, execution, and control of construction projects to achieve specific objectives. And within this framework Environmental Management tools (EMTs) have emerged as a major part of achieving these sustainable construction goals. These tools assist people involved in the project in identifying and mitigating environmental risks. It also helps with monitoring resource consumption and promotes practices that minimize waste and different forms of pollution (Ding et al., 2020). Several studies have explored the use of environmental management tools in the context of sustainable construction. One of the major studies that were conducted on the topic is a study conducted by Shen et al. in 2010 that was able to see how environmental management systems (EMS) could be incorporated and used in construction projects. The study showed how important it is to integrate environmental considerations into the different processes found in project management. In another study, Hwang and Ng (2013) examined the skills required by project managers to effectively manage environmental issues in green construction projects. More recent studies also support this as shown in the study by , Alaloul et al. (2020) who proposed a framework that would allow the integration of sustainability into construction project management. The study suggested that there is a need for an effective risk management strategy as it would aid with the implementation of sustainable practices.

Multiple researchers on the topic agree that the use of EMTs can be beneficial to boost the sustainability of construction projects. These researchers have also identified EMTs like environmental impact assessment (EIA) and strategic environmental assessment (SEA) as important tools for identifying and mitigating environmental risks. EIAs predict and evaluate the environmental impacts of a specific project (UNEP, 2022), whereas strategic environmental assessments (SEAs) assess broader policies and programs that may influence construction (World Bank, 2018). As shown above there has been a few research done on the topic of utilizing environmental management tools for attaining a positive impact on the environment. But there is limited research on the potential impact the tools have on the overall sustainability of construction projects. There needs to be more research done whether it is to assess the effect on environmental, economic and social aspects of sustainability (Shen et al., 2010). The gap in the works of the literatures that already exist in this field are great opportunity to further explore relationship that exists between EMTs and enhanced sustainability performance of construction projects.

This study aims to explore the relationship between various EMTs and project sustainability through a mixed method approach where the qualitative data uses a case stud approach as it analyzes the documents and interviews from project management professionals that worked on the Sawla-Maji Road Upgrading Project, whereas the quantitative data from a survey is analyzed through the correlation analysis. By analyzing existing data, the study will identify potential associations between the use of specific EMTs and different sustainability metrics. While correlation does not imply causation, the findings can provide valuable insights into how EMTs might influence project sustainability and guide further research in this area.

1.2 Background of the Company

The company chosen for the research is STADIA Engineering Works Consultant PLC. It is an engineering consultancy firm based in Addis Ababa, Ethiopia. The company was first established in September 2010 and has been offering a different range of construction services. Its main focuses are on road, bridge, and infrastructure design. The company's team contains civil engineers and architects who work on regional, national, and international projects. STADIA's mission is to uphold the principles of Synergy, Innovation, and Excellence as it continues to strive to protect the environment under their corporate social responsibilities and leaving a green legacy. The primary reason for selecting a project from this company as a case study is the company being an environmentally friendly engineering consultancy. One of the

projects it was involved in was the Sawla-Maji Road Upgrading Project. Which is a road upgrading project located in the South Western part of Ethiopia, in the Southern Nations, Nationalities and Peoples Regional State (SNNPRS); specifically in one administrative zone and one special Woreda namely; Gamo Gofa zone; and in Basketo special woreda. The towns and villages crossed by the project road include Sawla, Bulki, and Laska. The company was made the consultant for supervision of the project. It was given the responsibility of providing the needed knowledge to ensure that the project becomes a success and at the same time addressing environmental concerns.

1.3 Statement of the Problem

The construction industry has always had a stake in global development. Its contribution goes beyond infrastructure as it has aided the advancement of society for centuries. Despite its benefits, construction practices have had a horrible effect on the environment. According to (UNEP, 2019) the construction industry has been linked with causing pollution including a significant portion of air, water, and noise pollution. It is also responsible for about 33% of global waste generation. In another research done on this topic by Al-Sheyadi, S. et.al (2020), construction has been proven to be a major cause of resource depletion as the industry is a heavy consumer of raw materials like concrete, steel, and timber. Another issue that is related to construction practices is the issue that comes with land clearing for the sake of land development. This practice contributes to deforestation and habitat loss. It also causes the depletion of natural resources and disturbs delicate ecosystems (Alemu & Bewket, 2019). Hurni et al, in a research done in 2019 investigated how construction activities can affect and worsen soil erosion and sedimentation. The research further discovered that it also impacts water quality and natural drainage patterns which would exasperate soil erosion. These issues related to construction practices have become burdensome to the environment. This shows that there is a need for a shift towards sustainable practices that minimize the negative impact. According to Kumneger et al., 2021, one of the key strategies to minimize the negative environmental impact of construction projects and attain sustainable construction is by incorporating project management principles and utilizing environmental management tools (EMTs).

The industry has acknowledged the need for sustainability and developed various tools for it (Kumneger et al., 2021). Yet, there is a limited understanding of the relationship between specific Environmental Management Tools (EMTs) and project sustainability across environmental, social, and economic

dimensions. This lack of clear evidence from limited researches doesn't contribute and limits the decision-making process regarding EMT implementation to be able to achieve sustainable construction practices (Díaz & Antön, 2014). While a range of EMTs exist, environmental management systems (EMS), green material selection, and life cycle assessment (LCA), their relationship with all aspects of sustainability remains under explored (Díaz & Antön, 2014; Mohd Arif et al., 2019). Already existing empirical studies have explored some correlations between these variables. According to an empirical study done by Mohd Arif et al., in 2019, the results show that EMTs contribute to sustainability by reducing energy and water consumption. It was also suggested that the tools help minimize construction waste through lean construction practices (Mohd Arif et al., 2019). However, there is limited research that explores the correlations between the use of EMTs and various sustainability metrics including environmental, economic and social dimensions of sustainability. Existing studies highlight the potential benefits of EMTs for sustainability, but often lack data on the strength of these relationships. It also doesn't explain the challenges associated with EMT implementation (cost, knowledge gaps) are documented and their impact on the relationship between EMTs and sustainability remains unclear.

The desired state is to minimize negative environmental impact and enhance sustainability throughout the project lifecycle by using environmental management tools like EIA, LCA, and EMS to identify risks early, plan mitigation strategies, and monitor performance. Another goal is the improvement of resource efficiency through recycled materials and the optimization of construction techniques that adhere to sustainable practices. Based on the studies done on energy-efficient practices by UNEP in 2016 that state it is crucial for sustainable practice, it will also be another desired state to aim for. Pollution and waste reduction require control measures, minimizing waste generation, and responsible waste management, which is also a desired state to aim when thinking of achieving a better environmental impact (World Bank, 2018). The next issue will be trying to bridge the gap between the current state and this desired state which requires help from different stakeholders involved in the industry. By achieving this desired state, the construction industry can contribute to a future towards sustainability.

This study aims to explore the correlations between various EMTs and different aspects of project sustainability. By analyzing existing data, the study identifies potential associations between the use of specific tools and sustainability metrics. By employing a mixed-method approach that incorporates case studies, a literature review, and a survey of construction professionals, the study will assess the current state of the industry when it comes to the usage of environmental tools and the relationship EMTs have with sustainability. It will also explore the practical challenges and different factors that hinder the

relationship with the tools. The findings of this research aim to provide valuable insights for professionals who work in the construction industry. Its other aim is to help with making informed decisions and optimizing the environmental sustainability of projects. It tries to contribute to the existing body of knowledge in the field of sustainable construction.

1.4 Research Questions

1. What are the key environmental management tools that have been utilized in construction projects and to what extent is the use of EMTs correlated with sustainability in construction projects?
2. Is there a correlation between the implementation of various environmental management tools (EMTs) and environmental sustainability performance in construction projects?
3. Is there a correlation between the implementation of environmental management tools (EMTs) and social sustainability performance in construction projects?
4. Is there a correlation between the implementation of environmental management tools (EMTs) and economic sustainability performance in construction projects?

1.5 Objectives of the Study

1.5.1 General Objectives

To investigate the relationship between environmental management tools (EMTs) and the overall sustainability performance (economic, social, and environmental) of construction projects..

1.5.2 Specific Objectives

1. Identify and categorize the key environmental management tools (EMTs) used in construction projects and the relationship it have on sustainable construction
2. Assess the correlation between the implementation of environmental management tools (EMTs) and environmental sustainability performance in construction projects.
3. Evaluate the correlation between the implementation of environmental management tools (EMTs) and social sustainability performance in construction projects
4. Investigate the correlation between the implementation of environmental management tools (EMTs) and economic sustainability performance in construction projects.
- 5.

1.6 Significance of the Study

The study will have both theoretical and practical significance. Practically, this study tries to offer valuable insights for construction companies to improve their performance when it comes to the environment. It can also contribute when it comes to decision-making. It can help with the selection and implementation of the appropriate EMTs needed for that specific project as choosing the right tools would lead to a more sustainable construction project. Developing effective policies and regulations in regards to environmental impact is also another factor that this research can contribute to.

For the theoretical Significance, this study contributes to a better understanding of the correlation EMTs have with sustainable performance of construction. The knowledge gap that exists, can be addressed through this research. It can also be used to inform best Practices.

Overall, this research has the potential to bridge the gap that is found in theoretical knowledge about sustainable construction in the construction industry. The findings can lead to more sustainable construction practices, improved environmental outcomes, and contribute to achieving broader sustainability goals.

1.7 Scope of the Study

This study will focus on evaluating the correlation of environmental management tools and sustainable in construction. However, the scope will be based on the following:

- **Geographical Focus:** The applicability and the potential impact of the study is intended to be global but because of resource and time constraints as well as the need for in-depth analysis, it will focus on construction projects within urban and rural areas of Ethiopia.
- **Project Types:** The study will focus on construction projects where environmental impact tends to be more significant, which includes larger-scale construction projects, such as infrastructure development, commercial buildings, or high-rise developments. The specific project chosen for the case study used in this research is the Sawla-Maji Road Upgrading Project, which is categorized under a large infrastructure development.
- **Specific Environmental Management Tools:** The chosen EMTs include a wide range of EMTs employed in projects but it will mostly focus on the once widely used in construction projects and categorized on how they are used for specific purposes . It includes

- Waste Management Plans (WMP)
- Energy-efficient construction practices(ECP)
- Water conservation strategies(WCS)
- Life Cycle Assessment (LCA)
- Building Information Modeling (BIM) for sustainability
- Environmental Impact Assessment (EIA)
- Building commissioning (BC)
- Energy-efficient construction practices (ECP)
- Green materials selection(GMS)
- Energy monitoring systems (EMS)

1.8 Limitations of the study

The limitations of the study include logistical and resource constraints that limit on-site data collection at construction sites. The findings may also be limited in scope due to the given amount of time for the study. The study is focused on construction projects within Ethiopia. The impact of the findings are meant to be global but the applicability of the results to other geographical regions may be limited. Future research could expand the scope to include a more diverse set of construction projects from various parts of the world, allowing for a more comprehensive understanding of the link between environmental management tools and enhancing sustainability across different contexts. The research also recognizes that some references used in the study are older than five years. A lot of effort was made to use the most recent literatures available but there was a lack of recent data for the specific information that was needed. Relying on older sources may limit the findings' alignment with the latest advancements in the field. Another limitation is the fact that only 2 people were interviewed about the case study, which reduces the generalization and limited the saturation for the thematic analysis. It is also good to remember correlation doesn't imply causation, so further research and statistical testing will be crucial to validate these hypotheses.

1.9 Organization of the study

This research consists of five chapters that are put in logically sequenced. Chapter 1 is the Introduction. It sets the stage with background information. It includes the research problem, questions, objectives, significance, and limitations. Chapter 2 contains the literature Review; it explores the existing knowledge

on environmental management tools (EMTs) for sustainable construction. It includes theoretical, empirical, and conceptual reviews to identify gaps and construct a frame work to investigate the relationship of EMTs and sustainability of construction projects. Chapter 3 is the research Methodology. It details the chosen approach (mixed-method) and data collection methods which includes literature review, survey and case study. It justifies the sampling strategy, sample size, data analysis methods, and addresses methodological limitations. Chapter 4 is for research findings presentation, analysis and discussion. It analyzes data from all methods to answer research questions and assess EMT correlation with sustainable in construction projects. Chapter 5 contains the conclusion, summery and recommendations. This chapter summarizes key findings, draws conclusions, and provides recommendations for future research and practical applications. The References lists all the sources that were cited throughout the research in the appropriate referencing style and the Appendices section includes any supplementary materials that support the research, such as interview questionnaires, survey instruments, or checklists.

Chapter 2

2. Review of Related Literature

2.1 Introduction

The construction industry uses lots of resources and in turn, creates a lot of waste, and these issues have caused many environmental problems (World Green Building Council, 2023). Because of this, there is more and more demand for sustainable construction practices that do not harm the environment. One critical approach to accomplish this is by employing Environmental Management Tools (Alaloul et al., 2020).

In this literature review, we will examine the previous researches done on the topic of environmental management tools in construction projects. It will also focus on areas related to EMTs such as the type of tools available, how these tools are applied, and their relationship with sustainability performance of construction projects. The contents of this literature review will also contain information about the current studies on the relationship of EMTs with sustainability metrics. It is also meant to assess how the tools contribute to the overall sustainability of the construction projects. Furthermore, it seeks to find out how implementing EMTs can increase the sustainability performance of the construction project. It will focus on how environmental management tools contribute to attaining economic, social and environmental sustainability. Based on that it aims to help identify areas where current knowledge on EMTs is limited and propose recommendations for future research to bridge these gaps and ensure a more practical and impactful implementation of these tools.

This chapter is structured into three parts: a theoretical review, a conceptual review, and a review of empirical studies. By critically examining the available literature, this review seeks to offer practical insights to anyone who seeks to gain any knowledge on the topic. It also aims to offer Insight to construction professionals. The knowledge gained from this research can help inform decision-making when it comes to EMT selection and implementation which can lead to a more sustainable construction industry.

2.2 Theoretical Review

2.2.1 Sustainability in Construction Projects

The fact that the construction industry uses as many resources as it does have played a role in the industry having a large environmental footprint. (Achimowicz et al., 2019). It consumes a large amount of resources, including raw materials, water, and energy (Gan et al., 2018). Along with the large amount of resource depletion it causes, construction has been contributing to air, water, and noise pollution (Karakaya et al., 2018). Because of these reasons, the industry has been under a lot more pressure to fight the challenge by implementing sustainable construction practices (UNEP, 2021). In this context sustainability could be defined as the meeting of project's needs without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Sustainable construction practices aim to minimize the environmental impact of projects throughout their life cycle, from planning and design to construction, operation, and demolition (Ding et al., 2007).

Key Principles of Sustainable Construction

For a project to be considered sustainable construction, it should consider and deliver on the following issues:

- **Environmental:** For a project to be sustainable, the first thing it needs to be able to do make sure that it has as little negative impact on the environment as it can. It should also be able to minimize the resource used including materials, energy and water. It should also be able to have a reduced pollution and waste generation, and finally the project must work hard to protect the ecosystems.
- **Social:** The projects also have to deliver socially, making sure that it protects and aids the health, safety, and well-being of workers and people that live near it. For the project to be considered sustainable it should be able to minimize the negative impacts on the surrounding communities.
- **Economic:** The other major concern when it comes to sustainable construction is the economic impact. For the project to be considered sustainable it should be able to optimize the cost of the project throughout its life cycle. It should also consider long-term benefits and minimizing environmental liabilities.

Throughout the construction project lifecycle, significant progress can be achieved towards creating a more sustainable built environment by embedding these principles.

2.2.2 Environmental Management and Environmental Management Tools (EMTs)

Environmental Management

The process of limiting human activities so as not to have a huge impact on the environment is referred to as Environmental management. (International Organization for Standardization, 2015). It is also an organized approach of planning, implementing, and controlling activities that have the potential to impact the environment. It's a process in which organizations can use to minimize the impact they have on the environment. It helps the organizations with lessening their environmental footprint; as it guides them comply with environmental regulations. It also help contribute to a more sustainable future.

Key Components of Environmental Management

There are a few components that make up environmental management. This section contains the components listed by the International Organization for Standardization. One of the key component that is mentioned is environmental policy. It is a formal statement stating and outlining how the organization will contribute and commit to the protection of the environment (International Organization for Standardization, 2018). Another factor included is the environmental planning. It is used to identify the different aspects of the organization that can impact the environment. It includes any activities, services and products produced by the organization. Implementation and Operation is also another key component listed by the International Organization for Standardization, In this step the organization objective is to develop and execute different programs to achieve the target set in the environmental policy. The next step utilized in environmental management is monitoring and evaluation. It is the act of regularly assessing the environmental performance against the targets and objectives set (International Organization for Standardization, 2018). Lastly, environmental management includes continual Improvement, which is the process of constantly reviewing and revising the environmental management practices. This will help with making sure it is effective and able to adapt to changes.

Environmental Management Tools (EMTs)

Environmental Management Tools (EMTs) are a broad range of methodologies and practices that support organizations in implementing and achieving their environmental management goals (A decade of progress on sustainable buildings and construction: Global Status Report 2017, 2017). These tools can be applied at various stages of a project or an organization's operations and this review will explore existing

research on how the use of specific EMTs correlates with various environmental sustainability metrics in construction projects.

Examples of EMTs:

- **Environmental Impact Assessment (EIA):** This is an environmental management tool that is used to identifying, predicting, and evaluating the potential environmental impacts of a proposed project before it begins (Glasson et al., 2013).
- **Life Cycle Assessment (LCA):** Assesses the environmental impact of a product, service, or system throughout its entire life cycle, from material extraction and production to use and disposal (Dixit et al., 2010).
- **Environmental Management System (EMS):** As discussed previously, an EMS itself is a management tool that provides a framework for environmental management.
- **Building Information Modeling (BIM) with Sustainability Features:** BIM software with sustainability modules allows for the analysis of a building's environmental impact during design and helps optimize building performance (Eastman et al., 2011).
- **Green Materials Selection:** Selecting building materials with lower environmental impact considerations such as recycled content, energy efficiency during production, and potential for reuse or recycling at the end of their lifespan (Dixit et al., 2010).
- **Waste Management Plans:** Developing a comprehensive waste management plan helps minimize waste generation during construction and ensure proper disposal or recycling of construction and demolition waste” (A decade of progress on sustainable buildings and construction: Global Status Report 2017, 2017).
- **Energy-Efficient Construction Practices:** These practices encompass various techniques for reducing the energy consumption of a building throughout its operation. Examples include using energy-efficient building materials, optimizing building envelope design, and implementing energy-efficient mechanical, electrical, and plumbing (MEP) systems (Singh et al., 2019).
- **Building Commissioning:** Commissioning is a systematic process of ensuring that all building systems are designed, installed, and tested to perform according to the owner's requirements.” (ASHRAE Guideline 1.1-2007, 2007). Proper commissioning can significantly improve building energy efficiency and occupant comfort.

- **Energy Monitoring Systems:** These systems continuously monitor and track a building's energy consumption. This data can be used to identify areas for improvement and optimize building energy performance “(Singh et al., 2019).

Selecting and Implementing EMTs

The way the environmental management tools are selected and implemented seriously affect the impact the tools have on the construction project. The effectiveness of EMTs depends on several factors. Project type and scale is one factor that affects the selecting and implementation process as the chosen EMT will depend on the complexity and nature of the project (Glasson, et. Al 2018). The capabilities of the organization are also another factor that affects the implementation of EMTs. The organization needs to have the right amount of resource and capacity to be able to make the right choice. Regulatory requirements also matter when trying to choose the right tools. The EMTs used might need to comply with relevant environmental regulations. Another factor that influences the choice of EMTs is the Project goals and the priorities given to the project as it should align with the overall environmental goals and priorities of the project (Glasson, et. Al 2018).

So by considering the above factors, the organizations can select and implement EMTs that will allow the use of environmental management tools to their maximum capacity so that the tools can be able to enhance the sustainability of the construction project.

The potential of environment management tools to help affect the environment is huge as it aids the organization lessen its impact on the environment and allow it to operate utilizing sustainable practices. The company's ability to use fewer resources has a lot to do with how well the environmental management and associated instruments are handled. A well-defined environmental management system can create a frame work to guide through adoption, implementation and maintenance of EMTs geared towards the goal of the project. This will also help the organizations contribute to a more sustainable future.

2.2.3 Theoretical Frame Work

The study doesn't focus on one specific theoretical framework but rather looks at several theoretical foundations. It is grounded in the principles of sustainability and the application of environmental management tools in the construction industry.

The main theoretical perspective guiding this research is the concept of sustainable development. The theory behind it as described by the Brundtland Commission (1987) is that it is meeting the need of the present without compromising the future. In a study on sustainability development Alaloul et al. (2020) found that principle is relevant especially when it is put in the context of the construction industry. This finding aligns with the results of a systematic review by Wang, W. (2021), which highlighted that the environmental impact of construction activities has become a significant concern for the future generation. Another theoretical perspective used in this research is the theory of environmental management; which is an organized approach of planning, implementing, and controlling activities that have the potential to impact the environment. This has been discussed in detail in the previous section. The theoretical framework also draws upon the concept of project management. Based on a study done by Hwang & Ng, (2013), in which they pointed out how it emphasizes being able to integrate the planning, execution, and control of construction projects and environmental considerations. This perspective highlights the need to understand the contextual factors, such as project characteristics, organizational capabilities, stakeholder engagement, and industry regulations, as these factors influence the successful integration of environmental management tools into construction project management practices.

The last theoretical the study draws from is the theory of sustainability. This one is also used as a base for the conceptual frame work as it puts emphasis on the need to balance the environmental, social, and economic aspects of construction projects to achieve long-term viability (Shen et al., 2010). This theoretical perspective shows the importance of understanding of the link between different environmental management tools in terms of their relationship to the overall sustainability of construction projects.

By drawing upon these different established theories and concepts, the theoretical framework for this study provides a comprehensive understanding to assess the correlation between specific tools and environmental sustainability metrics.. The findings of this research will contribute to the existing body of knowledge in the field of sustainable construction by offering insights into the effective integration and optimization of environmental management tools for improved environmental and financial outcomes.

2.3 Empirical Review

The construction industry has been facing growing pressure to put forth solutions to minimize its environmental impact. While various environmental management tools (EMTs) have been developed to promote sustainable practices. The understanding we have of the relationship between these tools and improved environmental performance remains something to be further explored. This means there is a need for a comprehensive review of existing empirical research on EMTs in construction projects. This section of the literature review explores the existing researches and their empirical contribution to the topic at hand.

Search Strategy

- A comprehensive search strategy was employed to identify relevant studies. Academic databases like Science Direct and Google scholar were used. The study also utilized search engines such as Google Gemini, Bing and copilot to aid the research and analysis process. Search terms include combinations of keywords like "environmental management tools," "construction projects," "sustainability," "environmental performance," "life cycle assessment," "building information modeling," and relevant tool names (e.g., LEED).

Critical Analysis Framework

- The identified studies were then evaluated using a framework considering the following aspects:

Research Design:

- The type of research design employed (case study, survey, mixed-method)
- Consideration of different project types or sizes
- Methods used to show the correlation between environmental management tools and sustainability

Findings and Discussion:

- Reported benefits of using environmental management tools for sustainable construction.
- Identified limitations or drawbacks of environmental management tools use
- The contribution of the findings to understanding environmental management tools link with sustainability of construction projects

By systematically analyzing existing research through this framework, knowledge gaps and areas requiring further investigation can be identified. This was used to inform the development of the research design and methodology in the next chapter.

2.3.1 Key Findings from Existing Research

The data from the empirical research done by existing literature presents the relationship between environmental management tools and all three dimensions of sustainability. An empirical study done on sustainable construction by Koçak & Toprakli in 2024 analyzed how in order to achieve sustainable construction practices, all the dimensions of sustainability needs to be considered. This requires a comprehensive strategy consideration of social, economic, and environmental aspects throughout the project lifecycle (Koçak & Toprakli, 2024). This finding was further corroborated by another similar study done by Araújo et al in 2020 which showed how crucial it was to include all three aspects of sustainability as the construction industry's relied on heavy resource consumption and impacts the environment. The social, economic and environmental aspects of sustainability can also be used as indicators. Integrating sustainability indicators, including those related to EMTs, into project management practices is a key strategy for achieving sustainable construction (Stanitsas et al., 2021). This sentiment is further highlighted as similar researches have pointed out the need for a more nuanced evaluation of non-financial performance, encompassing environmental, social, and economic aspects, at the project level (Kim, as cited in Koçak & Toprakli, 2024).

Several studies have been conducted to explore the relationship of environmental tools on the environment and how it correlates to sustainability performance. In a study done on the use of Environmental Impact Assessments (EIAs) in construction projects, Shen et al. (2010) found that EIAs can be used to effectively identify and mitigate the potential environmental impacts of construction activities. This finding aligns with the results of a systematic review by OECD (2022), which highlighted the positive impact of EIA and emphasized on how it can be used to improve environmental outcomes. However, the researchers also note that different external factors have to be factored in during the implementation of EIA as these factors can hinder the effectiveness of the tool. The studies also point out that some of the factors to be considered include factors such as project complexity, stakeholder engagement, and regulatory compliance.

Researches done on other environmental tools also convey similar points by alluding to the fact that EMTs have a positive relationship with sustainability. The research done on Life Cycle Assessments (LCAs) has highlighted that it has a potential to evaluate the environmental impacts of construction materials and processes throughout the entire life cycle of a project (Alaloul, et.al, 2020). Another research that conducted a comprehensive review of LCA applications in the construction industry by Buyle, et.al (2013) also corroborate and agreed with the findings of Alaloul, et.al. However the study also found that while

LCAs can provide valuable data for decision-making, their adoption is often limited by the availability of reliable data and the complexity of the assessment process.

The empirical literature has also further examined the role other of EMTs, where an empirical study done by Hwang and Ng (2013) suggested that the implementation of Environmental Management Systems (EMSs) in construction projects can lead to improved environmental performance, cost savings, and enhanced stakeholder engagement. It also identified other EMTs like Building Information Modeling (BIM) with Sustainability Features, Green materials selection, Waste management plans and Energy monitoring systems as other tools that could be used in different stages of the project life cycle to improve the impact construction has on the environment (Hwang and Ng .2013).

Despite there being a lot of empirical research on the topic, there are still several knowledge gaps that require further investigation. For instance, the reviewed literature highlights the growing importance of sustainable construction practices within the industry. However, a comprehensive understanding of their interdependence across the environmental, social, and economic dimensions of sustainability remains limited. While studies suggest potential benefits in each area, there are also complexities to consider. Understanding long-term environmental benefits can be challenging, and social aspects like worker training and community engagement require additional focus. Economic sustainability also heavily depends on project specifics and a thorough cost-benefit analysis is crucial.

Despite these limitations, the reviewed research points towards EMTs offering a valuable approach to promote sustainable construction practices. Based on the reviewed studies, a clear trend emerges: EMTs have the potential to positively influence all three pillars of project sustainability (environmental, social, and economic).

2.3.2 Metrics for attaining Sustainable Construction with Environmental Management Tools

All these issues that arise from construction have been a great concern for the construction industry as it faces a pressing challenge. The aim of achieving project success while minimizing environmental impact and promoting social well-being has been a driving force to incorporate sustainability practices to construction projects. Traditional approaches often prioritize cost and schedule, neglecting the long-term

consequences the construction process would have on the environment. Environmental Management Tools (EMTs) offer a promising solution, promoting sustainable construction practices that deliver positive environmental, social, and economic outcomes. We have already discussed how Sustainability in the context of construction can be defined as the practice of meeting the needs of the present without compromising the ability of future generations to meet their own (WCED, 1987). This requires a holistic approach that considers the project's impact across environmental, social and economic aspects. This point is further supported by the Triple Bottom Line (TBL) framework which provides a valuable lens for evaluating a project's sustainability performance across these three dimensions (Elkington, 1994). Performance metrics play a crucial role in evaluating a project's success across these three dimensions, providing valuable data to inform decision-making and making sure that achieving a truly sustainable built environment is possible. By focusing on all three aspects simultaneously, we can achieve a more balanced and responsible approach to construction. This part of the review explores the relationship EMTs have with project sustainability performance, focusing on key performance metrics used to evaluate their impact.

For this research only a few of the performance metrics are chosen for each sustainability aspects to explore the correlation between environmental management tools (EMTs) and sustainable construction. The main reason for the choice of these specific matrices is:

1. **Focus and Depth:** Analyzing fewer metrics makes sure that each one is looked at deeper, increasing the understanding of the relationship between EMTs and those specific aspects of sustainability.
2. **Manageability:** Collecting and analyzing data for many metrics can be resource-intensive. Focusing on the main key metrics ensures the research will be more manageable.
3. **Representativeness:** The chosen metrics are the matrices that best represent the research objective.

Based on the above criteria the following matrices were chosen to evaluate how the implementation of EMTs can affect the sustainability performance of construction.

Environmental performance metrics

Environmental performance metrics focus on measuring the project's impact on the natural environment and promoting resource efficiency. These metrics help assess how construction activities and building operation affect various environmental aspects. For this research 3 performance metrics were chosen to assess the impact on the environment which includes:

- **Resource Consumption:** This metric tracks the quantity of materials (e.g., timber, concrete) and resources (e.g., water, energy) used throughout the construction process and building operation. LCA (Life Cycle Assessment) is a valuable tool for evaluating resource consumption across the entire lifespan of a building (Asif et al., 2013).
- **Waste Generation:** These metric measures the amount of construction and demolition waste that is generated by the construction process. It also assesses the percentage diverted from landfills through recycling or reuse. One of the EMTs that directly contribute to this is an effective waste management plans (WMP) which is a key element of many EMTs that contribute to minimizing waste generation (Hwang & Ng, 2013).
- **Air pollution:** These metric tracks the total carbon emissions as well as air related pollutions associated with construction activities. It tries to measure embodied carbon in materials and operational emissions from building use. EMTs, such as EIA and LCA helps identify potential environmental impacts associated with resource extraction and construction activities (Shen et al., 2010; OECD, 2022). This information can inform project decisions to minimize resource use and pollution.

Social performance metrics

- Social performance metrics focus on measuring the project's impact on workers, communities, and occupants. These metrics ensure that construction activities contribute positively to society and promote well-being. This includes:
- **Worker health and safety:** This metric tracks the number of accidents and injuries occurring on the construction site. A high safety rating indicates that EMTs are effective in promoting a safe work environment for construction personnel (Hwang & Ng, 2013).
- **Labor Practices/ job creation:** This metric assesses working conditions, fair wages, adherence to labor laws, and opportunities for training and skill development. EMTs may not directly impact labor practices, but sustainable construction companies often strive for ethical and fair treatment of workers.
- **Quality of life for local communities:** This metric considers factors like thermal comfort, air quality, and comfort of the user of the complicated project. Sustainable construction often prioritize occupant health and well-being through features that promote it.

Economic Performance Metrics

- **Financial returns:** This performance metric includes the "Return on Investment (ROI)" and "Payback Period." A high rating indicates the importance of EMTs in demonstrating financial benefits associated with sustainable construction practices. (Mohd Arif et al., 2019).
- **Market demand:** This metric connects to the broader concept of project marketability. Sustainable infrastructures with lower environmental impact are more attractive to tenants or buyers, impacting market demand. EMTs that promote green building features can indirectly contribute to this. (Dixit et al., 2012).
- **Cost savings:** This performance metric basically includes the project Cost and life Cycle Cost of the project. A high rating emphasizes the importance of EMTs in achieving cost savings through resource efficiency and improved building performance. (Ramesh et al., 2010).

EMTs are valuable tools for enhancing project sustainability performance across environmental, social, and economic dimensions. By focusing on metrics like resource consumption, waste generation, greenhouse gas emissions, worker safety, working conditions, community engagement, reduced waste disposal costs, improved energy efficiency, and cost savings in material selection, project teams can evaluate the effectiveness of EMT implementation and achieve successful sustainable construction outcomes.

2.3.4 Hypothesis Development

Based on the above performance matrices, this research proposes the following hypotheses to be tested through the research in order to assess the correlation between EMTs and sustainability performance:

H1: There is a correlation between the implementation of Environmental Management Tools (EMTs) in construction projects and environmental sustainability performance.

(measured by factors such as reduced resource consumption, waste generation, and pollution.)

H2: There is a correlation between the implementation of EMTs and social sustainability performance in construction projects.

(measured by factors such as Quality of Life, Job Creation and Health and Safety.)

H3: There is a correlation between the implementation of EMTs and economic sustainability performance in construction projects.

(measured by factors such as reduced waste disposal costs, improved energy efficiency leading to lower operational costs, and potential cost savings in material selection.)

2.4 Conceptual Framework of the Study

This conceptual framework outlines the key elements involved in evaluating the relationship between EMTs and project sustainability. It emphasizes the need for a holistic approach that considers the interplay between environmental, social, and economic dimensions, while acknowledging potential trade-offs between these aspects.

The Framework:

The framework is structured around two core components:

1. **Environmental Management Tools (EMTs):** This component encompasses various tools and methodologies that can be adopted throughout the project lifecycle to improve environmental performance.
2. **Project Sustainability Performance:** This component focuses on the environmental, social, and economic outcomes achieved through EMT implementation. It is measured by a set of relevant indicators, such as:
 - **Environmental:** Resource consumption (materials, water, energy), waste generation, pollution.
 - **Social:** Worker safety, working conditions, community engagement, occupant well-being.
 - **Economic:** Construction costs, operational costs (energy, water), waste disposal costs, potential cost savings from resource efficiency

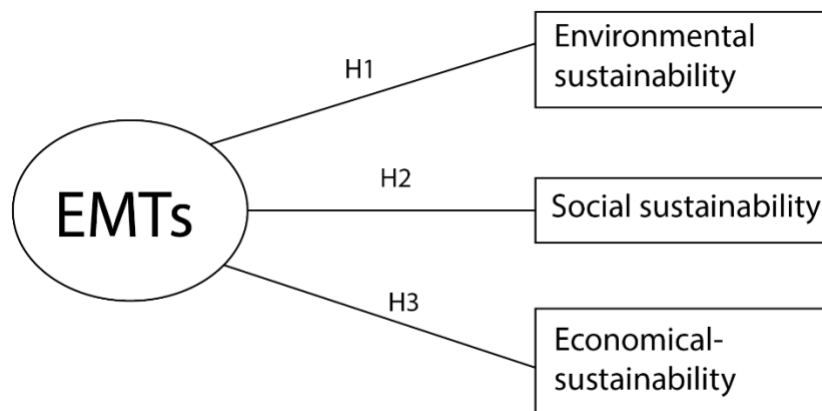


Figure 2.4. Conceptual frame work diagram

Chapter 3

3. Research Methodology

This chapter contains the methodology used to collect, present and analyze the data needed for the research. It will include research design, research approach, the population and Sampling technique, data collection tools & data Source, data analysis methods, validity and ethical considerations in detail.

3.1 Research Design

Research designs are blueprints for research, outlining the framework for data collection and analysis while ensuring relevance to the research question (Creswell, 2009). This research follows a descriptive design. The research tries to explore how the implementations of Environmental Management Tools (EMTs) relate to the sustainability performance of construction projects. The research aligns more closely with descriptive research as it tries describing causality and seeking to explain the observed outcomes. Both the quantitative and qualitative methods used try to provide a broader understanding of EMT usage across Ethiopian construction projects. The quantitative part of the research follows a survey conducted to collect the response of project management professionals that are familiar and work with environmental management tools. The qualitative study follows a detailed case study and uses the documents obtained about the use of EMTs in the project as well as incorporates interviews from 2 project managers that worked on the project.

3.2 Research approach

This study adopts a mixed methods approach meaning it combines a qualitative and quantitative data collection and analysis strategies. This allows for a comprehensive understanding of the effectiveness of EMTs in promoting sustainable construction practices. The quantitative data was gathered through a survey. It tried to capture the general experiences of construction project managers in Ethiopia. The qualitative data was obtained through a detailed case study analysis by the examination of the reports and interviews on the project. This data gathered from the case study provides a deeper look into the practical application and challenges of EMT implementation.

3.3 Target population

The target population for this research consists of construction project managers in Ethiopia. These are professionals that are actively involved in overseeing all aspects of construction projects, including planning, budgeting, scheduling, resource allocation, risk management, and quality control. An ideal project manager for this study would be someone that has experience in projects that incorporate environmental considerations.

3.4 Technique/methods and sample size

Sampling Approach: The sampling approach used for the survey is a simple random sampling. The reasoning behind this choice is to give a fair chance of selection to all project managers who work in construction in Ethiopia.

Sampling Procedure: Online surveys were distributed to construction professionals through professional organizations and online platforms.

Sample Size: In order to determine the sample size, the sampling approach and the potential need for a pilot survey is considered.

Based on the sampling approach a power analysis was conducted to determine the appropriate sample size. We needed to achieve a desired level of statistical power to conduct a power analysis for the research. This means we'll need to estimate the effect size (Cohen's d), desired statistical power ($1-\beta$), and significance level (α). Then, use these values to calculate the required sample size (n). Based on the expected strength of the relationship of the variables and existing studies, a medium effect size is used; Cohen's d is typically around 0.5. Desired Statistical Power ($1-\beta$) is typically at 0.8 (80%), to ensure a high probability of detecting significant relationships if they exist and the significance Level (α) is Set typically at 0.05 (5%), to control the probability of a type I error. Based on this the sample size can be calculated.

To calculate the required sample size (n) for a power analysis with Cohen's d = 0.5, desired statistical power = 0.8, and significance level = 0.05, we'll use the formula:

$$n = (2 \cdot (Z_{1-\alpha/2} + Z_{1-\beta})^2 / d^2)$$

Where:

$Z_{1-\alpha/2}$ is the Z-score corresponding to the significance level ($\alpha/2$).

$Z_{1-\beta}$ is the Z-score corresponding to the desired power ($1-\beta$).

d is Cohen's d (effect size).

For a desired power of 0.8, $Z_{1-\beta}$ is the Z-score at the 0.8th percentile of the standard normal distribution, which is approximately 0.84.

by plug these values into the formula:

$$n = (2 \cdot (1.96 + 0.84)^2 / 0.52)$$

$$n = (2 \cdot (2.8)^2 / 0.25)$$

$$n = (2 \cdot 7.84 / 0.25)$$

$$n = (15.68 / 0.25)$$

$$n = 62.72$$

Rounding up to the nearest whole number, the required sample size (n) is approximately 63 participants. Based on the power analysis the survey was distributed to 63 construction project managers in Ethiopia. Out of the distributed questionnaires there was a response rate of 87.3% and out of the 59 responses that were obtained only 55 of them were valid. This shows that it had a good response rate and ensures the validity of the research.

3.5 Types and Source of Data

- **Primary:** The primary data was collected through:

- Online survey instrument
- Document analysis of project - This involved analyzing reports or project documentation for the case study.

- **Secondary:** Secondary data was obtained through a comprehensive reports, and relevant government publications on environmental management tools and sustainable construction projects.

3.6 Data collection tools

With the idea of insuring it covers the research objectives the research employed a few data collection tools. A structured questionnaire was developed to gather data from construction professionals. A document analysis checklist was used to evaluate project case studies, focusing on aspects like project type, environmental monitoring practices, and the role of project management tools in achieving environmental goals. A semi-structured interview guide was also used to get more information about the case study.

3.7 Data Analysis Methods

Quantitative Data:

- Descriptive Statistics is used to summarize the data collected through the online survey. It describes the central tendency (average), variability (standard deviation), and distribution of variables like experience with EMTs, challenges faced, and perceived effectiveness.
- Inferential statistics is used including correlation analysis which was employed to identify potential relationships between variables

Qualitative Data:

- Thematic Analysis is used to analyze data from open-ended survey questions case study. It involves identifying recurring themes, patterns, and insights related to participants' experiences with EMTs, challenges encountered, and best practices.

Data Triangulation:

- By combining data from the literature review, online survey and in-depth analysis of the case study, data triangulation is used to enhance the validity and reliability of the research findings. This approach allows for a more comprehensive understanding of the topic by examining it from different angles and potentially revealing inconsistencies or areas for further exploration.

3.8 Validity and Reliability

Reliability

A pilot survey was distributed to assess the reliability and accuracy of the questionnaire. It was distributed to a total of 18 individuals where 14 of them gave a feedback. Based on the feedback given by these construction management professionals the questionnaire was adjusted.

Calculating Cronbach's Alpha

To ensure the survey effectively measures the perceived effectiveness of Environmental Management Tools (EMTs), Cronbach's Alpha is used to assess the internal consistency of the relevant questions. A total of 5 questions were chosen to assess the effectiveness of the survey from the pilot survey that was distributed to construction professionals (n=18, feedback from n=14). It helped refine the questionnaire. The questions chosen for the Cronbach's Alpha include: frequency of EMT use (Question 4.), directly

perceived effectiveness (Question 5), Question 7 (Agreement with Environmental Performance Statements), Question 14 (Importance of EMTs on Economic Performance Indicators) and Question 16 (Importance of EMTs on social Performance Indicators).

$$r_{kk} = \frac{k}{k-1} \left(1 - \frac{\sum s_i^2}{s_t^2} \right)$$

Where:

(k) is the number of items in the test or questionnaire.

(s_i²) represents the variance of the (i)th item.

(s_t²) represents the total variance across all items

$$5/5-1(1-3.521/8.64)= 0.741$$

The calculated Cronbach's Alpha was 0.741, which falls between 0.8 and 0.7 which is an acceptable internal consistency. This means the chosen questions measure the same underlying concept (r/n between EMTs and aspects of sustainability) and provide a reliable assessment of how construction professionals view the effectiveness of Environmental Management Tools.

Validity

This research prioritizes validity by using pre-validated survey questions and presenting interview data as is. Pre-existing questions ensure consistent measurement and allow for comparisons with past research and presenting the interviews this way enhance transparency. The design of the research instruments also is done as if it was to address the study's already predetermined objectives so as to make sure it has the appropriate level of validity.

3.9 Ethical Considerations

This research project adheres to high ethical standards to ensure the well-being and privacy of participants. The following principles will guide the research process:

- **Right to Choose:** Participation in the online survey and any potential interviews was entirely voluntary. Participants were clearly informed of their right to withdraw from the study at any point without penalty.
- **Right to Safety:** The research didn't pose any physical or psychological risks to participants. The survey was designed to be respectful and avoid any questions that could cause discomfort.

- **Right to Privacy:** The anonymity and confidentiality of participants was ensured. The survey did not collect any personally identifiable information. Data was stored securely and used only for the purposes of this research project. No individual responses will be disclosed in any reports or publications.
- **Confidentiality:** All data collected will be kept confidential. Data will be coded and makes sre that it is anonymous.

Chapter 4

4. DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.1 Introduction

In this part of the research paper, we are going to see the data analysis, findings, and discussion to evaluate the strength of the relationship between EMTs and sustainability performance of building projects. From the preceding chapters, the theoretical framework has already been laid, and previous studies that touch on this subject matter have been reviewed. This means this chapter will use the knowledge obtained from those sources to analyze, present, and discuss the data collected, it will also utilize correlation analysis to examine the relationships between EMTs and the three pillars of sustainability which are environmental, social, and economic aspects of sustainability.

The approach used for the qualitative study is a case study approach and this chapter utilized thematic analysis to analyze the qualitative data to gain a richer understanding of the correlation of how Environmental Management Tools (EMTs) are related to project sustainability. This analysis will have two key sections and sources which include interview transcripts and quotes from the two project managers who directly oversaw the Sawla-Maji Road Upgrading Project, and relevant project documents related to the case study. It's important to note that these interviews are not simply follow-ups to the survey. Instead, they aim to capture the specific experiences and perspectives of those who implemented these tools within the case study project, providing valuable insights into the on-the-ground realities of EMT implementation and its impact on sustainability goals. The research looked for recurring patterns and themes within the report and interview of the Sawla-Maji Road Upgrading Project to analyze and discuss the findings. Based on the research questions and to gain a more holistic understanding the correlation between Environmental Management Tools and sustainability performance of construction projects, the research will focus on examining four key themes which include the types of EMTs used and assess their relationship with sustainability goals. Second, would be to assess the relationship between EMTs and environmental sustainability. Third, explore the correlation between EMTs and economic sustainability performance of construction projects using economic sustainability metrics indicators. Finally, the last theme that is explored is how EMTs correlate to the surrounding community, worker safety, and overall social responsibility. By examining these interconnected themes, we can gain a comprehensive picture of the project's sustainability journey through the lens of EMTs.

Appropriate statistical approaches for the quantitative data was also utilized including descriptive statistics and correlation analysis in analyzing the findings effectively. The information is presented in a detailed manner and given out in the simplest form possible to better understand the essence of the correlation between environmental management tools and sustainability of construction projects. The first part of the presentation of the data is to understand the respondent's general demographic and understand who participated in the survey. The questionnaire included about three questions to identify if the respondents were the targeted demography, their level of experience, and familiarity with EMTs. This background data is necessary to understand the participant diversity in their field of responsibility in the project. Following these, a thorough discussion is conducted, where the findings are interpreted and triangulated with the literature, case study and framework developed earlier. The discussion will explore how the results align or divert from prior research and provide explanations for the observed patterns and trends. This chapter aims to present the data in a way that adds to the knowledge that already exists on the topic at hand.

4.2 Qualitative Data Presentation and Analysis

This section of the data presentation and analysis chapter aims to present the qualitative data and analyze it using the proper methods. The approach used for the qualitative study of the mixed method is a case study approach which assesses the use and impact of EMTs on the Sawla-Maji Road Upgrading Project. This analysis will focus on the interview transcripts from the two project managers directly involved in the project and use thematic analysis to identify recurring themes and patterns within their experiences and perspectives. Additionally, relevant project documents will be included to triangulate the findings and ensure a more comprehensive understanding. By presenting the qualitative data in the form of identified themes, we can gain valuable insights that complement the quantitative survey data and paint a more clearer picture of how EMTs influenced the project's sustainability on a practical level.

4.2.1 Background of respondents

This section includes the background of the two project managers that worked on the Sawla-Maji Road Upgrading Project. These two professionals were interviewed to provide their experiences and perspectives of how EMTs contributed to enhance the sustainability performance of the road upgrading project.

Key Informant (KI)	Age	Sex	Professional background of the Key informants	Position they currently hold	Key informants General work experience	Familiarity with EMTs
KI1	48	M	Masters in project Management	Senior Project Manager	12	Very familiar
KI2	31	F	Masters in project Management	Project manager	6	Very familiar

Table. 4.2.1 Background of respondents

4.2.2 Description of the cases

This section focuses on the qualitative data collected through a case study approach. A single in-depth case study of the Sawla-Maji Road Upgrading Project was chosen to provide a rich and detailed understanding the relationship between EMTs and project sustainability in a real-world context. Interviews were conducted with the two project managers directly involved in the project, as their firsthand experience provides valuable insights into the practical application of EMTs. While the sample size is smaller than what is used in a thematic analysis of interview data from a larger population, focusing on these key personnel allows for a comprehensive exploration of their experiences and perspectives on how the implementation of EMTs relate to the project's sustainability performance. For this data collection a semi-structured interview approach was employed. These questions look at the specific EMTs used and their correlation with sustainability goals of construction projects. It also assesses the relationship the tools have on the economic, social and environmental aspect of sustainability. By carefully documenting their experiences and observations, this study aims to provide a comprehensive understanding of EMT implementation within the project. This methodical approach ensures an exploration of EMTs on how these tools are used in real-world case study. Examining the perspectives of key professionals offers valuable insights into the effectiveness of EMTs in achieving sustainable construction practices.

	Category 1	Category 2	Category 3	Category 4
No	Types and correlation of Implemented Environmental Management Tools (EMTs) with sustainability	Environmental Sustainability and EMTs	Economic Sustainability and EMTs	Social Sustainability and EMTs
1.	Can you list the specific environmental management tools (EMTs) that were used in the Sawla-Maji Road Upgrading Project?	Can you elaborate on your level of agreement with the statement: "EMTs contribute to construction projects achieving reductions in resource consumption (e.g., material use, energy, water)"?	In your experience, how do environmental management tools influence the economic considerations of construction projects? Can you think of any examples from the Sawla-Maji project where EMTs might have had a positive economic impact?	In your experience, did any of the EMTs used in the Sawla-Maji Road Upgrading Project have any social sustainability benefits (e.g., improved worker safety, community engagement)? If so, can you elaborate?
2.	Based on your experience in this project, did you observe any positive environmental outcomes (reduced waste, lower energy consumption) from using these EMTs?	Beyond resource consumption, did any of the EMTs address other environmental concerns like waste generation and pollution? If so, how effective were these	Were there any additional costs associated with implementing EMTs in the Sawla-Maji project? If so, how were these costs justified in	How can we ensure that EMTs are implemented in a way that considers the social well-being of workers and

	Can you share a specific example?	tools in mitigating these concerns?	terms of long-term benefits?	the local community?
3.	What do you consider were the biggest challenges in implementing EMTs effectively in the Sawla-Maji Road Upgrading Project? (Probe further based on their response - lack of training, budget constraints, etc.)	How can we improve the way environmental impact is measured and monitored in construction projects to better assess the effectiveness of EMTs?	Looking ahead, how can we better integrate economic considerations with environmental goals when selecting and implementing EMTs?	Do you see any potential social challenges associated with the use of specific EMTs? If so, how can these challenges be mitigated?
4.		In your opinion, what are some critical environmental considerations for future construction projects similar to Sawla-Maji? How can EMTs be used to address these considerations effectively?		

Table. 4.2.2 Categories of interview Questions

4.2.3 Types and Effectiveness of Implemented Environmental Management Tools (EMTs)

Theme 1: Types and correlation of Implemented Environmental Management Tools (EMTs) with sustainability

Based on the provided case study excerpt of the reports as well as the interview conducted with the project managers that worked on the project, here's an analysis of Theme 1: Types and Effectiveness of Implemented Environmental Management Tools (EMTs) in the Sawla-Maji Road Upgrading Project.

Types of EMTs Implemented:

- **Environmental Impact Assessment (EIA):** Conducted during the planning stage to identify and mitigate potential environmental impacts.
- **Life Cycle Assessment (LCA):** Employed during the design stage to evaluate the environmental impact of materials and processes throughout the project lifecycle (though document evidence is not explicitly mentioned).
- **Building Information Modeling (BIM) for Sustainability:** While not explicitly mentioned in reports as a tool directly used to advance sustainability performance, interviews suggest the use of advanced design tools with sustainability considerations include BIM.
- **Green Materials Selection:** The project prioritized utilizing locally sourced and environmentally friendly construction materials whenever possible.
- **Waste Management Plans:** Developed and implemented to manage clearing and grubbing waste disposal, although challenges were encountered.
- **Environmental Monitoring and Management System:** Established to track environmental performance during the operation phase and implement corrective measures if required.

Implemented EMTs:

The case study provides evidence of the relationship between Environmental Management Tools (EMTs) and environmental performance. One way to observe the correlation between EMTs and sustainable performance is through the success stories of how EMTs implementation was able to contribute to sustainable material selection and conservation.

KI1 "LCA was a valuable tool in choosing gravel sources with minimal transport distances. This not only reduced emissions but also helped us conserve resources. Additionally, BIM played a crucial role in optimizing designs to minimize material needs overall. It even allowed us to consider incorporating recycled materials wherever possible, which further reduced our environmental footprint."

The statement from KI1 suggests a correlation between the implementation of LCA and BIM and reduced resource consumption and waste generation.

Based on the reports, the other relationship that was observed was the successful implementation of EMTs and its contribution towards biodiversity conservation. The case study shows the correlation between EMTs like EIA and green material selection and route and material selection. This was further corroborated by the responses from the interview.

KI1 "The Environmental Impact Assessment (EIA) was crucial in informing the route selection process. By carefully analyzing potential impacts, we were able to minimize disruption to critical habitats for local wildlife. Additionally, using green materials throughout the project helped lessen the ecological impact on surrounding ecosystems."

KI2 "Protecting the environment was a top priority throughout this project. The Environmental Impact Assessment (EIA) proved to be an invaluable tool. By thoroughly analyzing potential impacts of different route options, we were able to select one that minimized disruption to critical habitats for local wildlife. This helped us ensure the project's footprint on the surrounding ecosystem was as minimal as possible."

Both the respondent indicates a potential correlation between EIA implementation and reduced environmental impact.

The reports also highlight how the use of environmental management tools aided in enhancing the social and economic sustainability of the project.

(KI1): "While we faced some challenges with environmental aspects of the project, the use of Environmental Management Tools (EMTs) did have a significant positive impact on the local economy and social well-being. By minimizing disruptions and ensuring faster project completion, we facilitated earlier access to markets for local farmers. This is already stimulating economic growth in the region. Additionally, the EMTs focused on sustainable resource management, which is crucial for long-term agricultural productivity."

(KI2): "The social aspects were also very important. Dust control measures and air quality management, implemented as part of the EMT plan, helped reduce respiratory problems for nearby communities, leading to a healthier population. The fact that the local hiring and use of local materials provided income opportunities and fostered a sense of ownership within the communities. Additionally, the focus on safety protocols minimized accidents and injuries during construction. These factors contribute to a more productive workforce and a safer environment for everyone involved."

Both the respondents implied that the EMTs played a significant role in enhancing the social and economic sustainability of the project which suggests a correlation between EMT implementation and broader sustainability outcomes.

4.2.4 Environmental Sustainability and EMTs

Theme 2: Correlation between EMT Implementation and environmental sustainability performance in the Sawla-Maji Road Upgrading Project

The Sawla-Maji Road Upgrading Project clearly shows the relationship between Environmental Management Tools (EMTs) and environmental sustainability performance of the project. The case study provides evidence of the relationship between Environmental Management Tools (EMTs) and environmental performance.

For example, the use of LCA and BIM was associated with reduced resource consumption and waste generation. Similarly, EIA was linked to the protection of wildlife habitats. These findings suggest a potential correlation between specific EMTs and improved environmental outcomes.

- **(KI1):** "LCA was a valuable tool in choosing gravel sources with minimal transport distances. This not only reduced emissions but also helped us conserve resources. "
- **(KI2):** "The plan to use green material and utilizing green material selection played a crucial role in optimizing materials needed overall. It even allowed us to consider incorporating recycled materials wherever possible, which further reduced our environmental footprint."

These statements highlight the potential correlation between these EMTs and environmental performance.

- Other EMTs that was used was EIA. It played a crucial role in informing route selection, minimizing disruption to critical habitats for wildlife. This not only protected biodiversity but also potentially reduced the need for extensive land clearing, further minimizing the project's ecological impact.
 - **(KI1):** "The Environmental Impact Assessment (EIA) was crucial in informing the route selection process. By carefully analyzing potential impacts, we were able to minimize disruption to critical habitats for local wildlife. Additionally, using green materials throughout the project helped lessen the ecological impact on surrounding ecosystems."
 - **(KI2):** "Environmental impact assessment was a huge help in being able to assess the impact that would be imposed on the project, It helped us with the assessment and planning phase of the construction process."

This also suggests a potential correlation between EIA and reduced environmental impact.

- **Green Materials Selection:** The project prioritized the use of green materials with a lower environmental impact throughout their lifecycle. This selection process was able to reduce the energy use associated with the materials used in construction, contributing to a more sustainable outcome.
 - **(KI1):** "Selecting and using green materials with a lower ecological impact throughout their lifecycle was another key factor in reducing our environmental footprint. By using these materials wherever possible, we were able to reduce the overall ecological impact of the project on the surrounding ecosystems."

The analysis demonstrates a potential correlation between the implementation of Environmental Management Tools (EMTs) and environmental performance. While the case study shows the relationship between EMTs, such as LCA, BIM, and EIA, and environmental outcomes, further research is necessary to establish definitive relationships causation.

4.2.5 Social Sustainability and EMTs

Theme 3: Social Sustainability and EMTs in the Sawla-Maji Road Upgrading Project

This section explores the relationship between Environmental Management Tools (EMTs) and social sustainability performance within the context of the Sawla-Maji Road Upgrading Project. The project demonstrated potential associations between EMT implementation and social outcomes. For instance,

- **Improved Health Outcomes:** Dust control measures and air quality management plans implemented as part of different EMTs such as EIA helped reduce respiratory problems for communities near the construction zone. This contributes to a healthier population and a more productive workforce.

KI1 stated, "The focus on safety protocols as part of the EMT plan definitely paid off, We had a significant reduction in construction-related accidents compared to previous projects,"

This suggests a link and correlation between EMTs and improved worker safety.

- **Enhanced Safety:** Proper traffic management and worker safety protocols implemented through EMTs was able to manage accidents and injuries during construction. This protects lives and livelihoods within the communities.
- **Community Development:** The use of EMTs like green material selection was able to assess the use of local materials and encouraged measures like hiring local workers and using local materials. This was able to generate income opportunities within the communities and foster a sense of ownership over the project. Increased employment and income generation within the community can contribute to poverty reduction and improved overall well-being.

(KI2):" "The use of LCA and green material selection encouraged us to explore using locally available, sustainable materials for the project. This not only reduced our environmental footprint but also created job opportunities for local people by using local suppliers."

These examples highlight the potential for EMTs to contribute to positive social outcomes, including improved health, safety, and economic well-being for local communities.

4.2.6 Economic Sustainability and EMTs

Theme 4: Economic Considerations of EMT Implementation in the Sawla-Maji Road Upgrading Project

This section analyzes the relationship between Environmental Management Tools (EMTs) and economic sustainability in the Sawla-Maji Road Upgrading Project..

The report on the Sawla-Maji project highlights several potential economic benefits associated with effective EMT implementation:

- **Improved Market Access:** By minimizing environmental disruptions and ensuring smooth construction progress, EMTs were lined with improved market access.
 - **(KI1)** “The use of EMTs allowed for an improved infrastructure which allowed for easier transportation of goods and services, connecting producers to markets more efficiently.”
 - The project report highlights several potential relationships b/n economic sustainability performance and ETs implementation. One key correlation is between market access and the use of EMTs to facilitate minimum environmental disruptions and ensuring smooth construction progress
- **Sustainable Resource Management:** EMTs focused on resource management exhibited a potential relationship with economic benefits
 - **(KI2):** "EMTs like life cycle assessment (LCA) helped us identify ways to minimize construction waste and use local, sustainable materials. This not only reduced environmental impact but also lowered transportation costs and supported local businesses."
 - EMTs that promote responsible resource extraction and minimize waste can also contribute to long-term agricultural productivity and economic development. By safeguarding fertile soil and clean water resources, EMTs ensure the continued viability of agricultural activities, a crucial economic driver for many rural communities. For instance, (KI2) explained that EMTs like life cycle assessment (LCA) helped them identify ways to minimize construction waste and use local, sustainable materials. This not only reduced environmental impact but also potentially lowered transportation costs and supported local businesses.

- **Reduced Construction Costs:** EMTs have a relationship with utilization and optimized designs, potentially reducing overall construction costs. This aspect can be further explored in future research based on project data.
 - **(KI1)** "We used Building Information Modeling (BIM) with sustainability features," explained (KI1), "which helped us identify and fix potential design flaws before construction began. This saved us money on rework and material waste later on."
 - While not explicitly quantified in the reports, EMTs also have correlation to reduced construction costs. (KI1) described how Building Information Modeling (BIM) with sustainability features helped identify and fix potential design flaws before construction began, potentially saving money on rework and material waste later on.

(KI1): "The initial investment for EMTs was a hurdle, mainly because some of the tasks were outsourced. The utilization of tools like EIA needed outside help which resulted in high initial cost but the long-term cost savings from using fewer resources definitely outweighed it."

- Some of the challenges related to the implementation related to economic sustainability include the upfront costs associated with implementing certain EMTs, such as LCA and BIM software licenses, training for personnel, and additional planning efforts, can be a barrier for some projects. Finding a balance between cost-effectiveness and achieving sustainability goals is crucial. Inadequate resources is also another issue, as mentioned earlier, it can hinder the effectiveness of EMTs. Limited manpower, materials, or proper organization can lead to inefficiencies and potentially increase project costs. Complex projects with multiple stakeholders might face challenges in coordinating EMT implementation across different companies. This can lead to delays and potentially increase costs.

The strength of the relationship between EMTs and economic sustainability performance depends on effectively balancing the potential benefits with the associated costs. Finding cost-effective ways to implement EMTs, while maximizing their impact on project sustainability, is crucial. This shows that there is a correlation between EMTs and market access, sustainable resource management, and potentially reduced construction costs. By carefully analyzing costs and benefits, adopting a phased implementation approach, and investing in capacity building, future projects can leverage EMTs to achieve both economic and environmental sustainability goals.

4.3 Quantitative Data Presentation, Analysis and Data Triangulation

This section explores the correlations between the use of Environmental Management Tools (EMTs) and project sustainability performance across social, economic, and environmental dimensions. The research will utilize SPSS to analyze the data and test the hypothesis that the use of implemented EMTs correlates with positive sustainability outcomes. The analysis will involve categorizing the EMTs based on their primary function (environmental, social, or economic). It will then correlate the frequency of implementing each category of EMTs with the corresponding sustainability performance metrics. For example, the frequency of using environmentally focused EMTs such as Waste Management Plans (WMP), Life Cycle Assessment (LCA), Environmental Management System (EMS), Environmental Monitoring System (EMS2) and Water Conservation Strategies (WCS) will be correlated with environmental sustainability metrics. Whereas socially and economically focused EMTs will be correlated with their corresponding matrices. This approach allows us to identify potential correlations between specific types of EMTs and the sustainability dimension they are designed to address.

The study acknowledges that situations might differ based on the individual project. To make sure this limitation is addressed, the findings from the correlation analysis will be used and supported by the data from the case study of the Sawla-Maji Road Upgrading Project. This will allow the relationships to be explored in specific contexts and triangulating the findings with existing literature. This combined approach will provide a solid foundation for understanding the correlations between EMT implementation and sustainability outcomes.

4.3.1 Background of respondents

The research used a simple random sampling method to select the respondents. Based on the calculation and research done 63 survey questionnaires were distributed based on the calculations made to find the sample size. This section of the chapter presents and analyzes the data that was collected from the survey questionnaire that was distributed to construction project managers to evaluate the relation between the Environmental Management Tools (EMTs) usage and the sustainable performance of construction projects. Out of the total 63 questionnaires that were distributed, 59 were returned (93.6% response rate). Of those returned, 55 of them seemed to be valid for analysis, which meant that there was a high 93% valid response rate among those who responded.

Parties	Questionnaire			Percentage (%)	
	Distributed	Responded	Valid	Returned from distributed	valid from responded
Project Managers that work in construction	63	59	55	93.6%	93.2%

Table 4.3 The result of the respondent rate

Feature	Description	Responses (n=55)	Percentage (%)
Profession	All respondents are Construction Project Management Professionals	55	100%
Experience Level	* 1-5 Years	20	36.40%
	* 6-10 Years	15	28.90%
	* 11-15 Years	13	24.00%
	* 16+ Years	7	12.50%
Familiarity with EMTs	* Very Familiar	42	76.40%
	* Somewhat Familiar	13	23.60%

Table 4.3.1 profiles of the respondents

A 93% response rate for the survey is considered a high response rate as it is more than 70%. which shows that most of the respondents were able to respond. This shows that there was high participation and data quality. This strengthens the credibility of the findings since it is based on the input from a representative sample of the target population which is project managers that work in the construction industry.

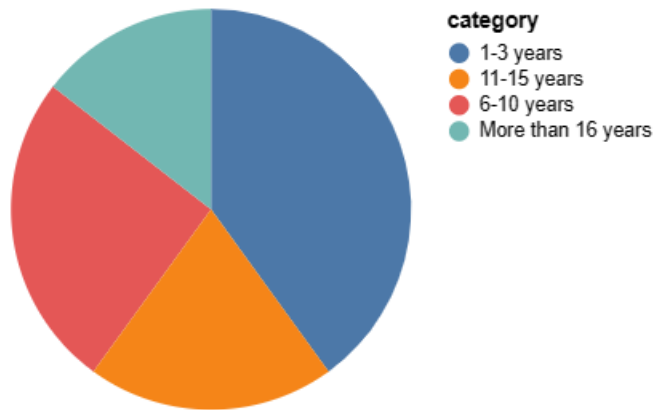


Figure 4.3 The respondent experience in the construction industry

The data shows that the respondents have different levels of experience. About 36 percent have only spent 1 to 5 years in the industry but about the same amount of people which is around 36.5 percent are professionals with 11 or more years of experience. This allows for more of a nuanced understanding where we can look at the perspective of both people that are new and experienced professionals as we can get different perspectives from them. This will allow us to understand how experience affects the understanding of the r/n between EMTs and sustainability.

➤ Familiarity with environmental management tools (EMTs)

The results from the 55 valid responses that were obtained from the survey revealed that a lot of the respondents were very familiar with environmental management tools. A significant majority of the respondents (76.4%) which is 42 out of 55 where the rest of the participant responded with saying that they were somewhat familiar with the use of EMTs. This indicated that all of the participants have used EMTs and are familiar with them. This shows that there is a high level of awareness in the construction industry, suggesting that many project managers know how to use these tools for environmental Sustainability.

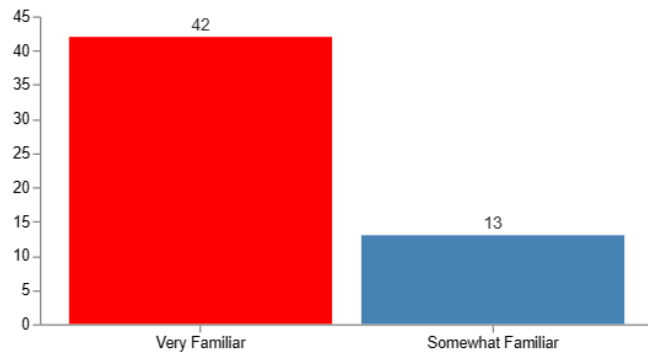


Figure 4.3.1 Familiarity with environmental management tools (EMTs)

However, the fact that 23.6% (13 out of 55) of the respondents stated that they had some knowledge about EMTs indicated that there may be a gap in knowledge that could possibly be filled through specialized training programs. According to the findings of a study conducted by Smith & Jones (2023), proper training is important to make sure that the implementation of EMTs is a success. The research then continues to make the point that making sure that project teams have a great understanding of EMTs and their functionalities can strengthen the relationship b/n the two.

4.3.2 Environmental Management Tools (EMTs) Usage

Environmental Management Tools (EMTs) Usage is discussed in this section. It presents, analyzes, and discusses the results of the survey on Environmental Management Tool (EMT) usage within the Construction Industry and triangulates the data obtained from the case study regarding the EMTs used in the Sawla-Maji Road Upgrading Project. The findings for both the case study and survey present a very

mixed picture. It shows that some tools are widely adopted and others underutilized.

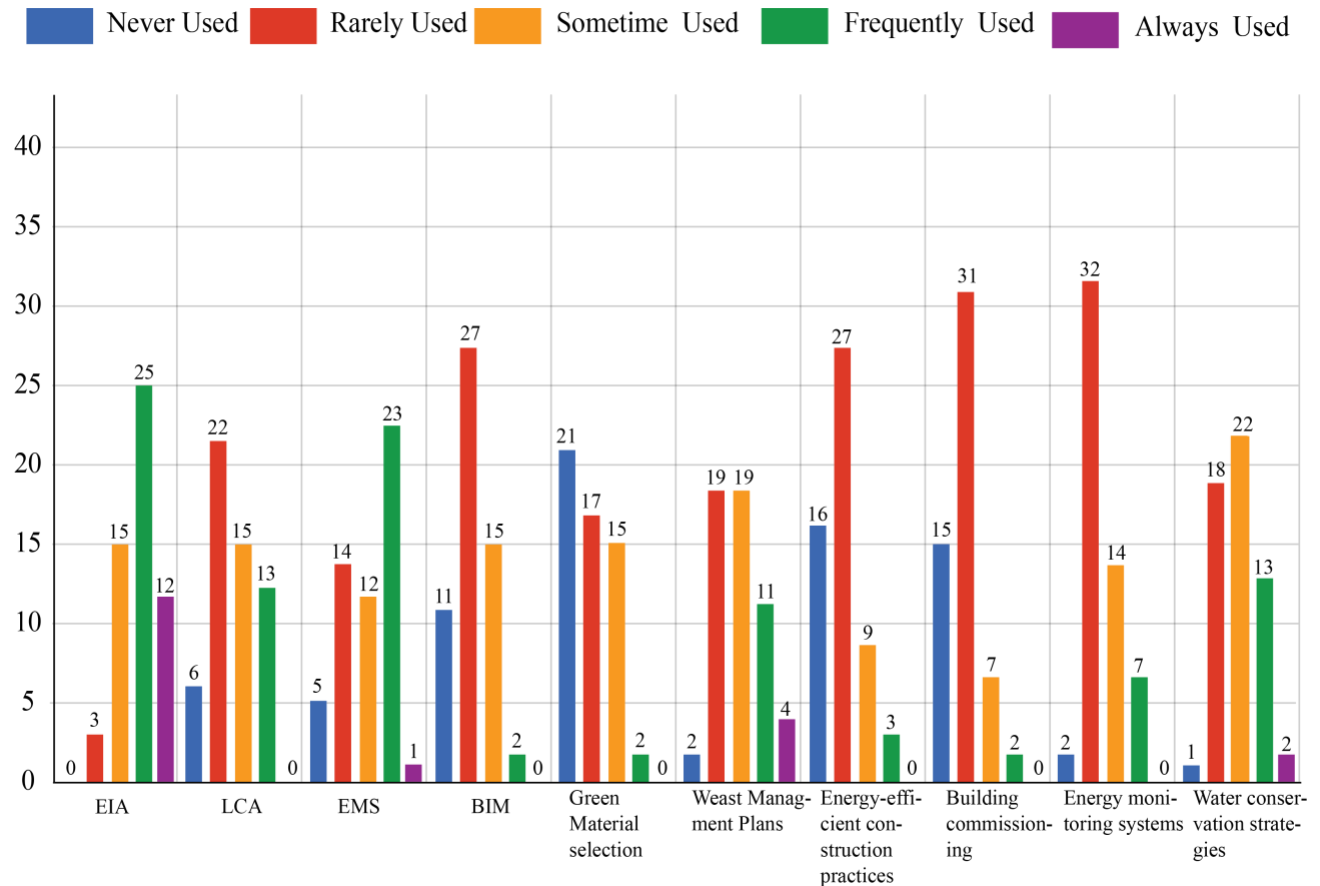


Figure 4.3.2 Environmental Management Tool (EMT) Usage Frequency

Data Breakdown:

- Environmental Impact Assessment (EIA): Never Used 0.0%, Rarely Used 5.45%, Sometimes Used 27.27%, Frequently Used 45.45%, Always Used 21.8%
- Life Cycle Assessment (LCA): Never Used 10.91%, Rarely Used 40.00%, Sometimes Used 25.45%, Frequently Used 23.3%, Always Used 0.00%
- Environmental Management System (EMS): Never Used 9.09%, Rarely Used 25.45%, Sometimes Used 21.82%, Frequently Used 41.82%, Always Used 1.82%
- BIM with Sustainability Features: Never Used 20.00%, Rarely Used 49.09%, Sometimes

Used 27.27%, Frequently Used 3.64% , Always Used 0.00%

- Green Materials Selection: Never Used 38.2%, Rarely Used 30.9%, Sometimes Used 27.3%, Frequently Used 3.64%, Always Used 0.00%
- Waste Management Plans: Never Used 3.64%, Rarely Used 34.55%, Sometimes Used 34.55%, Frequently Used 20.00%, Always Used 7.27%
- Energy-Efficient Construction Practices: Never Used 29.09%, Rarely Used 49.09%, Sometimes Used 16.36% , Frequently Used 5.45%, Always Used 0.00%
- Building Commissioning: Never Used 25.45%, Rarely Used 58.18%, Sometimes Used 12.73%, Frequently Used 3.64% , Always Used 0.00%
- Energy Monitoring Systems: Never Used 3.64% , Rarely Used 58.18%, Sometimes Used 25.45% , Frequently Used 12.73% , Always Used 0.00%
- Water Conservation Strategies: Never Used 1.82%, Rarely Used 32.73%, Sometimes Used 38.2%, Frequently Used 23.64% , Always Used 3.64%

	EIA		LCA		EMS		BIM		GMS		WMP		ECP		BC		EMS2		WCS	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Never Used	0	0.0%	6	10.91%	5	9.09%	11	20.00%	21	38.2%	2	3.64%	16	29.09%	15	27.3%	2	3.64%	1	1.82%
Rarely Used	3	5.45%	22	40.00%	14	25.45%	27	49.09%	17	30.9%	19	34.55%	27	49.09%	31	56.4%	32	58.18%	18	32.73%
Sometimes Used	15	27.27%	14	25.45%	12	21.82%	15	27.27%	15	27.3%	19	34.55%	9	16.36%	7	12.73%	14	25.45%	21	38.2%
Frequently Used	25	45.45%	13	23.63%	23	41.82%	2	3.64%	2	3.6%	11	20.00%	3	5.45%	2	3.64%	7	12.73%	13	23.64%
Always Used	12	21.81%	0	0.00%	1	1.82%	0	0.00%	0	0.00%	4	7.27%	0	0.00%	0	0.00%	0	0.00%	2	3.64%

Table 4.3.2 Environmental Management Tool (EMT) Usage Frequency

The data gathered through the survey on Environmental Management Tool (EMT) usage within construction Industry reveal a mixed picture, with some tools widely adopted and others underutilized. The survey data reveals a significant variation in the adoption rates of different EMTs employed by construction professionals. Of the 55 respondents 67.27% (Frequently Used 45.45% and Always Used 21.8%) choose Environmental Impact Assessment (EIA) making it the most frequently used tool where the respondents said that they use it constantly. This correlates with the emphasis placed on it in the Sawla-Maji case study, which showed that the tool had an important role in identifying and mitigating potential environmental impacts before the construction is started. This finding also resonates with the research done by Shen, et.al

(2010) where the study emphasized the importance of EIA in making sure that construction projects follow sustainable practices. However, the data shows that the rest of the EMTs weren't utilized as much as they needed to be. Tools like Building Information Modeling (BIM) with sustainability features and Green Materials Selection show low adoption rates. Only 3.64% of respondents reported frequent use of BIM with sustainability features. These low adoption rates correlates with a lack of training or software proficiency. This was corroborated by the interview from the case study. As one of the quotes from the interviewed project manager mentioned this exact reason for the possible cause for the survey results that showed a low adoption rate for BIM. It indicates the need for specialized knowledge and resources to fully utilize advanced BIM capabilities. Another EMT that was rarely used by the respondents was green materials, where about 47.27% said that don't use it. This is a missed opportunity considering the literature review by Smith & Jones (2023) highlights the EMTs potential to optimize sustainable design and Dixit et al. (2010) emphasize the environmental benefits of green materials. The case study of the Sawla-Maji Road Upgrading Project also mentions BIM and green materials. The case study is actually a good example of how to utilize these two tools. By using BMI and green materials, the project was able to utilize materials that were found on site contributing to enhanced sustainability, which also allowed for a cost saving from the transportation and obtaining materials from the imamate site.

Life Cycle Assessment (LCA) is another tool that is not used as much as it should be. The response for this particular EMT shows that nearly half (40.00%) of respondents rarely use it. This is also another missed opportunity as the literature review places a heavy emphasis on LCA's ability to assess a building's environmental impact throughout its lifecycle. Because of its ability to help throughout the entire construction process, it is able to contribute to sustainability (Smith & Jones, 2023). Similarly, Energy-Efficient Construction Practices and Building Commissioning show low adoption rates. Nearly 80% of the respondents for Energy-Efficient Practices and 58.18% for Building Commissioning said that they rarely or never used these tools. This also makes it another missed opportunity as both of these tools are crucial for achieving energy-efficient buildings. Nevertheless, there are some positive signs shown by the study results. In the case of Waste Management Plans, respondents have a fair acceptance level with slightly more than 1 out of every 3 people saying they use the EMT. Additionally, over 60% apply Water Conservation Strategies during construction. This aligns with the growing focus on responsible waste disposal and water conservation that is highlighted in the UN Environment Programme's Global Status Report (2017).

		Statistics									
		Environmenta l Impact Assessment	Life cycle Assessment	Environmenta l management systems	Building information model	Green material selection	Waste management plans	Energy- efficient construction practices	Building commissioni ng	Environmenta l monitoring systems	Water conservation systems
N	Valid	55	55	55	55	55	55	55	55	55	55
	Missing	0	0	0	0	0	0	0	0	0	0
Mean		3.8364	2.6182	3.0182	2.1455	1.9636	2.9273	1.9818	1.9273	2.4727	2.9455
Median		4.0000	2.0000	3.0000	2.0000	2.0000	3.0000	2.0000	2.0000	2.0000	3.0000
Mode		4.00	2.00	4.00	2.00	1.00	2.00 ^a	2.00	2.00	2.00	3.00

a. Multiple modes exist. The smallest value is shown

Table 4.3.2.1 Environmental Management Tool (EMT) Usage Statistics

These findings suggest that there is a potential correlation between the frequency of using specific Environmental Management Tools (EMTs) and project sustainability practices. For instance, from the survey data and the case study analysis we can see that the high usage of EIA correlate with its importance in minimizing environmental impacts. But there is a difference in the adaption rate among the EMTs alluding to the fact that the usage of tis tools could be project based. This is shown in the case study where the EMTs that were not frequently chosen by the respondents lie LAC and green material selection were the main environmental management tools used to help with sustainability performance. This shows that it is not a once size fit all satiation and the use of the tools could depend on the uniqueness of the projects. Further research could be done on these findings and explore the relationships as it can allow to inform strategies to promote the effective use of EMTs and contribute to achieving the construction industry's sustainability goals.

4.3.3 Environmental Sustainability and EMTs

This section explores the relationship between Environmental Management Tools (EMTs) and environmental sustainability performance in construction projects. The aim is to investigate the following hypothesis (H1):

H1: There is a correlation between the implementation of Environmental Management Tools (EMTs) in construction projects and environmental sustainability performance.

To assess this hypothesis, the research utilizes Environmental Performance Indicators such as resource consumption, waste generation, and pollution. A survey was conducted to explore the association between EMTs and environmental sustainability.

Survey Findings:

Survey results indicate a potential positive association between frequent EMT use and:

- Resource consumption: A significant portion of respondents (83.4%) believe EMTs have a negative relation with resource consumption and think that it can help reduce resource overuse.
- Waste generation: Many respondents (65.4%) believe that it has a negative relationship with EMTs where it consider helps in reducing construction waste.
- Pollution levels: Pollution was identified as a top concern, and respondents believe EMTs can help mitigate it (98.1) meaning with the increase use of EMTs there wold be a decreased level of pollution.

These findings suggest a potential correlation between EMT implementation and improved environmental performance. However, it's important to note that correlation does not imply causation. Further research is needed to establish a causal relationship.

Analysis Approach:

To investigate H1, we will analyze the correlation between the following variables:

- Variable: EMT Implemented and three environmental performance indicators (resource consumption, waste generation, pollution)

Data Source:

The data for this analysis will come from the survey responses regarding:

- Question 4: EMT implementation
- Question 7: EMTs contribution to the environment

Statistical Tests:

Correlation analysis will be employed to assess the strength and direction of the relationship between EMT and the selected environmental performance indicators. This method is appropriate as it allows for the exploration of potential associations without making causal inferences.

		Correlations							
		Life cycle Assessment	Environmental management systems	Waste management plans	Water conservation systems	Environmental monitoring systems	Resource consumption	Waste generation	Pollution
Life cycle Assessment	Pearson Correlation	1	.419**	.124	-.046	-.027	-.335*	-.297*	.099
	Sig. (2-tailed)		.001	.368	.739	.847	.012	.027	.474
	N	55	55	55	55	55	55	55	55
Environmental management systems	Pearson Correlation	.419**	1	-.051	.158	.080	-.312*	-.240	.232
	Sig. (2-tailed)	.001		.711	.251	.560	.020	.078	.089
	N	55	55	55	55	55	55	55	55
Waste management plans	Pearson Correlation	.124	-.051	1	.246	-.027	-.166	-.349**	.050
	Sig. (2-tailed)	.368	.711		.071	.846	.227	.009	.718
	N	55	55	55	55	55	55	55	55
Water conservation systems	Pearson Correlation	-.046	.158	.246	1	-.016	-.368**	-.261	-.020
	Sig. (2-tailed)	.739	.251	.071		.909	.006	.054	.886
	N	55	55	55	55	55	55	55	55
Environmental monitoring systems	Pearson Correlation	-.027	.080	-.027	-.016	1	-.012	-.133	.336*
	Sig. (2-tailed)	.847	.560	.846	.909		.931	.333	.012
	N	55	55	55	55	55	55	55	55
Resource consumption	Pearson Correlation	-.335*	-.312*	-.166	-.368**	-.012	1	.578**	.036
	Sig. (2-tailed)	.012	.020	.227	.006	.931		<.001	.797
	N	55	55	55	55	55	55	55	55
Waste generation	Pearson Correlation	-.297*	-.240	-.349**	-.261	-.133	.578**	1	-.027
	Sig. (2-tailed)	.027	.078	.009	.054	.333	<.001		.844
	N	55	55	55	55	55	55	55	55
Pollution	Pearson Correlation	.099	.232	.050	-.020	.336*	.036	-.027	1
	Sig. (2-tailed)	.474	.089	.718	.886	.012	.797	.844	
	N	55	55	55	55	55	55	55	55

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

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

Table 4.3.3 Correlation analysis of r/n b/n EMTs and environmental sustainability

This table shows the correlation coefficients (Pearson Correlation) and their significance levels (Sig. (2-tailed)) between various environmental management tools and environmental impact indicators in construction projects. Here's a breakdown:

Column Headers (Left):

- **LCA:** Life Cycle assessment
- **EMS:** Environmental Management System
- **WMP:** Waste Management Plans
- **WCS:** Water Conservation Strategies
- **EMS2:** Environmental Monitoring System
- **Res_Con:** Resource Consumption
- **Was_Gen:** Waste Generation
- **poll:** Pollution

Row Headers (Top):

Same as column headers.

Body Cells (Values):

- **Upper Left Triangle:** Shows the Pearson Correlation Coefficient between the two variables at the intersection of the row and column.
- **Lower Right Triangle:** Shows the significance level (Sig. (2-tailed)) of the correlation coefficient above it.
- **N:** Number of samples used for the correlation analysis (55 in this case).

Interpreting the Values:

- **Pearson Correlation Coefficient:** This value ranges from -1 to +1.
 - **Positive Correlation** A value closer to +1 indicates a positive correlation. As one variable increases, the other tends to increase as well.
 - **Negative Correlation** A value closer to -1 indicates a negative correlation. As one variable increases, the other tends to decrease.
 - **No Correlation:** A value close to 0 indicates no linear relationship between the variables.
- **Significance Level (Sig. (2-tailed)):** This value tells us if the correlation coefficient is statistically significant. A statistically significant correlation means the relationship is unlikely due to chance.
 - **Significant Correlation:** A low p-value (typically less than 0.05) suggests a statistically significant correlation.
 - **Non-Significant Correlation:** A high p-value (e.g., .718) suggests the correlation might be due to chance.

Key Observation:

- **Strong Positive Correlation:**
 - **Waste Generation (Was_Gen) & Resource Consumption (Res_Con):** 0.578 (significant) – There seem to be a strong positive correlation between waste generation and resource consumption.
- **Moderate Negative Correlations:**
 - **Waste Management Plans (WMP) & Waste Generation (Was_Gen):** -0.349 (significant) – There is a moderate negative relation between the use of waste management plans and waste generation.
 - **Environmental Management System (EMS) & Resource Consumption (Res_Con):** -0.312 (significant) - There is a moderate negative relation between the use of EMS and resource consumption.
 - **Water Conservation Strategies (WCS) & Resource Consumption (Res_Con):** -0.368 (significant) - There is a moderate negative relation between the use of WCS and resource consumption.

- **Environmental Monitoring Systems (EMS2) & Pollution (Poll):** -0.336 (significant) - There is a moderate negative relation between the use of EMS2 and pollution.
- **LCA & Resource Consumption (Res_Con):** -0.335 (significant) - There is a moderate negative relation between the use of LCA and resource consumption.
- **LCA & Waste Generation (Was_Gen):** -0.297 (significant) - There is a moderate negative relation between the use of LCA and waste generation.
- **Weak Correlations (Need Further Investigation):**
 - **Waste Management Plans (WMP) & Pollution (poll):** 0.050 (not significant) - The relationship between waste management plans and pollution levels is unclear and requires further exploration.
 - **Environmental Management System (EMS) & Pollution (poll):** 0.232 (not significant) - Similarly, the impact of EMS on pollution needs further investigation.

Overall Interpretation:

The correlation analysis provides insights into the relationships between environmental management tools and environmental performance in construction projects. Results indicate potential associations between certain tools and performance indicators. The correlation analysis shows a strong positive correlation was found between waste generation and resource consumption. Furthermore, the analysis shows moderate negative correlations were observed between waste management plans and waste generation, environmental management systems and resource consumption, water conservation strategies and resource consumption, environmental monitoring systems and pollution, LCA and resource consumption, and LCA and waste generation. It is important to note that the performance indicators used in this are negative so a negative correlations between waste management plans and waste generation, and between environmental management systems and resource consumption indicate that increased implementation of these tools is associated with decreased environmental impact. However, the correlations between waste management plans and pollution, as well as environmental management systems and pollution shows that it is non-significant, suggesting the need for further investigation into these relationships. To fully understand the impact of environmental management tools on sustainability, further research is necessary to explore the underlying factors influencing these relationships.

Data Triangulation:

To comprehensively understand the relationships between Environmental Management Tools (EMTs) and environmental performance, a triangulation approach was employed, incorporating correlation analysis, case study, interviews, and literature review.

Correlation analysis revealed associations between EMT implementation and environmental performance indicators. The case study of the Sawla-Maji Road Upgrading Project provided contextual evidence, supporting the findings. For instance, the project's use of LCA aligned with the negative correlation between the use of LCA and resource consumption. Similarly, the implementation of EMS on the project corresponded with the correlation between EMS and reduces resource consumption. Interviews with project managers offered further insights into the practical application of EMTs, complementing the correlation analysis and case study findings. These findings resonate with the literature review, highlighting the relationship between EMS (Shen et al., 2010; OECD, 2022) and LCAs (Alaloul et al. 2020; Buyle et al., 2013) with environmental sustainability. The reviewed research reinforces that relationships which is farther supported by studies conducted by Hwang and Ng (2013) suggest that various tools, including Environmental Management Systems (EMSs), LCA, water conservation strategies, waste management plans, and energy monitoring systems, have a positive relationship with environmental performance.

In conclusion all the data collected from the correlation analysis, case study, interviews, and literature review strengthens the argument for H1 which is that there is a correlation between the EMT implementation and environmental sustainability performance in construction projects. While the case study highlights different challenges that would affect the relationship between, by triangulating data from multiple sources, we can have a more deep understanding of the relationships between EMTs and environmental performance. This approach allowed for the identification of potential areas for further investigation and the development of more targeted research questions.

4.3.4 Social Sustainability and EMTs

This section examines the relationship between Environmental Management Tools (EMTs) and social sustainability performance in construction projects. The following hypothesis is explored:

H2: There is a correlation between the implementation of EMTs and social sustainability performance in construction projects.

Social performance metrics, including quality of life for local communities, worker health and safety, and job creation, were used to assess this hypothesis. Survey findings indicate a growing recognition of the social dimension of sustainability within the construction industry.

Survey Findings:

Survey results indicate a potential positive association between frequent EMT use and:

Improved Quality of Life: A significant portion of respondents (47%) believe that EMTs have a positive relationship with quality of life for local communities.

Enhanced Worker Health and Safety: Nearly half of the respondents (49%) consider worker health and safety a crucial factor and believe that EMTs have a positive correlation with these factors.

Potential for Job Creation: A considerable number of respondents (60%) perceive that EMTs do indeed have a positive correlation with job creation within construction projects.

Overall, the survey findings suggest potential positive associations between EMTs and social sustainability performance which supports the second hypothesis.

Analysis Approach:

To test H2, we will analyze the relationship between EMT and the key Social Performance matrices which includes Quality of Life for Local Communities, Worker Health and Safety and Job creation

Data Source:

The data for this analysis will come from the survey responses regarding:

- Question 4: EMT implementation
- Question 15: Social Performance indicators

Statistical Tests:

The second hypothesis (H2) focuses on the relationship between the implemented Environmental Management Tools and a dependent variable related to social sustainable performance which is the social sustainability performance indicators. We can effectively test this hypothesis using correlation analysis for the same reason correlation was used to test the first hypothesis.

		Correlations							
		Waste management plans	Water conservation systems	Building information model	Environmental impact Assessment	Building commissioning	Quality of life	Health and safety	Job creation
Waste management plans	Pearson Correlation	1	.246	-.034	.320*	-.057	.345**	.433**	.298*
	Sig. (2-tailed)		.071	.807	.017	.677	.010	<.001	.027
	N	55	55	55	55	55	55	55	55
Water conservation systems	Pearson Correlation	.246	1	-.228	.137	-.062	.323*	.453**	.274*
	Sig. (2-tailed)	.071		.094	.317	.652	.016	<.001	.043
	N	55	55	55	55	55	55	55	55
Building information model	Pearson Correlation	-.034	-.228	1	-.105	.019	.011	-.026	.091
	Sig. (2-tailed)	.807	.094		.445	.893	.937	.848	.509
	N	55	55	55	55	55	55	55	55
Environmental impact Assessment	Pearson Correlation	.320*	.137	-.105	1	.040	.442**	.337*	.394**
	Sig. (2-tailed)	.017	.317	.445		.770	<.001	.012	.003
	N	55	55	55	55	55	55	55	55
Building commissioning	Pearson Correlation	-.057	-.062	.019	.040	1	.269*	.229	.127
	Sig. (2-tailed)	.677	.652	.893	.770		.047	.092	.354
	N	55	55	55	55	55	55	55	55
Quality of life	Pearson Correlation	.345**	.323*	.011	.442**	.269*	1	.726**	.800**
	Sig. (2-tailed)	.010	.016	.937	<.001	.047		<.001	<.001
	N	55	55	55	55	55	55	55	55
Health and safety	Pearson Correlation	.433**	.453**	-.026	.337*	.229	.726**	1	.709**
	Sig. (2-tailed)	<.001	<.001	.848	.012	.092	<.001		<.001
	N	55	55	55	55	55	55	55	55
Job creation	Pearson Correlation	.298*	.274*	.091	.394**	.127	.800**	.709**	1
	Sig. (2-tailed)	.027	.043	.509	.003	.354	<.001	<.001	
	N	55	55	55	55	55	55	55	55

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

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

Table 4.3.4 Correlation analysis of r/n b/n EMTs and social sustainability

This output summarizes the results of a correlation analysis where it investigated the relationship between Environmental Management Tools and Social Sustainability Performance metrics

Breakdown of the Output:

- QOL: Quality of Life
- JC: Job Creation
- H_S: Health and Safety
-

Statistically Significant Correlations (p-value < 0.05):

- **Strongest Correlations:**

- Quality of life and Health & Safety (0.726 & 0.709): A strong positive relationship exists between quality of life and health & safety.
- Quality of life and Job Creation (0.800): A strong positive relationship exists between quality of life and job creation.

- **Moderate Correlations:**

- Waste management plans and Environmental impact assessment (0.320): A moderate positive relationship exists between waste management plans and environmental impact assessment.
- Waste management plans and Quality of life (0.323), Health & Safety (0.453), and Job Creation (0.298): Waste management plans have moderate positive relationships with quality of life, health & safety, and job creation.
- Environmental impact assessment and Quality of life (0.442), Health & Safety (0.337), and Job Creation (0.394): Environmental impact assessment has moderate positive relationships with quality of life, health & safety, and job creation.
- Water conservation systems and Quality of life (0.323) and Health & Safety (0.453): Water conservation systems have a moderate positive relationship with quality of life and a strong positive relationship with health & safety.

- **Weak or No Correlations:**

- Building information modeling (BIM) shows weak or no correlations with other variables.

Overall Interpretation:

The correlation analysis indicates potential associations between certain Environmental Management Tools (EMTs) and social sustainability performance in construction projects. Tools such as waste management plans (WMPs), water conservation strategies (WCS), and environmental impact assessments (EIA) appear to be linked with improved quality of life (QOL), health and safety (H_S), and job creation (JC). These findings suggest that the implementation of these specific EMTs may contribute to positive social outcomes.

However, the relationship between other EMTs, such as building information modeling (BIM), and social sustainability performance is less clear. This suggests that further research is necessary to deepen the understanding of the complex relationships between certain EMTs and social sustainability.

Data Triangulation

To comprehensively assess the relationship between Environmental Management Tools (EMTs) and social sustainability (H2), a triangulation approach was employed, incorporating correlation analysis, case study, and literature review.

Correlation analysis revealed significant positive associations between specific EMTs and social performance indicators, such as quality of life, health and safety, and job creation. These findings were supported by the Sawla-Maji Road Upgrading Project case study, which showed a positive link between EMTs with social sustainability performance, particularly waste management plans and environmental impact assessments, with worker health and safety. Interviews with project managers corroborated these observations. Furthermore, the correlation analysis identified moderate positive associations between waste management plans, environmental impact assessments, and social outcomes. The case study provided additional evidence, highlighting the relationship between proper waste management and health and safety of the community.

Water conservation systems were also found to be positively associated with quality of life and health and safety. This aligns with the understanding from the case study that effective water management is associated with overall project sustainability and well-being.

In conclusion, the correlation analysis as well as the qualitative data from the case study and literature review shows that the EMTs contribute and has a positive relationship with social sustainability in construction projects. While these findings suggest a positive relationship between EMTs and social sustainability, it is essential to acknowledge that correlation does not imply causation which means other factors may influence these relationships. Further research is necessary to establish causal links and to explore the specific mechanisms through which EMTs impact social outcomes.

4.3.5 Economic Sustainability and EMTs

This section of the chapter analyzes the survey data to investigate the third hypothesis (H3):

H3: There is a correlation between the implementation of EMTs and economic sustainability performance in construction projects.

This section uses Economic Performance metrics to analyze the validity of the hypothesis. It is measured by Economic Performance Indicators (EPIs) such as cost saving, financial returns and market demand. The survey data emphasizes a growing recognition of the economic benefits associated with EMT implementation.

Survey Findings:

Survey results indicate a potential positive association between EMT use and:

- **Cost Savings:** Thirty-nine percent of respondents reported that EMTs have a relationship and contribute to cost savings.
- **Financial Returns:** A significant portion of respondents (37%) believe that EMTs have a positive correlation as well as achieve with financial returns.
- **Market Demand:** Over a third of respondents (32%) perceive that EMTs have a positive correlation with increased market demand considering it a very important factor in highlighting economical sustainability.

Overall, the survey findings suggest potential positive associations between EMTs and economic sustainability performance, supporting the third hypothesis.

Analysis Approach:

To test H3, we will analyze the correlation between EMT implementation and the of key EPIs: which includes cost saving, financial returns and market demand.

Data Source:

The data source will be the survey responses regarding the frequency of EMT implementation (Question 4) and average of the economic impact of EMTs (Question 16).

Statistical Tests:

The third hypothesis (H3) focuses on the relationship between the implement Environmental Management Tools and variables related to economic sustainable performance. We can effectively test this hypothesis using correlation analysis for the same reason correlation was used to test the first hypothesis.

		Correlations					
		Environmenta l impact Assessment	Energy- efficient construction practices	Green material selection	Cost saving	Market demand	Financial Return
Environmental impact Assessment	Pearson Correlation	1	.103	.140	.567**	.234	.396**
	Sig. (2-tailed)		.454	.309	<.001	.086	.003
	N	55	55	55	55	55	55
Energy-efficient construction practices	Pearson Correlation	.103	1	.247	.206	.261	.275*
	Sig. (2-tailed)	.454		.069	.132	.054	.042
	N	55	55	55	55	55	55
Green material selection	Pearson Correlation	.140	.247	1	.104	.129	.050
	Sig. (2-tailed)	.309	.069		.449	.348	.719
	N	55	55	55	55	55	55
Cost saving	Pearson Correlation	.567**	.206	.104	1	.661**	.797**
	Sig. (2-tailed)	<.001	.132	.449		<.001	<.001
	N	55	55	55	55	55	55
Market demand	Pearson Correlation	.234	.261	.129	.661**	1	.682**
	Sig. (2-tailed)	.086	.054	.348	<.001		<.001
	N	55	55	55	55	55	55
Financial Return	Pearson Correlation	.396**	.275*	.050	.797**	.682**	1
	Sig. (2-tailed)	.003	.042	.719	<.001	<.001	
	N	55	55	55	55	55	55

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

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

Table 4.3.5 Correlation analysis of r/n b/n EMTs and economic sustainability

This output summarizes the results of the correlation analysis where it investigated the relationship between Environmental Management Tools and the Economic Sustainability Performance Indictors.

Breakdown of the Output:

This table shows the Pearson Correlation Coefficient and significance level (Sig. (2-tailed)) between various e economic performance indicators in construction projects. Here's a breakdown of the findings:

Abbreviations:

- CS: Cost Saving

- MD: Market Demand
- FN: Financial Returns
- EIA: Environmental Impact Assessment
- Energy-efficient construction practices (ECP)
- GMS: Green Material Selection

Statistically Significant Correlations (p-value < 0.05):

- **Strong Positive Correlations:**
 - EIA and CS (0.567): A strong positive relationship exists between conducting an EIA and achieving cost savings.
 - MD and CS (0.661): A strong positive relationship exists between market demand and cost savings.
 - MD and FN (0.682): A strong positive relationship exists between market demand and financial returns.
- **Moderate Positive Correlation:**
 - ECP and FN (0.275): A moderate positive relationship exists between energy-efficient construction practices and financial returns.
 - EIA and FN (0.396): A strong positive relationship exists between conducting an EIA and generating financial returns.
- **Weak or No Correlations:**
 - EIA and ECP (0.103): A weak positive relationship exists between conducting an EIA and implementing energy-efficient construction practices.
 - EIA and GMS (0.140): A weak positive relationship exists between conducting an EIA and green material selection.

A mentioned in the above correlation analysis, these findings indicates potential associations between variables and do not imply causation. Further research is necessary to establish causal relationships.

Overall Interpretation:

This analysis of economic project performance indicators reveals positive associations between achieving cost savings, strong market demand, and positive financial returns. It shows that cost saving (CS) market

demand (MD) and financial returns (FN) seem to be associated with each other. The correlation analysis reveals positive associations between economic performance indicators, suggesting potential benefits for construction projects. Furthermore, Strong positive correlations were found between conducting an EIA and achieving cost savings or generating financial returns, as well as between market demand and both cost savings and financial returns. A moderate positive correlation existed between energy-efficient construction practices and financial returns. While there were weak positive correlations between EIA and both energy-efficient construction practices and green material selection, these relationships were not statistically significant.

Data Translation

Examining the impact of Environmental Management Tools (EMTs) on economic sustainability (H3) requires triangulating data from various sources, including correlation analysis, a case study, interviews, and a literature review. This approach allows us to build a case for potential economic advantages associated with EMT implementation, while acknowledging some important considerations. The correlation analysis revealed a statistically significant positive association between EMT implementation and Economic Sustainability Performance matrices. This suggests a link between use of EMTs and improved economic outcomes. Positive correlations between EMT usage and individual performance indicators (Cost Savings, Market Demand, and Financial Returns) further support the hypothesis (H3). However, correlation doesn't imply causation. The correlation analysis is further corroborated by the Sawla-Maji Road Upgrading Project case study which highlights positive relationships like improved market access due to faster project completion through EMTs. Additionally, an instance which shows the positive correlation between the use of EMT and economic sustainability is the responsible resource use due to EMTs which was able to contribute to long-term agricultural productivity which is a key economic driver in the community where the construction was taking place. Interviews with project managers that worked on the project used for the case study also revealed additional benefits like reduced construction costs through improved resource management. These findings align with the concept of EMTs contributing to positive economic outcomes. These notions were further supported by the literature review on economic performance which highlights concepts that support the potential economic benefits observed in the case study. For example, a positive relationship between Return on Investment (ROI) and EMTs aligns with the case study's findings (Mohd Arif et al., 2019). Similarly, the case study's finding on improved market access aligns with the concept of EMTs link with increased market demand for

sustainable infrastructure (Dixit et al., 2012). Cost savings are other factors that are highlighted in the literature. The case study also suggests potential link between cost reduction and EMTs, further supporting the economic advantages.

The triangulation suggests a strong relationship between EMT implementation and improved economic sustainability performance. However, there are important considerations. The case study acknowledges challenges such as implementation costs (upfront costs for software, training, and planning) which can be a barrier. Additionally, resource limitations and poor coordination across stakeholders can decrease efficiency and increase costs, hindering economic benefits.

By combining the findings from the correlation analysis, qualitative data, and literature review, this triangulation approach provides a comprehensive understanding of the potential relationship the economic advantages have with EMT implementation, while acknowledging the limitations and challenges as it supports the third hypothesis.

Chapter 5

5. Summary, Conclusion and Recommendation

5.1 Summary Of Major Findings

This study investigated the relationship between Environmental Management Tools (EMTs) and the sustainability performance of construction projects. The findings suggest that the construction industry has been utilizing a good number of EMTs to fulfill sustainability goals. However some are used more than others. Both the survey and case study shows that EIA is the most utilized tool, other than that the popularity of the utilized EMTs differ in the case study than the survey which shows that the choice to implement certain environmental management tools may not be a one size fit all situation but more project based. The research also was able to explore three hypotheses:

H1: There is a correlation between the implementation of Environmental Management Tools (EMTs) in construction projects and environmental sustainability performance.

The correlation analysis revealed a statistically significant relationship between EMT implementation and the three environmental sustainability performance indicators used to assess the relationship. The findings show that there is a negative relationship between EMT implementation and resource consumption, waste generation and pollution. The case study and literature review also support this finding, highlighting the correlation between EMTs and environmental sustainability

H2: There is a correlation between the implementation of EMTs and social sustainability performance in construction projects.

The correlation analysis indicated a positive association between EMT implementation and a Social Sustainability Performance. The case study also further corroborate this notion by providing real life examples of potential social benefits, like improved worker safety and air quality due to dust control measures through the use of EIA and LCA. The literature review on social performance aligned with these findings, emphasizing the relationship between worker health and safety with social sustainability.

H3: There is a correlation between the implementation of EMTs and economic sustainability performance in construction projects.

The correlation analysis showed a statistically significant positive relationship between EMT implementation and economic sustainability performance. The case study offered examples of the correlation between improved market access and cost saving with EMTs. The literature review on economic performance also provided a framework for understanding these relationships. However, the case study also acknowledged challenges like upfront implementation costs and resource limitations as factors that could affect the relationship.

Overall, the findings suggest that the implementation of EMTs has a positive relationship with sustainability performance of construction projects across environmental, social, and economic dimensions. However, careful planning, cost analysis, and capacity building are crucial for maximizing these benefits.

5.2 Conclusion

This study investigated the link between Environmental Management Tools (EMTs) and sustainability performance of construction projects, focusing on three key areas which are environmental, social, and economic sustainability. The findings provide encouraging evidence for the potential of EMTs to contribute positively across all three dimensions. A statistically significant positive correlation was found between EMT implementation and environmental performance. The case study and literature review support this, highlighting EMTs' potential to minimize environmental impact through waste reduction, resource efficiency, and pollution control. The correlation analysis also indicated a possible link between EMTs and social outcomes, which showed that there is a relationship between EMTs and better quality of life, health as well as safety and job creation. The case study also provided examples of these relationships. The literature review aligned with these findings, emphasizing the association of worker health and safety with EMTs. The findings also show a significant positive correlation between EMT implementation and economic performance. The case study offered examples of potential correlations with market access and financial returns, which can contribute to economic growth. The literature review supported these findings, highlighting concepts like correlation between market demand, potential cost savings and environmental management tools. However, the case study acknowledged challenges like upfront implementation costs and resource limitations.

Overall, The findings shows that there is indeed a positive relationship between environmental management tools and sustainability performance of construction projects. The findings show that EMTs demonstrate promise as a valuable tool for enhancing the sustainability performance of construction projects. However, careful planning, implementation, and capacity building are crucial for maximizing the environmental, social, and economic benefits associated with EMT implementation.

5.3 Recommendation

The fact that there is a positive relationship between Environmental Management Tools (EMTs) and enhanced sustainability performance in construction projects shows that the tools should be utilized more. From the analysis done above it is clear to see that EMTs have a correlation with social outcomes and a relationship with economic considerations. The major recommendation based on the research is the fact that project managers seeking to maximize the correlation between EMTs implementation and sustainability performance should prioritize a more direct approach. A phased implementation strategy is one way that can be used to manage costs and complexities to make sure the implementation of EMTs is smooth and aligns with the already existing work flow. Investing in capacity building programs to make sure the staff has the necessary skills and knowledge to effectively utilize EMTs is also recommended. Embracing a more holistic approach to using EMTs to lessen the environmental impact is another recommendation that could strengthen the relationship as the construction industry can move itself towards fulfilling sustainability goals. It is also recommended to make sure EMTs cater to all three aspects of sustainability to make sure we have environmentally and socially conscious development, as well as economically viable projects. This recommendation will not only contribute to a healthier planet and more equitable communities but also ensure the long-term success and competitiveness of the construction sector itself.

5.4 Areas of further study

While the link between Environmental Management Tools (EMTs) and improved sustainability in construction projects appears promising, several areas warrant further investigation to make sure this connection and optimize their effectiveness.

One crucial area for further study understands the specific mechanisms through which EMTs contribute to improved social outcomes. Currently, the evidence suggests potential benefits like enhanced worker safety and community well-being lacks a little. However, a deeper understanding of the how it happens is critical.

Another key area for further study concerns optimizing the economic benefits associated with EMTs. The current understanding suggests potential cost savings and increased market demand. However, a more comprehensive picture is needed through Long-Term Economic Impact Analysis, Project-Specific Cost-Benefit Analysis Framework and Life Cycle Assessment (LCA) Integration.

By addressing these areas of further study, researchers and industry professionals can gain a deeper understanding of how EMTs impact construction project sustainability. This knowledge can be used to refine EMT implementation strategies, ultimately contributing to a more sustainable construction industry. It is also good to remember correlation doesn't imply causation, so further research and statistical testing will be crucial to validate these hypotheses

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Annex

Survey Questionnaire

Survey Questionnaire: Evaluating the Effectiveness of Environmental Management Tools in Enhancing Sustainability of Construction Projects

Introduction

Thank you for participating in this survey. This research aims to understand the use of environmental management tools (EMTs) in construction projects and their impact on project sustainability. Your valuable insights will contribute to a more sustainable construction industry.

* Indicates required question

1. What is your current role in the construction industry? Mark only one oval.

- ☐ Project Manager
- ☐ Other:

2. Please select the range that best represents your experience in the construction industry: Mark only one oval.

- No experience
- 1-5 years
- 6-10 years
- 11-15 years
- 16+ years

3.How familiar are you with the concept of environmental management tools (EMTs) used in construction projects? Mark only one oval.

- Not Familiar
- Somewhat Familiar
- Very Familiar

4. Considering the impact on project sustainability, please indicate how often you have used the following EMTs in construction projects:

	Never Used	Rarely Used	Sometimes Used	Frequently Used	Always Used
Environmental Impact Assessment (EIA)					
Life Cycle Assessment (LCA),					
Environmental Management System (EMS),					
Building Information Modeling (BIM) with Sustainability Features					

Green materials selection					
Waste management plans					
Energy-efficient construction practices					
Building commissioning					
Energy monitoring systems					
Water conservation strategies					

6. How effective do you perceive environmental management tools to be in enhancing sustainability in construction projects?

NE is Not Effective,

VE is very Effective

1 2 3 4 5

NE VE

6. In your opinion, how well have the EMTs been able to address the key environmental challenges faced in the construction project? Mark only one oval.

- ☐ Very good
- ☐ Good
- ☐ Bad

- Very bad

7. Please rate your level of agreement with the following statements regarding the environmental performance of the construction project: (Select one answer per row)

1. Strongly Disagree

2. Disagree

3. Neutral

4. Agree

5. Strongly agree

EMTs contribute to construction projects achieving reductions in resource consumption (e.g., material use, energy, water)

1 2 3 4 5

EMTs help in managing and reducing waste generation (e.g., construction and demolition waste, hazardous waste)

1 2 3 4 5

EMTs contribute to minimized environmental pollution (e.g., air emissions, water pollution, noise)

1 2 3 4 5

Overall, EMTs enhance the environmental performance of the construction project?

1 2 3 4 5

8. Environmental Management Tools (EMTs) Strengths: Please rate your level of agreement with the following statements regarding the strengths of Environmental Management Tools (EMTs) in construction projects: (Select one answer per row)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
EMTs can significantly reduce the environmental impact of construction projects.					
EMTs can lead to cost savings in the long run for construction projects.					
EMTs improve communication and collaboration among project stakeholders on environmental issues.					
EMTs provide a structured approach to environmental performance monitoring and improvement.					
EMTs can enhance the overall sustainability of construction projects (considering environmental, social, and economic aspects).					

9. Environmental Management Tools (EMTs) Weaknesses: Please rate your level of agreement with the following statements regarding the weaknesses or limitations of Environmental Management Tools (EMTs) in construction projects: (Select one answer per row)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
EMTs can be complex and time-consuming to implement in construction projects.					
A lack of knowledge or training on EMTs among project staff can hinder their effectiveness.					
The upfront costs of implementing EMTs can be a barrier for some construction projects.					
Difficulty integrating EMTs with existing project workflows can limit their effectiveness.					
The effectiveness of EMTs can be influenced by factors beyond a project's control (e.g., regulations, client resistance).					

10. Environmental Management Tools (EMTs) Trade-offs: Please rate your level of agreement with the following statements regarding the trade-offs associated with the application of Environmental Management Tools (EMTs) in construction projects: (Select one answer per row)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

The potential cost savings from EMTs may not always outweigh the upfront implementation costs.					
Implementing EMTs may require additional time and resources, potentially impacting project schedules.					
The complexity of some EMTs can require specialized expertise, which may not be readily available on all projects.					
The benefits of EMTs on environmental performance may not be immediately realized, requiring a long-term perspective.					
Focusing on environmental sustainability through EMTs may require trade-offs with other project goals (e.g., cost, schedule).					

11. How do you rate the influence of contextual factors such as project characteristics on the successful integration of environmental management tools in construction projects? Mark only one oval.

- ☐ Very low influence
- ☐ Low influence
- ☐ Moderate influence
- ☐ High influence
- ☐ Very high influence

12. Which project management and contextual factors have been the most critical in determining the effectiveness of EMT implementation? (choose all that applies) Check all that apply.

- ☐ 1: Project complexity
- ☐ 2: Organizational commitment
- ☐ 3: Adequate resources
- ☐ 4: Effective training and communication
- ☐ 5: Stakeholder engagement
- ☐ 6: Regulatory compliance
- ☐ 7: Staff expertise
- ☐ 8: Industry regulations

13. How effective are Sustainable performance indicators in measuring the effectiveness of environmental management tools in construction projects? Mark only one oval.

- ☐ Not effective
- ☐ Slightly effective
- ☐ Moderately effective
- ☐ Very effective
- ☐ Extremely effective

14. Please rate the importance of how the implementation of Environmental Management Tools (EMTs) influence specific environmental performance indicators and sustainability performance in construction projects

	Not important	Somewhat important	Moderately important	Very important	Extremely important ¹
Resource consumption (e.g., material use, energy consumption, water use)					

Waste generation (e.g., construction and demolition waste, hazardous waste).					
Pollution (e.g., air emissions, water pollution, noise pollution)					

15. Please rate the importance of how the implementation of Environmental Management Tools (EMTs) influences specific social performance indicators and sustainability performance in construction projects

	Not important	Somewhat important	Moderately important	Very important	Extremely important ¹
Quality of life for local communities					
Health and safety					
Labor Practices					

16. Please rate the importance of how the implementation of Environmental Management Tools (EMTs) influence specific economic performance indicators and sustainability performance in construction projects

	Not important	Somewhat important	Moderately important	Very important	Extremely important ¹
Cost savings					
Market demand					
Financial returns					

17. Have you observed any differences in the effectiveness of environmental management tools to enhance the sustainability of construction projects? Mark only one oval.

- ☐ Yes
- ☐ No
- ☐ Unsure

18. To what extent do you agree that the combined application of multiple environmental management tools can enhance the overall environmental performance of construction projects? Mark only one oval.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

19. To what extent do you believe environmental management tools contribute to cost savings in construction projects? Mark only one oval.

- ☐ Significantly
- ☐ Moderately
- ☐ Minimally
- ☐ Not at all

20. How would you rate the contribution of the EMTs in enhancing the overall sustainability of the construction project?" Mark only one oval.

- ☐ Negligible contribution
- ☐ Minor contribution
- ☐ Moderate contribution
- ☐ Significant contribution
- ☐ Major contribution

21. Do you believe there is a need for further research to evaluate the effectiveness of environmental management tools in construction projects? Mark only one oval.

- ☐ Yes
- ☐ No
- ☐ Unsure

22. How likely are you to recommend the use of environmental management tools to enhance sustainability in construction projects to others in your field? Mark only one oval.

- ☐ Very likely
- ☐ Likely
- ☐ Neutral
- ☐ Unlikely
- ☐ Very unlikely

23. Do you have any additional comments or suggestions regarding environmental management tools and their role in achieving sustainable construction practices?

24. Would you be interested in participating in a follow-up interview to discuss your experiences with EMTs in more detail? Mark only one oval.

- ☐ Yes
- ☐ No

Thank you for your valuable participation!

Structured Checklist

Structured Checklist for Document Analysis: EMTs and Environmental Performance in Construction Projects

This checklist aims to evaluate the role of environmental management tools (EMTs) in achieving environmental goals in construction projects through document analysis.

Document Information:

- **Document Title:**
- **Author(s):**
- **Publication Year:**
- **Source (e.g., Journal, Conference Proceedings, Report):**

EMTs Employed:

- Does the document discuss specific environmental management tools (EMTs)? (Yes/No)
 - If yes, list the EMTs mentioned.
- Does the document explain the purpose and function of each EMT? (Yes/No)

Environmental Goals Addressed:

- Does the document identify specific environmental goals for construction projects (e.g., reduced waste, energy efficiency, decreased pollution)? (Yes/No)
 - If yes, list the environmental goals mentioned.

Impact of EMTs on Environmental Performance:

- Does the document analyze the potential impact of EMTs on achieving environmental goals and sustainability in construction projects? (Yes/No)
 - If yes, how does the document evaluate this impact? (e.g., case studies, data analysis, theoretical framework)
- Does the document present evidence for the effectiveness of EMTs in improving environmental performance? (Yes/No)
 - If yes, what types of evidence are provided? (e.g., quantitative data, qualitative data, expert opinions)

Project Management and Contextual Factors:

- Does the document discuss the role of project management practices in facilitating the implementation of EMTs? (Yes/No)
 - If yes, what specific project management practices are mentioned?

- Does the document consider how project characteristics (e.g., size, complexity) can influence the selection and implementation of EMTs? (Yes/No)
- Does the document explore the impact of industry regulations and policies on the use of EMTs in construction projects? (Yes/No)

Integration and Outcomes:

- Does the document discuss the benefits of integrating various EMTs for a holistic approach to sustainability? (Yes/No)
- Does the document identify challenges associated with integrating different EMTs? (Yes/No)
- Does the document explore the potential for measuring the combined environmental impact of integrated EMTs? (Yes/No)

Overall Analysis:

- Does the document offer a clear and concise explanation of how EMTs can contribute to achieving environmental goals in construction projects? (Yes/No)
- Does the document identify any gaps in knowledge or areas for further research related to EMTs and environmental performance? (Yes/No)
- Based on this document, what are the key takeaways regarding the role of EMTs in sustainable construction practices?

Additional Notes:

Use this space to record any additional notes or observations about the document, such as strengths, weaknesses, methodological limitations, or potential biases.

Interview Guide

Interview Guide: Evaluating Effectiveness of Environmental Management Tools in the Sawla-Maji Road Upgrading Project

Introduction (2-3 Minutes)

- Thank the participant for their time and willingness to participate in the interview.

- Briefly explain the research project and its goals - to understand the use of EMTs and their impact on sustainability in the Sawla-Maji Road Upgrading Project.
- Explain the interview format - it will be semi-structured with open-ended questions.

General Information (5 Minutes)

1. Can you tell me about your role in the Sawla-Maji Road Upgrading Project and your experience in the construction industry?
2. How familiar were you with the concept of environmental management tools (EMTs) used in this construction project? (Very Familiar, Somewhat Familiar, Not Familiar)

Awareness and Implementation of EMTs (10 Minutes)

1. Can you list the specific environmental management tools (EMTs) that were used in the Sawla-Maji Road Upgrading Project?
2. Based on your experience in this project, did you observe any positive environmental outcomes (reduced waste, lower energy consumption) from using these EMTs? Can you share a specific example?]
3. What do you consider were the biggest challenges in implementing EMTs effectively in the Sawla-Maji Road Upgrading Project? (Probe further based on their response - lack of training, budget constraints, etc.)

Environmental Sustainability and EMTs (10 Minutes)

1. Can you elaborate on your level of agreement with the statement: "EMTs contribute to construction projects achieving reductions in resource consumption (e.g., material use, energy, water)"? Can you provide specific examples from the Sawla-Maji project to support your response? (Focus on resource reduction achieved through EMTs)
2. Beyond resource consumption, did any of the EMTs address other environmental concerns like waste generation and pollution? If so, how effective were these tools in mitigating these concerns? (Explore impact on broader environmental aspects)
3. How can we improve the way environmental impact is measured and monitored in construction projects to better assess the effectiveness of EMTs? (Look for insights on improving environmental impact evaluation)

4. In your opinion, what are some critical environmental considerations for future construction projects similar to Sawla-Maji? How can EMTs be used to address these considerations effectively? (Explore future applications of EMTs for environmental benefits)

Economic Sustainability and EMTs (10 Minutes)

1. In your experience, how do environmental management tools influence the economic considerations of construction projects? Can you think of any examples from the Sawla-Maji project where EMTs might have had a positive economic impact? (Probe for potential cost savings, resource efficiency, or other economic advantages)
2. Were there any additional costs associated with implementing EMTs in the Sawla-Maji project? If so, how were these costs justified in terms of long-term benefits? (Explore cost considerations and justifications)
3. Looking ahead, how can we better integrate economic considerations with environmental goals when selecting and implementing EMTs? (Focus on balancing economic viability with environmental sustainability)

Social Sustainability and EMTs

1. In your experience, did any of the EMTs used in the Sawla-Maji Road Upgrading Project have any social sustainability benefits (e.g., improved worker safety, community engagement)? If so, can you elaborate? (Explore potential social benefits of EMTs)
2. How can we ensure that EMTs are implemented in a way that considers the social well-being of workers and the local community? (Focus on responsible implementation with social considerations)
3. Do you see any potential social challenges associated with the use of specific EMTs? If so, how can these challenges be mitigated? (Explore potential drawbacks and mitigation strategies)

Closing (2-3 Minutes)

1. Thank the participant for their valuable insights on the Sawla-Maji Road Upgrading Project.
2. Briefly summarize the key points discussed.
3. Ask if they have any additional comments or suggestions regarding EMTs and sustainable construction practices in the context of this project.

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