Assessment of Sustainable Practices in Building Construction projects: The Case of a Federal Government Budgeted Buildings in Addis Ababa.

Mintesinot Gelaneh Game

A Thesis Submitted to The Department of Civil Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Civil Engineering (Specialization in Construction Engineering and Management)

Office of Graduate Studies

Adama Science and Technology University

June, 2023

Adama, Ethiopia

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APPROVAL PAGE OF M.SC. THESIS

I, the advisors of the thesis entitled "**Assessment of Sustainable Practices in Building Construction project: The case of a federal government budgeted buildings in Addis Ababa**" and developed by Mintesinot Gelaneh Game, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Mintesinot Gelaneh Game have read and evaluated the thesis entitled "**Assessment of Sustainable Practices in Building Construction project: The case of a federal government budgeted buildings in Addis Ababa"** and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Civil Engineering (Specialization in Construction Engineering and Management).

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DECLARATION

I hereby declare that this Master Thesis entitled "**Assessment of Sustainable Practices in Building Construction project: The case of a federal government budgeted buildings in Addis Ababa**" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Mintesinot Gelaneh Game	__________________________	__________________
Name of the student	Signature	Date

RECOMMENDATION

I, the advisor(s) of this thesis, hereby certify that I have read the revised version of the thesis entitled "**Assessment of Sustainable Practices in Building Construction project: The case of a federal government budgeted buildings in Addis Ababa"** prepared under my guidance by Mintesinot Gelaneh Game submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Civil Engineering (Specialization in Construction Engineering and Management).

Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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Major Advisor	Signature	Date

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LIST OF ACRONYMS/ LIST OF ABBREVIATIONS

BREEAM	Building Research Establishment Environmental Assessment
CO2	Carbon Dioxide
EBSC	Ethiopian Building Code Standard
EFQM	The European Foundation for Quality Management
EGBC	Egyptian Green Building Council
EMS	Environmental Management System
ERGE	Climate Resistant Green Economy
ETGBC	Ethiopian Green Building Council
GBCN	Nigerian Green Building Council
GDP	Gross Domestic Product
HVAC	Heating Ventilation Air-conditioning
KGBS	Kenya Green Building Society
LEED	Leadership in Energy and Environmental Design
NOA	National Audit Office
OSC	Operational context space
ROI	Return on Investment
R	Multiple Correlation Coefficient
SPSS	Statistical Package for the Social Sciences
UNDP	United Nation Development Program
VIF	Variance Inflation Factor
WGBC	World Green Building Council

Abstract

Sustainable construction is an urgent and effective approach to mitigate the negative environmental, social and economic impacts of the construction industry, which has been criticized for its poor sustainability performance resulting from unsustainable consumption patterns and human-driven activities. In this context, this research focuses on assessing the level of implementation of sustainable practices during the physical construction stage of buildings, specifically examining Federal Government budgeted buildings in Addis Ababa. The objectives of the study are to evaluate the extent of sustainability practice implementation during the physical construction phase, examine the barriers encountered during implementation, identify the driving factors behind sustainability practice adoption, and develop a conceptual framework for effective implementation. To accomplish these objectives, the research utilizes a mixed-methods approach, incorporating both quantitative and qualitative research methods. The target population comprises federal government budgeted buildings currently under construction in Addis Ababa, with a sample size of 28 selected through stratified random sampling. Building professionals involved in the selected sample population are purposively chosen for interviews and questionnaires. Primary data is collected from 49(75%) respondents out of 65, while secondary data is obtained from relevant sources. The collected data is analyzed using a combination of descriptive and inferential analysis techniques, specifically employing SPSS, fuzzy synthetic evaluation, regression, correlation and Excel. The validity of the questionnaire is ensured through pre-testing and internal and structural validity tests, while reliability is assessed using Cronbach's Alpha. The study findings indicate that among Federal Government budgeted buildings, the most commonly implemented sustainability practices during the physical construction stage include proper storage and handling of materials, regular inspection and monitoring, Collaboration and communication. However, the overall level of sustainable practice implementation during the physical construction stage is between low and moderate. The study identifies various barriers hindering the implementation of sustainable practices, such as the lack of regulations enforcing sustainability, limited availability of suppliers for sustainable products and materials, and a lack of training and education. On the other hand, driving factors that motivate the implementation of sustainable practices include government regulations, environmental compliance, and the commitment of professionals and stakeholders. Based on the research findings, conceptual framework is developed, encompassing policy and strategy development, action plans, assessment criteria, and effective implementation strategies. Finally, the study recommends several measures to enhance sustainable practice implementation, including strengthening regulations and enforcement, promoting supplier engagement, enhancing training and education, fostering collaboration and coordination, developing expertise in sustainability, and integrating sustainability considerations from the early stages of construction.

Keywords*: Sustainable Construction, Implementation, Physical Construction Stage, Building Development, Barriers, Drivers, Conceptual Framework.*

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry plays a crucial role in economic development and societal progress. It encompasses organizations involved in designing, producing, altering, renovating, maintaining, managing facilities, demolishing, and recycling building and civil engineering works (Hills et al, 2008). However, according to Awuzie et al, (2021) the construction industry has gained a negative reputation for its poor sustainability performance due to many human-driven activities and unsustainable consumption patterns. To address these issues and minimize their impact on the environment, innovative approaches and methods must be adopted and implemented.

The building construction industry involves several phases, each consuming a large amount of energy and emitting considerable emissions. Energy is consumed directly during building construction, use, and demolition and indirectly through producing materials used in the building (Abd Rashid, Yusoff, & Reviews, 2015).

In recent years, the importance of sustainability measures in the construction sector has grown significantly due to their potential to mitigate negative environmental impacts, enhance social well-being, and improve economic performance (Lam et al, 2012). Sustainable strategies must be integrated into the development phase of building projects to reduce negative impacts and optimize positive outcomes (Hein et al., 2019).

According to Enshassi et al, (2016) Sustainability is often conceptualized through the three pillars of environmental, social, and economic sustainability. Environmental sustainability focuses on minimizing the negative effects of building operations on the environment by promoting the efficient use of natural resources, waste reduction, and the adoption of environmentally friendly materials and practices (Sun et al., 2018). Social sustainability addresses the industry's legal, moral, and ethical obligations to stakeholders, including employees, suppliers, and the communities in which it operates (Adetunji et al, 2003).

Economic sustainability involves raising productivity, improving project delivery, and ensuring steady rates of economic development and employment (Hein et al., 2019).

In the Ethiopian context, the implementation of sustainable practices in the construction industry is still limited due to various factors, including a lack of understanding, awareness, personal commitment to sustainability, political will, and legislation to enforce sustainability (Dessalegn, Araya, & Asfaw, 2015). Addressing these challenges and promoting sustainable construction practices is vital for the country's long-term well-being and environmental preservation (Beyene et al., 2020).

To bridge the gap between the potential benefits of sustainability practices and their limited implementation, a well-planned scientific investigation is necessary. This study focuses on federal government budgeted building projects in Addis Ababa, Ethiopia, aiming to assess the level of implementation of sustainability practices during the construction phase. By identifying the drivers and barriers to implementation, the study aims to develop conceptual framework for effective implementation and enhancing sustainable practices in the Ethiopian construction industry.

The research contributed to the existing body of knowledge by providing insights into the challenges and opportunities related to sustainability practices in the construction industry. It also offered guidance for policymakers, researchers, and organizations involved in the construction sector, facilitating informed decision-making and effective measures to integrate sustainability principles (Atnaw, 2021). In the following sections, the literature on sustainability practices in the construction industry was reviewed to provide a comprehensive understanding of the topic. The research methodology was outlined, detailing the approach, data collection methods, and analysis techniques. Finally, the study's findings were discussed, and implications for recommendations were provided, offering valuable insights for further research and practical application in the construction industry.

1.2 Statement of Problem

There has been an emphasis on how new structures are commissioned and built, particularly in their use of energy and resources, as environmental and climate change concerns have grown. Construction work is frequently seen to have negative effects on the environment, which is the cornerstone of sustainable development for humans, according to (L. Shen et al, 2011). Large amounts of natural resources are used up, a lot of water is utilized, a lot of garbage is produced, greenhouse gases are released, and a variety of ecosystems are damaged during building construction activities. The focus on building construction is justified due to its significant environmental impact. Buildings consume vast amounts of resources, energy, and water throughout their lifecycle, contribute to greenhouse gas emissions, and can have adverse effects on ecosystems (Shen et al., 2011). By addressing sustainability practices in building construction, we can make substantial progress in mitigating these environmental impacts and promoting more sustainable development.

The physical construction phase is a critical stage where sustainability practices can have a substantial impact. It is during this phase that resource consumption, waste generation, and emissions occur at a large scale (Akadiri et al., 2017). By implementing sustainable practices during construction, we can minimize the negative environmental consequences and enhance resource efficiency. Additionally, this phase offers opportunities for incorporating innovative technologies and strategies that can contribute to long-term sustainability.

According to Bauer, Mösle, and Schwarz (2009) and Kibert (2016), sustainable practices during the design phase were considered, including the use of recycled or low-impact materials, the integration of renewable energy sources, water conservation measures, and site-specific design considerations. These practices aimed to reduce the environmental impact of buildings. However, their implementation during physical construction limited by factors such as cost, availability, lack of expertise, complexity, or budgetary constraints. Nevertheless, sustainable practices should still be prioritized and implemented as much as possible during construction stage. While various studies have been conducted on sustainable construction practices in different nations, including Ethiopia, the existing literature on the implementation of sustainability practices specifically during the construction phase of building projects in the country is limited. Some studies conducted in Ethiopia have explored sustainability practices (Anshebo et al, 2023; Assefa et al., 2022; Mengesha, & Sokido, 2022; Baron & Donath, 2016). However, there is a need for further research to address unanswered questions in this specific area.

The current study aims to address this research gap by examining the practices of sustainable building in the case of federal government budgeted building in Addis Ababa. The study provides insights into building professionals' understanding and level of implementation of sustainability practices during the physical construction phase. It also identifies drivers and barriers to implementing sustainable building practices and developing a conceptual framework essential to guide the research and provide a systematic approach for understanding and implement sustainable construction practices.

1.3 Objective of The Study

1.3.1 General Objective

The general objective of the study is to assess implementation of sustainable practices in building construction projects: The case of federal government budgeted building in Addis Ababa.

1.3.2 Specific Objectives

- To evaluate the level of implementation of sustainability practices during construction phase of building projects by building professionals.
- To investigate the barriers of implementing sustainability practices during construction phase of building projects
- To identify the factors that drive the implementation of sustainability practices during the physical construction phase of building projects.
- To develop a conceptual framework for the effective implementation of sustainability practices during the physical construction phase of building projects.

1.4 Research Question

- What is the level of implementation of sustainability practices during the physical construction phase of building projects by building professionals?
- What are the barriers encountered the implementation of sustainable practices during the physical construction phase of building projects?
- Which factors are influential in driving the implementation of sustainability practices during the physical construction phase of building projects?

- How can a conceptual framework be developed to enhance the effective implementation of sustainability practices during the physical construction phase of building projects?

1.5 Significance of the Study

The proposed study fills a significant gap in the literature by examining the implementation of sustainable construction practices during the building phase of projects in the case of federal government budgeted building in Addis Ababa, Ethiopia. This study expands the existing body of knowledge by providing insights into the level of implementation of sustainable practices in the country, informing policymakers and building professionals on how to improve current practices. The study findings have policy implications that can help develop more environmentally friendly, resource-efficient, and sustainable policies, leading to improved construction practices that align with sustainable development goals. By examining the drivers and barriers to implementing sustainable practices, the study provides building professionals with effective strategies to promote environmental sustainability, resource efficiency, and building performance. Finally, the study develops a conceptual framework that guides the effective implementation of sustainable practices during the construction phase of building projects, leading to improved construction practices that are more environmentally friendly, resource-efficient, and sustainable. Overall, the proposed study's specific objectives are crucial steps towards promoting sustainable building practices in the case of federal government budgeted building in Addis Ababa.

1.6 Scope Study

This paper's geographic or spatial focus was limited to the case of federal government budgeted buildings in Addis Ababa. The goal of this research was to assess the level of implementation of sustainability practices during the construction phase of building projects by building professionals in the study area, with a view to developing a detailed practical framework for the effective implementation of sustainability practices during the physical construction phase of building projects. The study analyzed the situation under study with buildings that were under construction in the case of federal government budgeted buildings in Addis Ababa.

1.7 Limitation of the Study

The study exclusively focuses on active federal government budgeted buildings in projects within Addis Ababa, omitting other building types like residential and privately owned buildings. Consequently, the findings' applicability to a broader context may be limited. The study relies on primary data sources, which may possess certain limitations regarding accuracy, relevancy, and reliability. As a result, the validity of the findings could potentially be affected. One of the major challenges faced during the research was the unavailability of up-to-date and comprehensive data on the construction sector in Addis Ababa, leading to incomplete or insufficient data in certain aspects of the research. Moreover, potential biases could be present in the data collected from various sources, including government entities, private companies, and other stakeholders in the construction industry, potentially impacting the objectivity of the study. The research was conducted within a constrained time frame, which may have hindered a more in-depth analysis. This limitation prevented extensive primary data collection, such as interviews or surveys, to further support the findings or address any identified gaps in the existing literature. In addition to the aforementioned limitations, it should be noted that the questionnaire survey responses collected in the study represented individual views within each organization. This approach may have led to differing opinions among respondents within the same organization, introducing subjectivity and potential bias to the findings.

1.8 Thesis Structure

Chapter 1: Introduction

In this chapter, the background of the researched topic is presented. The core research problem is introduced, and the path towards the thesis' conclusion is outlined. The main purpose of this chapter is to provide an explanation of the problem's background, objectives, and the contribution made by the project.

Chapter 2: Literature Review

This chapter delves into the knowledge surrounding sustainability practice implementation on building construction projects in Addis Ababa, with a focus on sustainability. It serves as a theoretical foundation for formulating propositions that guide the research methodology.

Chapter 3: Methodology

The methodology chapter details the research plan. It explains the research paradigm, approaches, strategies, and data collection methods employed in the study.

Chapter 4: Data Analysis and Discussions

This section presents the results obtained from observations, interviews, and questioner survey discussions. The collected data is analyzed to achieve the research objectives, and the findings are discussed in detail.

Chapter 5: Conclusions and Recommendations

The final chapter provides a summary of the main findings from the study. It offers concluding remarks and presents recommendations based on the research outcomes. These recommendations serve as valuable points for further action or improvement in the study.

1.9 Definition of Terms

Sustainability: Balancing present needs with the ability of future generations to meet their own needs by considering environmental, social, and economic factors.

Implementation: Putting a plan or idea into action by carrying out specific activities to achieve desired goals.

Physical Construction Stage: The actual construction phase of a building project, involving site preparation, foundation work, structural assembly, utilities installation, and finishing.

Building Development: The process of planning, designing, and constructing a building, from concept to completion.

Barriers: Obstacles that hinder progress or achievement t of goals, such as lack of awareness, financial constraints, or resistance to change.

Drivers: Factors that motivate or encourage the adoption of certain practices, such as incentives, regulations, market demands, or environmental concerns.

Conceptual Framework: A model or structure that guides research by establishing relationships between variables or ideas and providing a theoretical foundation

CHAPTER TWO

LITERATURE REVIEW

2.1 Sustainability and Sustainable Development

2.1.1 Definition of sustainability

In recent years, there has been an increasing awareness and interest in sustainability in construction industry, especially in developing countries(Khalfan et al, 2002). In general, the concept of sustainability is the utilization of resources with consideration for the long term.

Defining sustainability is not an easy task. The literature shows that sustainability is a philosophy, approach or practice that guides the use of today's resources in an efficient manner to ensure that resources are available and sufficient to meet today's needs and the needs of future generations(Grant & Issues, 2010; Greenland, 1997). Sustainability is also defined as the ability to make responsible decisions in using and allocating resources to economic and non-economic activities in an effort to achieve certain desired social, economic and environmental outcomes(Grant & Issues, 2010). Many studies defined sustainability in relation to other contexts or disciplines such as business sustainability Bansal, career sustainability (Tordera et al, 2020), urban sustainability(James, 2014), product sustainability (Dyllick & Rost, 2017) and fiscal sustainability(Byrne, Fiess, & MacDonald, 2011). Although the sustainable development and sustainability concepts should be defined according to accepted standards of academic rigor, there is some critique of what the two concepts actually mean, and to whom. Regarding the question 'to whom?', we know that over the years the two concepts have influenced, and have been influenced by policy-makers, activists and academics. Academics view the two concepts broadly as the process of increasing average material wellbeing without irreversibly damaging the natural environment(Ozili, 2022).

2.1.2 Sustainable development

The first definition of sustainable development surfaced in a 1987 United Nations report titled Our Common Future which is now generally referred to as the Brundtland Report of the World Commission on Environment and Development 1987. It defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs(Imperatives, 1987).

In addition, Khalfan et al. (2002) stated that sustainable development referred to the fulfillment of human needs through simultaneous socio-economic and technological progress and conservation of the earth's natural systems. Sustainable world progress is dependent upon continued economic, social, cultural, and technological progress.

2.2 Sustainable Construction

From the general definitions in the previous section, construction industry researchers determined that any further research on sustainable development or sustainability needed to include social, economic, and environmental criteria. Applying these three criteria to industrial construction, previous research addressed "sustainable construction" as "creating and operating a healthy built environment based on resource efficiency and ecological design "Kibert (2016), "creating construction items using best-practice clean and resource-efficient techniques, from the extraction of the raw material to the demolition and disposal of its components" Ofori and Management (2000) and as "practices that have sustainability benefits during the construction phase of a project, including those benefits that may result from decisions made during the planning and design phases of a project (Program et al., 2011). The prevailing trend towards economic growth in developing countries has resulted in a huge demand for delivering construction projects Zhang, which in turn has overshadowed sustainability concerns(Chang et al., 2017).

L.-y. Shen et al, (2010), said that in construction practice, sustainable construction refers to the different methods used in construction project which bring less harm to the environment, benefit the society and increase profit of the company. Tan, Shen, and Yao (2011) stated that sustainable construction refers to "the integration of environmental, social and economic considerations into construction business strategies and practices". Sustainable construction covers the comprehensive construction cycle from the extraction of raw materials, through the planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste.

O'Connor et al, (2016) defined the "sustainable construction" as the processes, decisions, and actions during the construction phase of capital projects that enhance current and future environmental, social, and economic needs while considering project safety, quality, cost, and schedule.

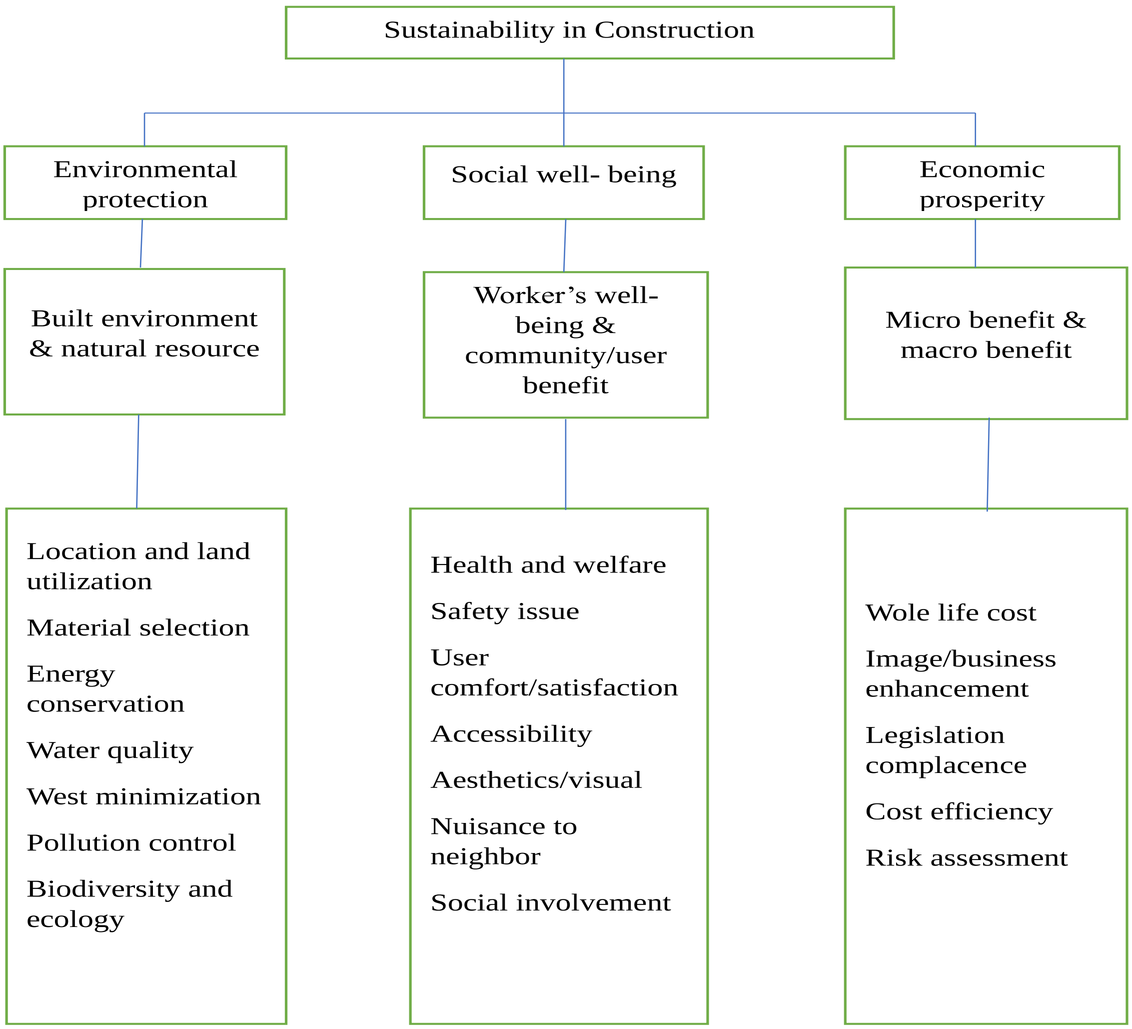

Figure 2.1: The diagram of sustainability in construction(Zainul Abidin, 2009).

2.2.1 Sustainable building construction

According to Sassi (2006), Sustainable building" can be explained as individuals' structures which have minimum undesirable effects about the constructed as well as the environment when it comes to the actual structures on their own, their own instant environment and also the wider local as well as the worldwide environment. "Sustainable building" might be understood to be creating methods, that shoot for essential high quality (including financial, interpersonal as well as environmental performance) in an exceedingly wide method. Therefore, the actual logical utilization of organic assets, as well as suitable administration from the creating share, may bring about preserving rare assets, decreasing power usage (energy conservation), as well as enhancing environment high quality. Sustainable building approach is considered as a way for the building industry to move towards achieving sustainable development taking into account environmental, socio and economic issues, and protecting the environment

Green building philosophy is derived from the term "Arcology" which stands for a combination of architecture and ecology. It addresses environmental and health problems as well as minimizes the effects of the construction sector on the natural habitat and individuals. Green buildings are also more energy-efficient so that the adverse effect of building on the environment and inhabitants is reduced (Anshebo et al., 2022).

2.2.2 Sustainable building construction standards

Leadership in Energy and Environmental Design (LEED) is a globally recognized sustainable building certification program developed by the U.S. Green Building Council (USGBC). It focuses on building design, construction, operation, and maintenance, awarding points based on criteria such as energy efficiency, water conservation, indoor environmental quality, materials, and innovation. LEED promotes sustainable practices and raises awareness in the building industry (USGBC, n.d.). The Building Research Establishment Environmental Assessment Method (BREEAM) is a widely used sustainability assessment method from the UK. It evaluates building environmental performance across categories like energy, water, materials, waste, and management. BREEAM provides ratings from Pass to Outstanding, emphasizing a holistic approach to sustainability (BRE, n.d.). Green Star is an Australian sustainability rating system developed by the Green Building Council of Australia (GBCA). It focuses on environmental performance, energy efficiency, and sustainable design. Green Star evaluates aspects such as energy, water, materials, indoor environment quality, and emissions, offering ratings ranging from 1 to 6 stars (GBCA, n.d.). ISO standards, such as ISO 14001 for environmental management and ISO 50001 for energy management, provide frameworks for organizations to improve their environmental performance and energy efficiency, respectively. ISO 21930 offers guidelines for assessing the environmental performance of building products through life cycle thinking and sustainable sourcing (ISO, n.d.).

The Living Building Challenge (LBC) is a rigorous sustainable building certification program by the International Living Future Institute (ILFI). LBC focuses on net-zero energy and water consumption, non-toxic materials, social equity, and beauty. Buildings must meet all requirements and demonstrate performance over 12 months for certification (ILFI, n.d.). The Passive House Standard, originating in Germany, prioritizes energy efficiency through airtightness, insulation, and ventilation systems. Passive House buildings achieve exceptional thermal performance and minimal energy requirements for heating and cooling (Passive House Institute, n.d.). These standards, along with regional and national ones like Estidama Pearl Rating System, CASBEE, Green Mark, and GRIHA, address specific environmental concerns and promote sustainable construction practices.

2.2.2.1 Sustainable building construction standards in Africa

Sustainable construction practices are gaining traction in several African countries. South Africa leads the way with the Green Star South Africa (GSSA) rating tool and certifications from the Green Building Council (GBC) (Michael Gbolagade Oladokun et al, 2021). Kenya has experienced growth in green building practices, but faces challenges with regulation enforcement and high costs (Michael Gbolagade Oladokun et al, 2021). Nigeria is making strides through the Nigerian Green Building Council (GBCN), yet financial constraints and limited awareness impede progress (Michael Gbolagade Oladokun et al, 2021). Egypt is committed to sustainability, as demonstrated by the establishment of the Egyptian Green Building Council (EGBC) in 2010. However, widespread implementation is hindered by limited resources and technical capacity (Michael Gbolagade Oladokun et al, 2021).

2.2.2.2. Sustainable building construction and standards in Ethiopia

According to studies and assessments, 50 years of infrastructure development in Africa have not resulted in economic progress and have also been accused of causing greater social and environmental issues (Du Plessis & Information, 2005). According to the United Nations Conference on Trade and Development Canton (2021), Ethiopia is one of the 50 or so African nations that are considered to have the least developed economies. The continent problem is made more difficult by the lesser quantity, quality, and accessibility of infrastructure (Gurara et al, 2018) as well as the rising global temperature(Green & Jacobs, 2020).

This research team's desk study found that Ethiopia faces different sustainable building construction issues than most other developing and developed countries. The major issues that cause resource waste (Hwang et al, 2015), time (Cheng & Darsa, 2021; Godfrey, Asmare, Gossa, & Paba, 2019; Sinesilassie et al, 2017)) & cash (Sinesilassie et al., 2017). The following factors also have an impact on the environment: poor implementation of policy/regulation and lack of professional collaboration(Mengistu, Mahesh, & Technology, 2020); lower stakeholder engagement , poor construction and demolition waste management practices (Nigussie et al, 2019); poor implementation of health and safety measures(Alemu et al, 2020); ineffective site management and project planning, insufficient drainage systems(Adugna et al, 2019) are also the major challenges in the country construction industry.

Regarding Ethiopia, some progress has been made in promoting sustainable construction practices, emphasized by its Climate Resilient Green Economy (CRGE) strategy. Government-supported affordable housing projects in Ethiopia have incorporated energy-efficient and environmentally friendly materials. However, the degree of implementation is quite low due to a lack of knowledge and expertise, as well as the limited use of sustainability methods in many projects (Michael Gbolagade Oladokun et al, 2021).

2.3 Sustainable Building Construction Pillar

As sustainable development hinges on three pillars, the same holds for sustainable construction. The three aspects of sustainable construction are environment, social and economic aspects respectively

2.3.1 Environmental pillar

The built environment should be environmentally friendly by reducing negative impacts on the environment. The construction industry causes a detrimental effect on the environment both locally and globally. Local impacts of construction include air pollution, noise pollution, construction wastes, urban heat islands, and land clearance(Pero et al, 2017). Global impacts of the building consist of Global warming, Resource usage, and Ozone layer depletion.

To curb this harmful practices, environmentally sustainable practices involve minimizing resource consumption, use of renewable and recyclable resource and materials, protection of agricultural lands, enhancing air quality by minimizing emissions of harmful gases, use of local construction materials, and energy efficiency(Dosumu & Aigbavboa, 2018; Pero et al., 2017).

2.3.2 Social pillar

Even though the environmental and financial aspects are heavily emphasized, little study is done on social sustainability in building. It is challenging to define social sustainability since it depends on how individuals perceive it (Farzanehrafat et al, 2015). A study was conducted on how various clients define and which social sustainability aspect is considered most crucial within the scope of construction(Mireé & Toryalay, 2016). The result showed that the perception of one client differs from the other. Despite the difficulty to define social sustainability, some attempts have been made to define social sustainability. Social sustainability in construction refers to "the engagement among employees, local communities, clients, and the supply chain to ensure meeting the needs of current and future populations and communities"(Valdes-Vasquez, Klotz, & management, 2013). Social sustainability is also defined as full filling the necessity of present and future generations in a manner that protects the health of the community (Farzanehrafat et al., 2015).

Despite different interpretations of social sustainability, generally social sustainability in construction focuses on the positive impact of construction on people(Valdes-Vasquez et al., 2013). Giving equal opportunities to work, Provision of Education and Training for employees, protection of cultural heritages during construction, involving the community during the decision process, and satisfying the expectation of clients for the money spent are some features of social sustainability in construction industry (Dosumu & Aigbavboa, 2018). It is suggested that to have a broad understanding of social sustainability, considering the effect of construction on people throughout the lifecycle is vital(Valdes-Vasquez et al., 2013).

2.3.3 Economic pillar

A country's development may be greatly aided by the building sector. The sector generates employment prospects for a huge number of people, particularly in underdeveloped nations where manual labor accounts for the majority of labor. hence providing a chance to raise living standards and reduce poverty. Furthermore, by supplying homes and infrastructure, the building sector may serve as the foundation for socioeconomic growth(Durdyev & Ismail, 2012).

But, the performance of the construction industry is crucial in attaining economic development. Usually, Performance is measured based on Quality, cost, schedule, and safety. For example, although it is difficult to finish construction projects within the exact timeframe, minimizing delay is necessary. Because delay results in additional cost, it reduces profit to be earned by companies. Similarly, inferior quality structures led to high maintenance cost since the built structures are unable to meet their service life. Hence, a sustainable economy can be achieved through minimizing construction costs, reducing completion time, improving productivity, satisfying the needs of the client, ensuring job satisfaction, proper distribution of resources, etc.

2.4 Benefits of Sustainable Building Construction

Sustainable construction can benefit the society and their users by consuming fewer resources in construction and operation through conservation of energy, water and natural resources by reuse, recycling, innovative design and the minimization of waste and pollution which providing healthier working and living environments (Azis et al, 2012).

The use of sustainable construction has been shown to have some advantages, such as reduced construction time, lower overall construction costs, improved quality, increased durability, better architectural appearance, improved occupational health and safety, material conservation, reduced waste on construction sites, reduced environmental emissions, and decreased energy and water use. (Chen et al, 2010).

Improved Health, Comfort, and Productivity/Performance:- Abolore and Sciences (2012) indicated that sustainable building significantly increases occupant's productivity, increased workplace productivity and well-being and will contribute positively to a better quality of life, work efficiency and a healthy working environment.

Lower construction and operating cost: Not only should sustainable conduct in construction be sought because environmental legislation mandates it and because it benefits people and the environment, but also because it considerably boosts financial gain and long-term competitiveness (Abolore & Sciences, 2012). This is mostly accomplished through recycling and cost savings through material reuse. For instance, the environmentally problematic debris can be used to fill some gaps in building materials, whether for construction utilizing complete blocks, filling, leveling roads, or other uses.

Increased Building Value: Landman (1999) believed that including environmental elements in a building increases its worth and improves its quality.

Table 2.1: Environmental, social, and economic benefit of sustainable construction.

Benefits	Indicators
Environmental Benefits	Protecting air, water, and land ecosystems; Conserving Natural Resources; Preserving animal and genetic diversity, Protecting the Biosphere; Using renewable natural resources; reducing waste generation or disposal, reducing CO2 emissions, actively recycling, and upholding environmental integrity; the reduction of global warming.
Social Benefits	Improving the quality of life for individuals and society as a whole; Alleviating poverty; Satisfying human needs; Optimizing social benefits; Improving health, comfort, and well-being; Minimizing cultural disruption; Providing education services; Promoting harmony among human beings and between humanity and nature.
Economic Benefits	Improving economic growth; Reducing energy consumption and costs; Raising Real Income; Improving productivity; Lowering infrastructure costs; Decreasing environmental damage costs; Reducing water consumption and costs; Decreasing health costs; Decreasing absenteeism in organizations; and Improving Return on Investments (ROI)

2.5 Sustainability Practices During Construction Phase of Building Projects

In order to achieve the aim of sustainable development, the sustainability performance of each building project throughout its life cycle is a crucial factor (L. Y. Shen et al, 2007; Ugwu et al, 2007) claim that it is challenging to translate strategy sustainability objectives into actual project-specific action. The project life cycle was broken down into conception, design, construction, operation, and destruction by(L. Y. Shen et al., 2007). The project design plans are translated into reality during the building phase. Using different resources, such as people, machinery, supplies, and money, is a part of this process. The authors noted a strong correlation between construction-related activities (pre-construction and construction execution) and environmental effects including waste production and pollution.

This research concentrated on sustainable building principles employed during construction. Accordingly, Lafarge (2015) listed the following as sustainable construction practices: lowering the negative effects of construction sites (noise, dust); using renewable materials in construction to protect natural resources; increasing the thermal inertia of buildings to lower heating and air conditioning costs and CO_2 emissions; and recycling materials and structures after demolition. In a similar vein, Abolore and Sciences (2012) suggested that selecting building materials that are recyclable after their useful lives, selecting construction techniques that are resource and energy efficient, and incorporating HVAC (Heating, Ventilating, Air-conditioning) systems are all ways to achieve sustainability in construction projects.

For the implementation of sustainability practices during building construction, (Thivaharan, 2015) identified five criteria: reducing, recycling, and reusing the amount of construction materials used, protecting the environment, improving energy and water efficiency, and improving indoor environmental quality. According to the author, ethical contractors are incorporating sustainable site design and innovation into their plans in order to adhere to sustainability principles and prevent contamination of the environment. Michael Gbolagade Oladokun, Isang, Emuze, and Environment (2021)discusses sustainable practices that can be implemented in building construction projects in Nigeria. These practices include using locally sourced materials, waste reduction and management, energy-efficient designs and technologies, water conservation, and green spaces. The paper emphasizes the importance of adopting sustainable practices in building construction projects to promote sustainable development and reduce negative environmental impacts.

The paper "Towards sustainable construction: promotion and best practices" (Pitt et al, 2009) provides a literature review on sustainable practices in construction. The review highlights the importance of designing for sustainability, using sustainable materials, maximizing energy efficiency, conserving water, reducing waste, and obtaining green building certification. The paper emphasizes the need for sustainable construction practices to minimize the environmental impact of construction and ensure that buildings are environmentally responsible and sustainable.

Table 2.2: Summary of sustainability practices during building construction phase.

No	Sustainability practices	Source
1	Social sustainability practice; Participation of stakeholders; Creation of job possibilities; Promotion of community development and public safety Involve stakeholders to improve a participatory approach, encourage public involvement, and evaluate the effects on health and quality of life.	(Carvalho, Bragança, & Mateus, 2019; Hussin, Rahman, & Memon, 2013; L. Shen et al., 2011; Tan et al., 2011)
2	Environmental sustainability includes water reuse, waste management for solid excavated materials, and Site sustainability, water efficiency, waste reduction, interior environmental quality, and community effect; the impact on waste production, air and water quality, noise, and energy savings; selecting the best building approach for resource and energy efficiency, recycling materials after their useful lives, and integrating HVAC systems; Enhance material recycling, restrict the use and dispersion of harmful materials, and take into account the project's impact on air, soil, and water; Improve material efficiency; Reduce material intensity through technology-based replacement; utilizing renewable resources, recycling after demolition, and minimizing the detrimental effects of construction sites (noise and dust); reduce, recycle, and reuse the resources used in building; protection of the environment (new systems and technologies); efficiency of water and energy; environmental conditions within.	(Abolore & Sciences, 2012; Carvalho et al., 2019; Hussin et al., 2013; L. Shen et al., 2011; Tan et al., 2011; Thivaharan, 2015; Ugwu et al., 2007; Willar, Waney, Pangemanan, Mait, & Environment, 2020)

3	Economic sustainability practice; Take into account labor employment, life cycle cost, benefit, and profit, as well as profitability and customer happiness; Provide economic tools to encourage sustainable consumption, taking into account the effects on regional structures.	(Carvalho et al., 2019; Hussin et al., 2013; Tan et al., 2011; Ugwu et al., 2007)

According to Zainul Abidin (2009) The implementation of sustainable practices in the Malaysian construction industry is not at an excellent level. The majority of respondents believe that it is at a low level, with some believing it is at a moderate level. Many construction developers also believe that the implementation of sustainable practices is at a low level in Malaysia. Several factors are impeding active implementation, such as a lack of knowledge, poor enforcement of legislation, education vs. experience, and passive culture. It is believed that with the current pace of implementation, this situation will only improve slightly, from a low to a moderate level.

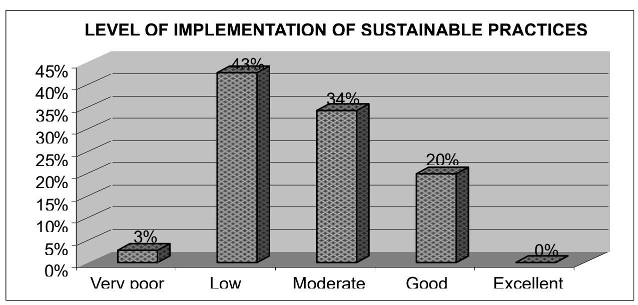

Figure 2.2: Level of implementation of sustainable practice in Malesia (Zainul Abidin, 2009).

2.6 Barriers of Implementing Sustainability Practices during physical Construction

The adoption of sustainable building has been observed to be hampered by a variety of factors, according to a study of the literature. Ochieng et al. (2014) highlighted five characteristics as potential hurdles to sustainability in construction, including lack of funding, lack of consideration from clients and stakeholders, a lack of sustainability-related knowledge and skills, a lack of government rules, and resistance to change.

Serpell et al. (2013) equally noted that a large variety of factors is usually considered as barriers. This could be explained by the fact that most research focused on identifying specific obstacles to the use of sustainable building. In the current study, a thematic examination of the literature was used to identify similar themes among the mentioned impediments to sustainable building across various studies rather than highlighting specific things described as barriers. The adoption of sustainable building is hindered by various factors. Ochieng et al. (2014) identified lack of funding, client/stakeholder consideration, knowledge/skills, government rules, and resistance to change as barriers. Cost-related barriers are commonly highlighted, such as the perception of higher expenses and scarcity of sustainable resources (Tokbolat et al., 2020). Policy issues, including government incentives and regulations, also impact sustainable construction (Ohiomah et al., 2019). Construction professionals face barriers like limited expertise, awareness, and communication (Ohiomah et al., 2019). Client-related barriers include a lack of demand and knowledge about environmentally friendly practices (Dalirazar & Sabzi, 2023). Understanding these obstacles is essential for promoting sustainable construction projects (Dalirazar & Sabzi, 2023).

Table 2.3: Summary of the barriers of implementing sustainability practices

No	Barriers	Source
1	Lack of client demand, lack of client awareness and building regulations	(Pitt et al., 2009), (Dalirazar & Sabzi, 2023; Durdyev et al., 2018)
2	Lack of awareness on sustainability; lack of training and education in sustainable design and construction; the higher cost of sustainable design option; procurement issues; regulatory barriers; and lack of professional capabilities	(Shafii et al., 2006; Tan et al., 2011)
3	Lack of considerations from client and stakeholders; insufficient knowledge and skills about sustainability; insufficient regulations by government; and resistance to change were identified as potential	(Ochieng et al., 2014)
4	Guiding mechanisms, economics, client comprehension, processes, and underlying knowledge	(Thivaharan, 2015)

5	Government incentives, laws, and regulations, promotion, enforcement, and codes and regulations	(Durdyev et al., 2018; Ohiomah et al., 2019; Tokbolat et al., 2020)
6	Incapacity, aversion to change, and lack of education and training	(Durdyev et al., 2018; Ohiomah et al., 2019; Tokbolat et al., 2020)
7	financial disincentives, the cost structure does not account for environmental expenditures, government inefficiency, knowledge gap about sustainable technology, lack of care about the environment Affordability	(Serpell et al., 2013),(Darko et al., 2017; Zulu et al., 2022)

2.7 Drivers for Implementing Sustainability Practices during Construction

Few motivators for adopting sustainable techniques have recently been discovered by academics from various nations. The review was offered in the subsection that followed.

According to (Durdyev et al, 2018) the top drivers of sustainability practice implementation are resource conservation, increased energy efficiency, reducing the environmental effect of buildings, enhancing indoor environmental quality, and waste reduction were also early adopters among the other SC pillars in Cambodia. This conclusion shows that more effort has to be put into choosing more durable materials in order to increase the lifespan of buildings and reduce material usage.

Shafii, Arman Ali, and Othman (2006) noticed that drivers for sustainability in construction include a legislative framework, technology, tools, commitment from stakeholders and experts, education, and training.. Michael Gbolagade Oladokun, Isang, Emuze, and Environment (2020) said that the drivers of sustainable construction include educational programs, financial incentives, public-private partnerships, and regulatory and non-regulatory sustainable building initiatives.

Ochieng et al. (2014) recognized law and regulation; ethics and behavioral change; as the main forces behind sustainability in construction. The authors also promoted the use of financial incentives, such as public benefit charges and initiatives to raise public awareness, as well as the active involvement of end users, knowledge and information sharing by businesses and building authorities, the development of strong methods for sustainability requirements, and the development of powerful methods for sustainability requirements. Adetunji et al. (2003) demonstrated that the forces driving change are coming from a variety of places, such as new client procurement procedures, stakeholder expectations, growing awareness of the value of construction image, branding, and reputation. Shafii et al. (2006) opined that total and ardent commitment by all players in the construction sectors including the government and the public at large are required in order to achieve sustainability in construction.

Thivaharan (2015) demonstrated that the forces behind sustainable measures include government actions and incentives, cost savings and value-added advantages, improved reputation and increased completeness of companies, and proof of environmental harm. Project owners are also important forces for sustainability. Ochieng et al. (2014) Moreover, the delivery of green building projects is strongly correlated with owners' commitment to sustainability and their early introduction of green aims at the project level. (Yates & management, 2014).

Table 2.4: Summery of the driver of implementing sustainability practice during construction stage

No	Drivers	Source
1	Regulations, company awareness, corporate image, client demand, cost reduction, market differentiation, suppliers.	(Serpell, Kort, Vera, & Economy, 2013)
2	Client awareness, building regulations, client demand, financial incentives, investment, labelling/measurement, planning policy, taxes/levies.	(Pitt et al., 2009)
3	Development of the awareness of clients about the benefits of sustainable building, the development and adoption of methods for sustainable building requirement management, the mobilization of sustainable building tools, the development of designers' competence and team-working, and the development of new concepts and services.	(Häkkinen et al., 2011)

4	Branding and enhanced reputation, stakeholder's expectations; increased competitiveness	(Ochieng et al., 2014)
5	Cost reduction, value added benefits, evidence of environmental damage; operational efficiency	(Thivaharan, 2015)
6	greater energy-efficiency of buildings, reduction in the environmental impact of buildings, greater water-efficiency of buildings, enhancement of occupants' health and comfort and satisfaction, good company image/reputation or marketing strategy, better indoor environmental quality.	(Darko, Chan, Owusu-Manu, & Ameyaw, 2017)
7	legislation and legal requirements, building regulation, advocacy and awareness, developing regulatory mechanisms and client demand.	(Zulu, Zulu, Chabala, & Chunda, 2022)

2.8 Conceptual Framework for Sustainable Practice

A conceptual framework provides a structure for understanding a subject by identifying connections and relationships between its components. It helps analyze and explain a decision problem, but does not predict outcomes. It guides the research process by identifying variables and their relationships. The framework is developed based on a literature review, which determines the study's main focus areas (Dine et al., 2015; Lenz, 2010).

The conceptual framework focuses on several key issues related to sustainable practice implementation during construction stage. In the realm of construction projects, stakeholders have access to policies and guidance documents that assist in implementing sustainable construction (SC) practices. These resources provide interpretations of SC and offer valuable insights into its application. Understanding how different stakeholders interpret and implement SC is essential, as it allows for the identification of diverse strategies and approaches. Furthermore, recognizing the barriers and drivers influencing sustainable practices during the physical construction stage helps address challenges and leverage opportunities. By exploring real-life examples, stakeholders can gain practical insights into successfully implementing sustainable practices. Ultimately, a comprehensive understanding of policies, interpretations, barriers, drivers, and practical implementation is crucial for promoting sustainability in construction and creating a positive impact on the environment and society.

In Ethiopia, the construction sector is essential for achieving sustainable development goals. The government has prioritized social, environmental, and economic issues in the industry, leading to the development of advisory documents and strict regulations. Sustainable construction practices are being enforced through fiscal policies, regulations, and government initiatives. Recycling of construction materials has become necessary due to taxes and waste management licensing regulations. The government has set ambitious goals for reducing greenhouse gases, waste, and water usage, demonstrating its commitment to sustainable development. Evidence-based policy and the national policy framework are driving forces in promoting sustainability in the construction sector in Ethiopia.

Sustainable construction practices are essential for promoting environmental and social sustainability in the building industry. In Ethiopia, various policies and guidance documents have been developed to support these practices. The Ethiopian Building Code Standards (EBCS) incorporates sustainability principles, such as energy efficiency and waste management, providing guidance for sustainable design and construction. The Leadership in Energy and Environmental Design (LEED) certification program is recognized in Ethiopia, with LEED-accredited professionals and firms offering advisory services for implementing sustainable practices. The Ethiopian Green Building Council (ETGBC) promotes sustainable construction through advisory services, training programs, and resources on design, energy efficiency, water conservation, and waste management. The United Nations Development Program (UNDP) and the World Green Building Council (WGBC) also support sustainable development in Ethiopia, providing technical assistance, resources, and guidance on sustainable construction practices.

2.8.1 Review on existing frameworks

Anzagira, Duah, and Badu (2019) proposes a conceptual framework for promoting the uptake of green building practices in Ghana. The authors argue that while there is growing awareness of the benefits of green buildings, there is a lack of uptake due to various barriers. The proposed conceptual framework includes four main components: policy and regulations, financial incentives, stakeholder engagement, and capacity building. The authors suggest that by addressing these four components, Ghana can promote the uptake of green building practices and contribute to sustainable development. Overall, the article highlights the importance of a comprehensive approach that considers the various barriers and factors that influence the uptake of green building practices.

Operational Context Space (OCS) is the name of the framework suggested by (Matar et al, 2008). This approach tackles the problem of the absence of an operationally sound framework for addressing both SC concerns and building methods. It is presented as a modular integration grid with the following three axes: project life cycle phases (i), project executing entities (ii), and sustainability performance criteria (iii). none of the aforementioned frameworks has been sufficiently developed to be a helpful tool for taking proactive efforts to solve SC, based on the degree of prescription within them. frameworks address concerns pertaining to the "implementation" of SC. In order to increase the 'uptake' of SC, no information has been given to project level stakeholders.

A framework for the achievement of SC was offered by (Hill et al, 1997). They propose SC principles broken down into the four sustainability "pillars" of social, economic, technological, and biophysical, which might serve as checklists for accomplishing each of these goals. The 'what' in terms of SC in a certain building project is represented by these concepts. A list of "over-arching, process-oriented" principles is also provided in addition to the previously listed ones. The latter might assist in determining each pillar's relevance and relative value in a particular scenario. the four pillars listed above and the various values that each of them. These process-oriented concepts promote multidisciplinary cooperation, timely stakeholder participation, prior assessment of planned activities, and the use of life-cycle frameworks. The framework explains "how to" do this by using "Environmental Assessment (EA) during the planning and design stages of projects" and "implementing Environmental Management Systems (EMS)...during construction, operation, and where appropriate...decommissioning.

There are various reasons why this framework is different from the other two frameworks stated. First of all, it offers a list of SC principles that might help the project participants understand and grasp the idea of SC. Second, rather of approaching SC from the perspective of a physical facility, Hill and Bowen's paradigm does it from an organizational one. The policymakers and managers in construction organizations are the target audience for this prescriptive approach. The fact that the SC principles proposed by Hill and Bowen have been created at a very high aspirational level is a major problem, though. As a result, it may be difficult to apply principles in practice at the project level.

2.9 Chapter Summary

Sustainability encompasses responsible decision-making and efficient resource use. Sustainable construction prioritizes resource efficiency, ecological design, and healthy living conditions throughout the building lifecycle. However, infrastructure development in Africa, including Ethiopia, faces challenges. Sustainable construction practices offer benefits such as energy conservation, improved quality, cost reduction, and occupant well-being.

Sustainable construction is crucial for achieving sustainable development in building projects (Shen et al., 2007; Ugwu et al., 2007). Practices include minimizing site impacts, using renewable materials, improving energy efficiency, and recycling (Lafarge, 2015; Abolore & Sciences, 2012). Ethical contractors prioritize sustainability by reducing material use, protecting the environment, and enhancing indoor quality (Thivaharan, 2015). Literature reviews highlight sustainable design, materials, energy efficiency, water conservation, waste reduction, and green building certification (Pitt et al., 2009). Increased awareness, financial support, and capacity building are needed to promote sustainable construction practices in Africa (Abolore & Sciences, 2012).

Various drivers for adopting sustainable construction practices have been identified. These include resource conservation, energy efficiency, environmental impact reduction, indoor environmental quality, waste reduction, legislative frameworks, technology, stakeholder commitment, education, law and regulation, ethics, financial incentives, stakeholder involvement, client procurement, stakeholder expectations, construction image, government actions, cost savings, reputation, and project owner commitment (Durdyev et al., 2018; Shafii et al., 2006; Ochieng et al., 2014; Adetunji et al., 2003; Thivaharan, 2015). These drivers contribute to the promotion and adoption of sustainable construction practices.

The adoption of sustainable building practices faces barriers such as lack of funding, limited client consideration, knowledge gaps, absence of government rules, and resistance to change (Ochieng et al., 2014). Other challenges include cost perceptions, policy issues, limited expertise, and client-related barriers (Tokbolat et al., 2020; Ohiomah et al., 2019; Dalirazar & Sabzi, 2023). Overcoming these barriers is essential for promoting sustainable construction.

Effective implementation of sustainable construction practices during the construction stage requires understanding policies, interpretations, barriers, drivers, and practical implementation. Stakeholders can utilize available resources to promote sustainability and positively impact the environment and society.

2.10 Research Gap

1. Although research has been done to look at how sustainability practices are implemented across the project life cycle, there is still a significant study vacuum in understanding the particular intricacies and issues linked to the physical construction stage of building projects. A major knowledge gap exists regarding the efficient integration and application of sustainability concepts throughout the building phase as a result of the paucity of research in this area.

2. Although the idea of sustainable building has gained popularity in research, only a small number of previous studies specifically addressed the topic of sustainability in Ethiopia, as was evident from the literature study. our demanded further knowledge, particularly about the level of implementation, the drivers, obstacles, and metrics of strengthening sustainable practices during the construction phase of the building project, and our study effort satisfied that need.

3. Some of these research date back more than ten years. In order to reflect recent developments, it was necessary to conduct a more recent assessment of the motivations for and obstacles to implementing sustainable practices.

4. The majority of these researchers based their opinions on the literature review from writers who were located in different nations other than Ethiopia. Professionals have a common understanding of building projects, but they also have a variety of perspectives and are impacted by the circumstances in their own nations. For instance, it was very improbable that laws rather than incentives were the Government's first priority when it came to adopting sustainable measures in Ethiopia. Consequently, research located in Addis Abeba and financed by the federal government was carried out.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides an overview of the methodology employed in this study. It encompasses the study area, research design, sampling process, data collection methods and instruments, as well as the analysis technique. To effectively address the key research objectives, a combination of qualitative and quantitative data gathering methods was utilized, drawing from both primary and secondary sources. Qualitative data were collected to complement the quantitative data analysis and enhance the understanding of the research findings and results.

3.2 Study Area

Addis Ababa, the capital city of Ethiopia, serves as the setting for the investigation conducted in the study. Geologically, Addis Ababa is located in the central part of the country. The city's altitude ranges from 2200 to 3000 meters above mean sea level, contributing to its cool and pleasant climate. The morphology of Addis Ababa is characterized by rolling to hilly terrain with moderate to steep slopes. The city is situated within a plateau region surrounded by mountain ranges, which adds to its scenic beauty. This topographical diversity creates a unique landscape within the city. Administratively, Addis Ababa is divided into ten sub-cities and 116 woredas (districts). The city covers an area of 540 square kilometers, providing ample space for urban development and various activities. Additionally, 220 square kilometers of green space, including forests, parks, river buffers, and urban agriculture areas, have been designated within the city. Vegetation plays a significant role in Addis Ababa, with approximately 80 square kilometers of the city covered by vegetation, primarily dominated by eucalyptus trees. This vegetation contributes to the city's aesthetics, provides shade, and contributes to the overall environmental quality. Moreover, the presence of diverse and rare plant and animal species enhances the biodiversity within Addis Ababa.

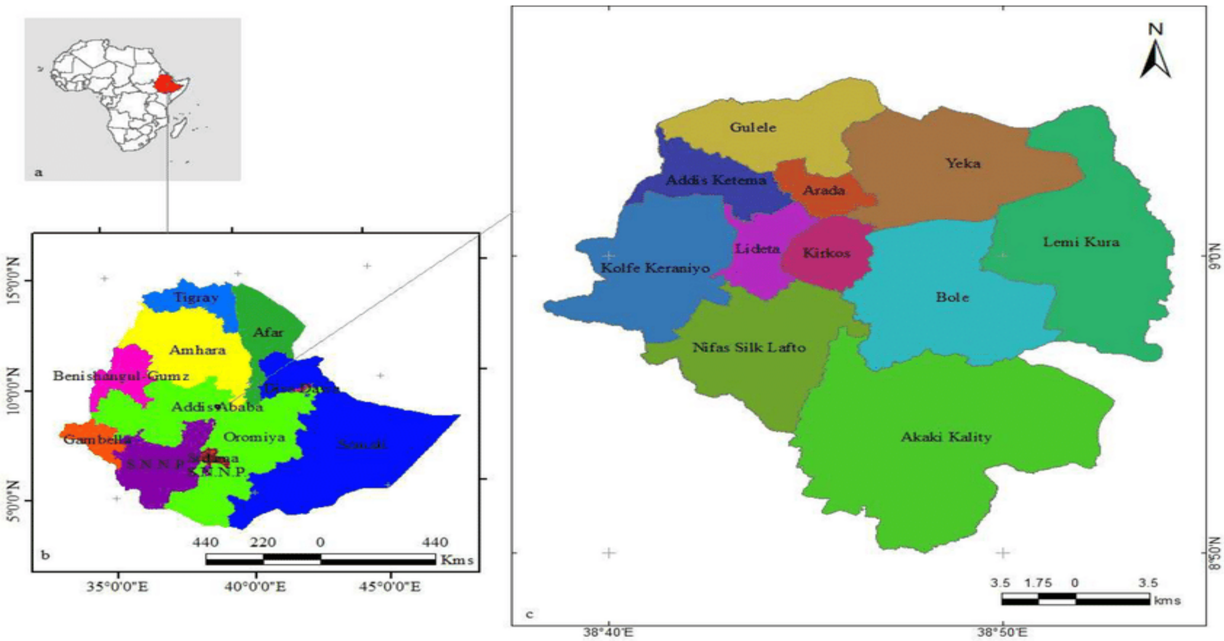

Figure 3.1: Map of Addis Ababa with administrative sub-city designation.

3.3 Research Design

The goal of the research design is to offer a suitable framework for a study. The choice to be made about the research strategy is an important decision in the research design process since it impacts how information for a study is acquired. It also refers to the overarching approach used to combine the many study components coherently and logically in order to successfully answer the research challenge.

A research design entails critical evaluation and formulation of the research questions that are tailored to the problem statement, methodical design of the research and philosophical stance adopted, critical design of the research instrument, collection of the necessary data, and critical analysis of the same to reach to the informed conclusion.

The research design of this study is summarized in the following steps.

Step 1 Initiation of the research idea

Step 2 Gathering preliminary information about sustainability practice of building practice and its implementation

Step 3 Proposal writing and approval

Step 4 Survey federal government budgeted building in Addis Ababa sites selected as a case study, to overview the status of buildings and sustainability practice

Step 5: Design questionnaire & interview questions and get advisor's approval

Step 6: Intensive site investigation and data collection from the respective personnel

Step 7: Statistical analysis of data and extract results using descriptive and inferential analysis.
Step 8: Data interpretation and development of sustainable practice implementation framework

Step 9: Based on the analysis result, development of conclusion and recommendation.

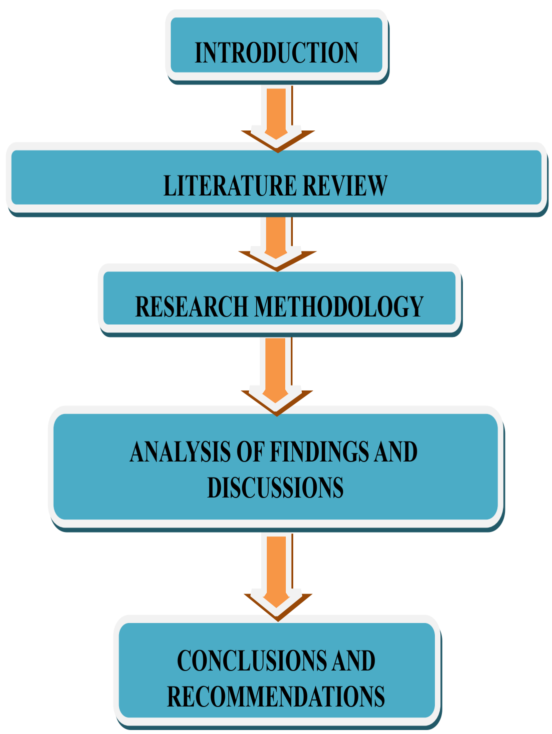

Figure 3.2: Research farmwork

3.4 Research Approach

The goal of the study and the research question are the two main factors that influence the methodological choice. This study uses a mixed-approach research paradigm, incorporating both quantitative and qualitative methods, to examine the degree of implementation, identify the factors that are causing it and what is preventing it, and propose solutions. Statistics are employed to analyze, test hypotheses, organize, and present quantitative data, which is generated using standardized procedures to obtain numerical data. This method involves using a questionnaire survey to collect information from the respondents (Naoum, 2012). In order to understand or determine specific characteristics, factors, or issues related to the given topic, the qualitative research technique examines people's behavior, activities, knowledge, and opinions from a distance (Naoum, 2012). This approach is utilized to further gather the opinions and expertise of building professionals on the degree of implementation and the strategies for improving the implementation of sustainable practices, using interviews to collect subjective data.

3.5 Population of the study

The research population includes the totality of all elements (individuals, objects, and events) that meet the sample criteria for inclusion in the study. The parent group from which a sample is drawn is known as the population or universe, which refers to the whole collection of observations. Currently, the population of this study consists of federal government budgeted buildings in Addis Ababa that are active and ongoing. Based on these criteria, our population is 33 active ongoing building construction projects for the study**.**

3.6 Sampling Technique

In this study, the researchers utilized stratified random sampling to select a representative sample of active projects in Addis Ababa. The population of 33 active projects was divided into distinct subgroups or strata based on their locations. The goal was to obtain a sample that accurately reflected the characteristics of the entire population. The 11 sub-cities served as the basis for creating the strata, and the sample size was allocated proportionately, considering the relative importance or representation of each stratum. Within each stratum, specific sub-cities were randomly selected using a random number generator, with adjustments made to ensure a total of 8 sub-cities were chosen. Thorough documentation was maintained, recording the selected sub-cities and their respective strata for future reference and reporting. This strategy allowed for an examination of sustainability practices in Addis Ababa, providing reliable insights into the overall population of active projects based on location-based considerations. The 95% confidence level further indicates a high level of confidence in the findings derived from the selected 28 projects

3.7 Sample Size determination

The sample is a subset of the total population and is chosen to represent that population accurately (Liu, Meng, & Fellows, 2015). Determining an appropriate sample size aims to estimate the prevalence of the population with a desirable level of precision (Naing, Winn, & Rusli, 2006).

$$n = \frac{(Z^2)pq}{e^2} \text{.. Equation 1}$$

Where n = required sample size,

p = proportion of the population having the characteristic,

q = 1-p and

e = the degree of precision (5%)

z=confidence level (it is 1.96 for 95% confidence level)

The proportion of the population (p) may be known from prior research or other sources; if it is unknown use p = 0.5 which assumes maximum heterogeneity (i.e., a 50/50 split). The degree of precision (e=5%) is the margin of error that is acceptable.

After finding the sample size since the population is finite, the sample size will be adjusted by population correction for proportions formula as follows.

$$n = \frac{no}{\left(1+\frac{no-1}{N}\right)} \text{...Equation 2}$$

The sample size for the population, as determined in Equation 1, is further calculated using Equation 2, employing a stratified random sampling technique for each subgroup. In this method, all the building projects within the population of the study are selected based on their purpose, and the selection is done proportionally in accordance with the sample size calculated using the Cochran method.

$$n = \frac{(1.96^2)pq}{e^2} = n = \frac{(1.96^2)*0.5*0.5}{0.05^2} = 384.16 \sim 385 \text{ Building projects .... Equation 1}$$

To adjust the calculated size of buildings projects and to correlate with selected 33 (N) building projects, equation 2 has been used. in this step n=385 used as no.

$n = \frac{no}{\left(1+\frac{no-1}{N}\right)} = n = \frac{385}{\left(1+\frac{385-1}{33}\right)}$ = 28 is required sample size of building projects

So, the selected 28 building projects is proportional with calculated.

According to table. 3.1, the sample size for assessing the implementation of sustainability practices during the physical construction stage of building in Addis Ababa is as follows. In Kirikos, five construction projects were chosen for assessment, while in Bole, six projects were included in the study. The area of Arada had four projects selected, while Akaki Kality had three. Nifas Silk was represented by five projects, Kolife by two, and Yeka by three projects.

Table 3.1: Number of selected buildings in the sub city.

Sub city	Number of buildings
Kirkos	5
Bole	6
Arada	4
Akaki kality	3
Nifassilk	5
kolife	2
Yeka	3
Total	28

3.8 Data Source

Data gathering is necessary to accomplish a research's goals and objectives. Naoum (2012) asserts that there are two methods for gathering data: primary data collection (fieldwork) and secondary data collection (desk study). Utilizing many data gathering techniques helps to enhance and validate the study. Multiple sources of information are added to enhance the data's veracity. The strategy used to gather the data for this study is split into two categories: primary and secondary.

3.8.1 Primary Data Source

The primary source of data is connected to three practical approaches: the survey method, structured interview, the case study approach, and the problem-solving methodology (Naoum, 2012). Both the survey and the structured interviews methodologies are used in this study from respondents.

3.8.2 Secondary Data Sources

The secondary source is the literature review, which includes reports from the Ethiopian construction authority office, annual reports from corresponding sub-city offices, government documents, books, journals, and published and/or unpublished research papers addressing the challenges and opportunities of sustainable building projects/construction.

3.9 Methods of Data Collection

The study employed a mixed-methods approach to gather information about the current status of the phenomenon. Data collection involved both secondary and primary sources. Secondary data was obtained through a comprehensive literature review, while primary data was gathered through interviews, questionnaires, and physical observations. Based on an extensive literature review and initial site observations, the researchers identified the most suitable tools for gathering necessary information about the situations of federal government budgeted buildings. The selected methods for data collection included physical observation, interviews, and questionnaires. These tools were chosen to ensure comprehensive and accurate data collection, allowing for a holistic understanding of the subject matter.

The 5-point Likert scale is widely used to gauge attitudes or opinions on various topics. It allows individuals to express their level of agreement, satisfaction, or endorsement regarding specific statements, policies, beliefs, or values. This scale provides clear and distinct response categories, while also allowing for some degree of nuance in respondents' answers. It's important to acknowledge that the specific wording and number of response options may vary depending on the particular scale being used (Kerzner, 2017).

In this study, a closed-ended questionnaire was used to assess the level of implementation of sustainability practices during the physical construction phase of building projects. Participants were asked to rate the degree of implementation on a 5-point Likert scale, ranging from "Very low implementation" to "Very high implementation." The assigned scores for the scale were as follows: 1 = Very low, 2 = Low, 3 = Medium, 4 = High, and 5 = Very high implementation. Additionally, the study aimed to investigate the barriers encountered in implementing sustainable practices during the physical construction phase of building projects, as well as identify the factors driving the implementation of sustainability practices. Participants were asked to rate their level of agreement using a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree." The assigned scores for the scale were as follows: 1 = strongly disagree, 2 = agree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

3.9.1 Questionnaire design

Based on the findings from the literature review and preliminary site investigation, the researchers developed a set of questionnaires to collect essential information from key stakeholders involved in federal government budgeted buildings in Addis Ababa. The questionnaires were tailored to target clients, consultants, contractors, and regulatory bodies. They were divided into three sections: the first section focused on gathering personal and general information about the respondents, while the remaining two sections were designed to address the specific objectives of the study (Appendix A). By structuring the questionnaires in this way, the researchers aimed to obtain comprehensive data that would contribute to achieving the study's objectives.

Section A: Demographic Background of the Respondents

Section B: Implementation of sustainability practices during physical construction stage of building

Section C: Drivers and barriers of implementing sustainability practices during physical construction stage of building. The questionnaire part is summarized in the table (3.1)

Table 3.2: Questionnaire questions and research objectives

No	Objectives	Questionnaire section
1	To evaluate the extent to which sustainability practices are implemented during physical construction stage of building	Section B: Implementation of sustainability practices during physical construction stage of building

2	To examine the barriers encountered the implementation of sustainable practices during physical construction stage of building	Section C: Drivers and barriers of implementing sustainability practices during physical construction stage of building
3	To identify the factors that drive the implementation of sustainability practices during physical construction stage of building	Section C: Drivers and barriers of implementing sustainability practices during physical construction stage of building

3.9.2 Interview

The researchers recognized that interviews provide an opportunity to engage in meaningful conversations with professionals from relevant sectors without making them feel like they are being formally interviewed. These interviews were crucial for obtaining important data that may not have been accessible through observations or questionnaires. By conducting face-to-face interviews, the researchers were able to gain insights into successfully addressing the research questions and enhancing the study's objectives. Senior professionals from various sectors, regulatory bodies, contractors, and consultants were invited to participate in semi-structured interviews. These interviews aimed to gather information on the level of implementation of sustainable practices, barriers hindering implementation, and drivers for achieving effective implementation in federal government budgeted buildings. The interview results were valuable in refining the initial questionnaire, which was developed based on the literature review, for and in checking and validating any unexpected findings from the collected and analyzed data.

3.10 Method of Data Analysis

Kombo and Tromp (2011) emphasize that the data analysis procedure involves organizing and structuring the collected information in a systematic manner to facilitate clear and effective communication of the findings. This process entails packaging the data, arranging it in a logical order, and identifying the main components that are relevant to the research objectives. By following a structured data analysis procedure, researchers can present their findings in a coherent and meaningful manner, enabling others to easily understand and interpret the results.in this study both descriptive and inferential data analysis techniques are employed.

The collected data from questionnaires and interviews were analyzed using descriptive statistical methods, including frequencies, percentages, and averages. Microsoft Excel was employed for the analysis, and the results were presented in a table format. To determine the relative importance of sustainable practice implementation, as well as to identify barriers and drivers in federal government budgeted buildings in Addis Ababa, the "Mean Score" method was utilized. As previously discussed, a Likert scale with five ordinal measures of agreement (1, 2, 3, 4, and 5) was used. The formula used to calculate the mean score (MS) for each variable, as described by Frost, J. (2021), can be expressed as:

$$MS = (f \times S) / N \quad \ldots \quad (3.3)$$

Where f represents the frequency of each response category, S denotes the score assigned to each response category, and N represents the total number of respondents.

3.10.1 Factor Analysis/Principal Component Analysis

FA is a statistical technique used to reduce a set of many interrelated variables to a relatively small number of groupings, which aim to explain the studied problem in a clearer manner (Brown 2008). It is mostly adopted to explain complex phenomena (Xu et al. 2010). In addition, this technique is powerful to identify and interpret noncorrelated group of elements (Fang et al. 2004). Considering the large number of sustainable practice barriers, driver, and to know level of implementation in this study, FA technique using principal component analysis (PCA) was conducted to regroup them into a smaller group of principal factors. To obtain the principal factors, extraction with varimax rotation and Kaiser normalization was conducted with aid of SPSS as carried out in (Osei-Kyei and Chan 2017). In addition, prior to using the FA/PCA, the appropriateness of the factor model was evaluated conducting some preliminary statistical tests including reliability test, correlation matrix, Kaiser-Meyer-Olkin (KMO), and Bartlett's test of sphericity (Chan et al. 2010).

Cronbach's alpha (α) was carried out to examine the reliability and internal consistency of the collected data, Cronbach's α value between 0.70 and 1 is considered reliable (Field 2005). Furthermore, The KMO statistic and Bartlett's test of sphericity measure the sampling adequacy

(Osei-Kyei and Chan 2017). In this regard, KMO test is one of the tests to define the appropriateness of factor analysis. The KMO measures the sufficiency of sampling by comparing the observed correlation coefficients to the partial correlation coefficients (Asiedu and Adaku 2019). KMO values are between 0 and 1, values close to 1 show robust correlations among variables, creating high suitability for factor analysis. On the contrary, values close to 0 show low correlations between variables, creating less suitability for factor analysis (Field 2013).

Accordingly, Yang et al. (2009) recommended that a minimum KMO value greater than 0.6 is acceptable for developing a factor analysis. Bartlett's test of sphericity could be employed to consider whether or not the correlation matrix is an identity matrix among variables. An identity matrix indicates that all diagonal terms are one and all off-diagonal terms are zero. This examination shows the sufficient distribution of Bartlett's test of sphericity $\chi 2$ value. High correlations between variables and high $\chi 2$ value indicate greater appropriateness for factor analysis (Hsueh and Chang 2017), The value of Bartlett's test of sphericity is measured with chi-square test and its associated significance level (p), indicating that whether not the population correlation matrix is an identity matrix (Chan et al. 2010).

3.10.2 Fuzzy Synthetic Evaluation

Normally, decision-makers have to deal with complex issues under uncertain conditions in the construction industry. These issues are unavoidable because practitioners might find it easy to rate linguistic terms such as "very low," "low," "moderate," "high" and "very high" (Islam et al. 2017). Natural languages are known as linguistic variables in cases where values are words, not numbers. Fuzzy set theory (FST) is a useful tool for decision-making regarding uncertainty based on expert opinion. This tool can express and calculate these uncertain variables through mathematical logic, despite the challenge of giving them a single numerical value (Ameyaw and Chan 2015). As a branch of Fuzzy Set Theory (FST), Fuzzy Synthetic Evaluation (FSE) is able to solve the complex issues having multiple levels and attributes of variables (Islam et al. 2017). FSE is also considered as a prominent method for multi-criteria synthetic evaluation (Xu et al. 2010) in real-life problems, which contain numerous aspects such as multi-criteria, ambiguous, incorrect data, uncertain information and many decisionmakers use it (Singh and Tiong 2005). Thus, FSE method is suitable to assess the level of implementation, driving variables and barriers. It is used as the main tool in this study to formulate a project driving index and a project's implementation enabling index for sustainable building construction projects in Ethiopia. It is considered appropriate compared to the normal weighted method because it has the ability to objectify and manipulate the subjective judgement that is inherent in human cognitive processes (Ameyaw and Chan 2015).

This study uses to applies the FSE method to evaluate level of implementation of sustainable practice, to investigate driving factors and enabling factors of sustainable practice implementation. The process of the FSE method is described as follows (Gebremeskel et al. 2021; Osei-Kyei and Chan 2017b; Xu et al. 2010):

Step 1: Establish a basic set of principal variables/factors. $F = \{f_1, f_2, f_3, f_i \dots, f_m\}$

Step 2: Construct a set of grade alternatives. $L = \{l_1, l_2, l_3 \dots, l_j\}$ is the scale measurement adopted for the research (l_1 = very low, l_2 = low, l_3 = moderate, l_4 = high, l_5 = very high);

$$w_i = \frac{M_i}{\sum_{i=1}^{5} M_i} \quad 0 \le w_i \le 1, \sum w_1 = 1 \text{ .... } (3.4)$$

Where Wi = weighting; Mi = mean score of a particular variable or factor component; and $\sum w_1$ = summation of mean ratings.

Step 3: Calculate the weightings of each factor f_i. Mean scores can be used to determine the weightings of each variable/factor $W = \{w_1, w_2, w_3, w_i \dots, w_m\}$, where $0 \le w_i \le 1$; i = 1 ÷ m

Step 4: Establish a fuzzy matrix for each criterion or principal variable/factor $R = [r_{ij}]_{m \times n}$. Where r_{ij} represents the degree of l_j regarding the criterion f_m. It is constructed by the fuzzy membership function of $l_j (j = 1 \div n)$ within the criterion f_m. The fuzzy matrix R can be presented as:

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} & \cdots & r_{1n} \\ r_{21} & r_{22} & r_{23} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & r_{m3} & \cdots & r_{mn} \end{bmatrix}$$

Step 5: Calculate the final evaluation matrix via the equation below:

$$D = W_i \bullet R_i \quad (3.5)$$

Where:

D = final evaluation matrix

W = weighting vector

R = fuzzy evaluation matrix

"•" = fuzzy composite operation

From step 3 and step 4, Eq. (2) can be shown as follows:

$$D = \{w_1, w_2, w_3, w_i, \dots, w_m\} \bullet \begin{bmatrix} r_{11} & r_{12} & r_{13} & \dots & r_{1n} \\ r_{21} & r_{22} & r_{23} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & r_{m3} & \dots & r_{mn} \end{bmatrix} = [d_1, d_2, d_3, d_i, \dots, d_n]$$

Step 6: Calculate the index of each principal component by the following equation:

$$G = \sum_{j=1}^{5} D \times L \quad (3.6)$$

Where: L = Linguistic variable (L = 1 ÷ 5)

3.10.3 Regression Analysis Model

The study utilized a multiple regression analysis model because it aimed to examine the effects of more than one independent variable on a dependent variable. In this study multiple regression model was utilized to establish a functional relationship between the independent variables (barriers and drivers) and the dependent variable (sustainable practice implementation) The multiple regression equation utilized in the study, as presented by Dong (2013), is as follows:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \varepsilon \quad (3.7)$$

Where:

Y represents the dependent variable (sustainable building)

β0 represents the constant (the value of Y when X1, X2, are equal to 0), or the interception point of the regression line and the y-axis.

$\beta1$, $\beta2$, $\beta3$, $\beta4$, and $\beta5$ represent the coefficients of the independent variables that are determined

X1 represents barrier

X2 represents driver

ε represents the error term.

In order to examine the causal relationship between the independent and dependent variables, inferential statistics were utilized. Specifically, Pearson's correlation analysis was performed to assess the strength, direction, and nature of the associations between the variables by using SPSS.

3.11 Reliability and Validity Test

3.11.1 Validity Test

Validity refers to the degree to which a measuring instrument accurately measures what it claims to measure, as defined by (Kimberlin & Winterstein, 2008). Emphasized that validity is concerned with the meaningfulness of research components, particularly when researchers are measuring behaviors. They must ensure that they are measuring what they intended to measure. To ensure the validity of the research instrument, several steps were taken (Drost & perspectives, 2011). Firstly, a pre-testing phase was conducted to identify and address any potential issues with ambiguous, awkward, or offensive questions or techniques. This involved administering the instrument to a sample group and collecting feedback to make necessary improvements. Furthermore, the research instruments underwent a rigorous review and verification process by both the advisor and subject matter experts. Their insights were invaluable in identifying areas for refinement. Based on their feedback, certain items were rephrased to enhance clarity, while others were omitted from the list of items as recommended by the experts. Additionally, to assess the validity of a questionnaire, statistical validity, which encompasses internal validity and structural validity, is used.

3.11.1.1 Internal validity

One way to assess the validity of a questionnaire is through the use of statistical tests, with internal validity being the first such test. This test involves measuring the correlation coefficients between each item within a given field and the entire field as a whole. By examining the strength and direction of these correlations, researchers can determine whether the questions accurately capture the intended construct and whether there are any potential biases or extraneous influences that may affect the results.

3.11.1.2 Structure Validity of the Questionnaire

In this study, the second statistical test used to evaluate the validity of the questionnaire was structure validity. This test involved assessing the validity of each field as well as the questionnaire as a whole, by measuring the correlation coefficient between one field and all other fields in the questionnaire that shared the same level of Likert scale. By examining these correlation coefficients, researchers could determine whether the structure of the questionnaire accurately represented the intended constructs and whether the questions were organized in a clear and meaningful way.

3.11.2 Reliability test

Reliability refers to the degree of consistency with which an instrument measures the attribute it is intended to measure. According to (Drost & perspectives, 2011), reliability can be defined as the extent to which measurements are repeatable across different people, occasions, and conditions, using different instruments that measure the same thing. Cronbach's Alpha is a statistical measure that can be used to assess the reliability of a questionnaire, both for individual fields and for the questionnaire as a whole. Higher values of Cronbach's Alpha indicate a greater degree of internal consistency, with the normal range falling between 0.0 and +1.0. By examining Cronbach's Alpha, researchers can determine whether the questionnaire produces reliable and consistent results across different conditions and respondents.

3.12 Ethical Consideration

Ethics is interpreted as moral choices that affect decisions, standards and behaviors, in relation to the rights of those who form the subject of a study. Therefore, the respondent provides data based on their agreements and voluntarism based on informed consent, ensuring there is no harm to the participants, being anonymous and confidential and not cheating subjects. The researchers maintain transparency throughout the whole research process and clearly answer any questions as well as address any concerns highlighted by participants. All participants also offer a soft copy of the final version of the thesis through email.

3.13 Conceptual Framework and Validation

This section outlined the methodology that was used to develop and validate a conceptual framework for the effective implementation of sustainable practices during the physical construction phase of building projects. The objective aligned with the broader research goals of promoting sustainability in construction and addressing challenges in the construction stage. The section provided an overview of the research objectives and highlighted the importance of the framework in guiding sustainable practices. Additionally, it emphasized the need for validation to ensure the effectiveness and practical applicability of the framework. The subsequent sections included a comprehensive review of existing literature and frameworks, the process of conceptualizing the framework, its development, and the validation procedures that were employed to assess its validity and usefulness. As illustrated in Figure 3.4, the following sections provided detailed explanations of how the research framework progressed through each of these stages.

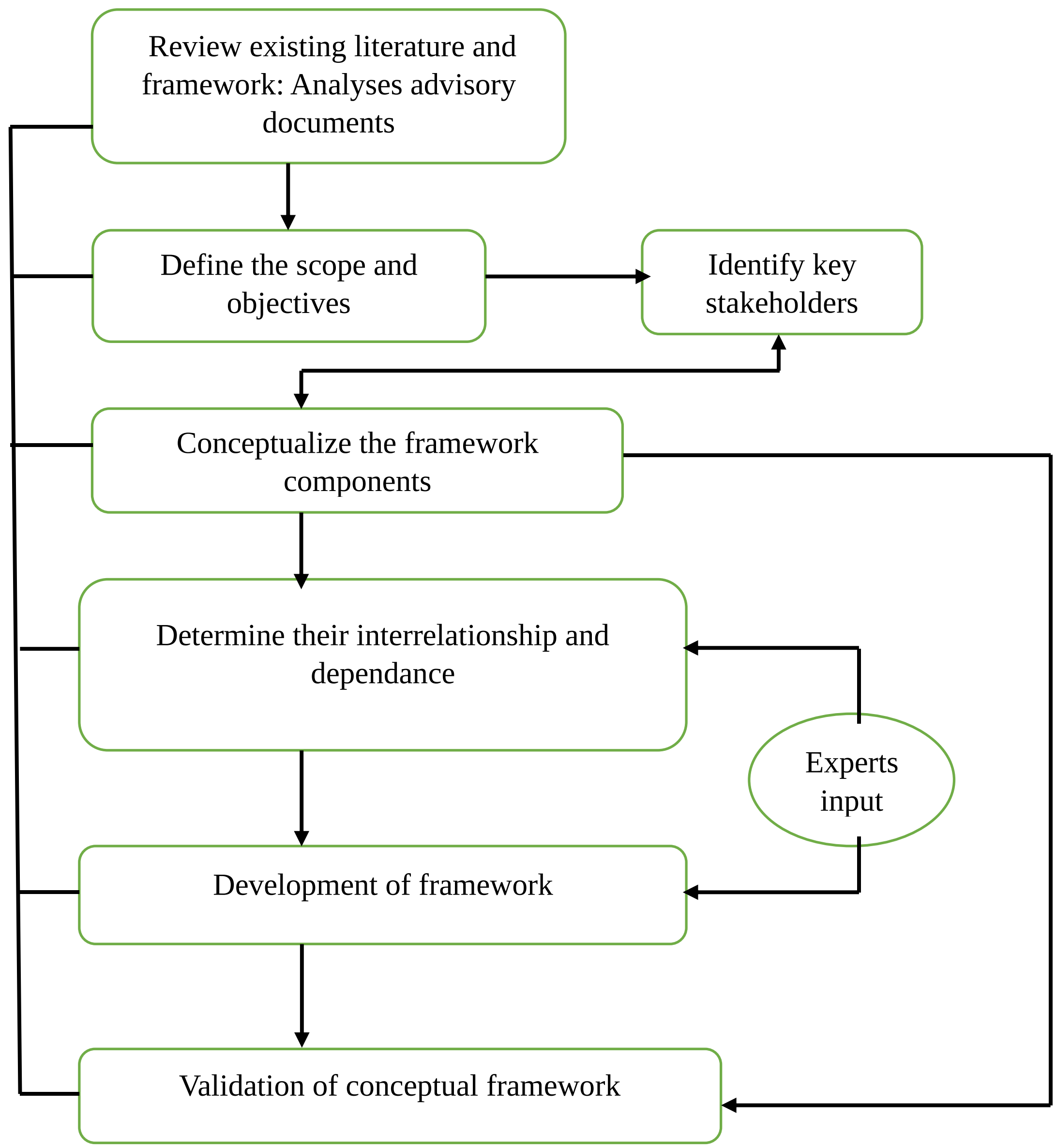

Figure 3.3: The conceptual Framework methodology

Stage 1 Literature Review

The literature review conducted in Chapter 2 informed the development of the conceptual framework by summarizing key findings, identifying gaps, and reviewing existing frameworks related to sustainable practices during the construction stage. It highlighted the importance of integrating sustainability principles in construction and revealed gaps in knowledge and frameworks. The reviewed literature guided the formulation of components and guidelines within the conceptual framework, addressing the identified gaps and building upon existing knowledge. This section serves as the foundation for the subsequent discussions on the conceptualization, development, and validation of the framework.

Stage 2: Define Scope and Objectives

The second phase of the study focused on defining the scope and objectives of the conceptual framework involves specifying the focus areas and sustainability objectives it aims to address, such as energy efficiency, waste management, water conservation, or indoor air quality. Measurable goals aligned with sustainability standards or certifications are established to track progress and evaluate the framework's effectiveness. This ensures a clear and targeted approach to achieving sustainability outcomes during the construction stage.

Stage 3: Conceptualize Framework Components

Conceptualizing the framework components involves identifying key elements based on the literature review and stakeholder input. These components may include sustainability goals, objectives, barriers, drivers, performance indicators, and communication channels. The process ensures a comprehensive and integrated approach to guide the implementation of sustainable practices during the construction phase.

Stage 4: Determine their Interrelationship and Dependence

Determining the interrelationships and dependencies of framework components involves analyzing how different elements interact and influence each other. This ensures a holistic and integrated approach to sustainable construction practices. By examining the connections and dependencies between components, the framework can be designed to work cohesively, taking into account cause-and-effect relationships and broader contextual factors. This analysis promotes consistency, synergy, and adaptability within the framework.

Stage 5: Development of Conceptual Farmwork

The development of the conceptual framework for implementation involves conducting a literature review, engaging stakeholders, conceptualizing framework components, analyzing interrelationships, designing the framework, validating its effectiveness, and refining it based on feedback. This process ensures a structured and comprehensive approach to implementing sustainable practices during the construction phase of building projects.

Stage 6: Validation of the Conceptual Framework

The validation process of the conceptual framework for the effective implementation of sustainable practices during the physical construction stage of federal government budgeted buildings in Addis Ababa focuses on ensuring the accuracy and relevance of the underlying concepts and relationships proposed within the framework. Expert opinion is commonly employed as a method for validating the conceptual framework. This validation is achieved by developing a questionnaire specifically designed to assess the validity of the framework's constructs. The questionnaire utilizes a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Experts are requested to rate their level of agreement with the proposed concepts and relationships, providing valuable feedback on the validity of the framework. The academicians were individuals who had specialized knowledge in the field of sustainable construction. As a result, their advice helped demonstrate the theoretical validity of the framework that was created. The professionals in the field were individuals who had knowledge of dealing with sustainable construction problems in building project contexts. Their suggestions helped guarantee that the proposed framework could be used in real-world situations. This validation process aimed to enhance the robustness and applicability of the conceptual framework for the sustainable implementation of practices in the construction of federal government budgeted buildings in Addis Ababa.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

In order to achieve the objectives of the study, this chapter provides a detailed analysis of the data collected through various methods, including questionnaires, interviews, and physical observation. The chapter begins by presenting the characteristics of the respondents, followed by an analysis of the level of implementation of sustainability practices during building construction. The drivers and barriers to implementation are also discussed. The last section of the chapter focuses on the conceptual framework for effective implementation of sustainable practices during the physical construction stage. The data collected from the questionnaires, interviews, and physical observation is summarized and discussed based on the specific objectives of the study. A total of 65 questionnaires were distributed to clients, contractors, consultants, and government officials who participated in selected federal government budgeted buildings in Addis Ababa. Out of the 65 questionnaires, 50 respondents filled and returned them, accounting for 75% of the total number of questionnaires distributed. In addition to the questionnaires, interviews were conducted with higher government officials who participated in the project. The use of different methods of information gathering is aimed at increasing the reliability and validity of the data, thereby enhancing the quality of the research findings and the conclusions drawn from them.

4.2 Profile of Respondents

In a study or survey, a total of 65 questionnaires were distributed to collect responses from participants. Out of these, 50 questionnaires were successfully returned by the respondents. However, upon examination, it was discovered that one of the returned questionnaires was incomplete, and as a result, it was excluded from the analysis. After excluding the incomplete questionnaire, there were 49 completed questionnaires remaining. Despite this exclusion, the remaining 49 questionnaires were deemed sufficient for conducting the analysis. These 49 questionnaires were considered complete and provided the necessary data for the intended analysis or study.

Table 4.1: Response rate of questioner.

	Contractor	Consultant	Client	Regulatory body	Total
No of questioners distributed	20	15	15	15	65
Questioners returned	16	12	10	11	49
Percentage	80%	80%	67%	73%	75%

4.2.1 Level of education/academic status of respondent

Based on the data presented in Table 4.2, it is evident that among the listed educational levels in the questionnaire, only two educational levels are represented by the respondents. The majority of participants, accounting for 73.5% of the total, hold a B.Sc. degree as their highest educational qualification. This indicates that a significant proportion of the respondents have acquired a Bachelor of Science degree. The second most common educational level among the respondents is a M.Sc. degree, with 13 individuals representing 26.5% of the total. It is worth noting that there are no respondents with a PhD or diploma qualification in the dataset. These findings have important implications for the study, as they suggest that the majority of the respondents possess a B.Sc. degree, indicating a solid foundation of knowledge and skills in their respective fields. This educational background positions the respondents to provide valuable insights and perspectives on the research questions under investigation.

Table 4.2: Level of education/Academic status of respondent

Level of Education				
		Frequency	Percent	Cumulative Percent
Valid	First Degree	36	73.5	73.5
	MA/MSc Degree	13	26.5	100.0
	Total	49	100.0	

4.2.2 Years of work experience of the respondents

Table 4.3 displays the distribution of work experience among the respondents. The majority of participants, accounting for 26 individuals or 53% of the total, reported having between 6 to 10 years of work experience in their respective positions. This group was considered valuable for the study as they possessed substantial knowledge and insights to contribute. Furthermore, 13 respondents (27%) reported having 11 to 15 years of work experience, indicating a considerable level of expertise. A smaller proportion of participants, 6 individuals (12%), had worked between 0 to 5 years, suggesting a relatively less experienced subgroup. Lastly, a minority of respondents, consisting of 4 individuals (8%), reported having more than 16 years of work experience, signifying a smaller but notable group with extensive professional background.

Table 4.3: Years of work experience of the respondents

No	Year of work experience	Respondent	Percentage
1	0-5 years	6	12%
2	6 to 10 years	13	27%
3	11-15 years	26	53%
4	More than 16 years	4	8%

4.3 Result of Reliability and Validity Test

4.3.1 Result of reliability test

To assess the reliability of the questionnaire, the internal consistency was evaluated using Cronbach's Alpha reliability test. Cronbach's Alpha is a measure that determines the degree of interrelatedness among a set of items, such as survey questions. By calculating Cronbach's Alpha, we can determine the extent to which the questionnaire items are closely associated with each other, indicating the internal consistency of the questionnaire

Table 4.4: Cronbach Alpha pretest

No	**Field**	Number of items	**Cronbach's Alpha**
1	Sustainability practice	17	0.917
2	Barrier	14	0.873

3	Drivers	19	0.903
	All item of the Questioner	50	0.919

Table (4.4) displays the results of the reliability analysis of the questionnaire. The Cronbach's Alpha values ranged from 0.873 to 0.917 for each field, indicating good reliability. The overall Cronbach's Alpha value for the whole questionnaire was 0.919, which is considered to be excellent reliability for the entire questionnaire.

4.3.1 Result of validity test

4.3.1.1 Internal validity test

Table (4.5) displays the p-values (Sig.) for each sustainability practice during the physical construction stage and for the total sustainability factors. The results reveal that all p-values are less than 0.05, indicating that the correlation coefficients for these factors are statistically significant at the 0.05 level of significance ($\alpha = 0.05$). These findings provide evidence that the sustainability practices during the physical construction stage are both consistent and valid measures.

Table 4.5: Correlation coefficient of each sustainability practice and the total sustainability practice during physical constructions stage

No	Sustainability Practices	Correlation coefficient	p-value
1	Use of sustainable building material	0.623	0.000
2	Waste reduction and management	0.772	0.000
3	Indore environmental quality	0.704	0.000
4	Protection of Worker health and safety	0.524	0.000
5	Energy efficiency	0.609	0.000
6	Commissioning and monitoring	0.617	0.000
7	Minimizing site disturbance	0.668	0.000
8	Proper storage and handling of material	0.291	0.042
9	Use of prefabricated component	0.759	0.000
10	Dust and noise control	0.636	0.000

11	Training and certification of worker	0.684	0.000
12	Collaboration and communication	0.441	0.002
13	Control of dust to reduce pollution on building	0.753	0.000
14	Use of vertical green wall at the site to cool the office and improve aesthetics	0.696	0.000
15	Controlling the use and dispersion of toxic materials	0.772	0.000
16	Regular inspection and monitoring	0.559	0.000
17	Employee education and training	0.803	0.000

Table (4.6) demonstrates that the p-values (Sig.) for each of the barriers during the physical construction stage and the total barrier factor are less than 0.05. This suggests that the correlation coefficients for these factors are statistically significant at $\alpha = 0.05$, indicating that the barriers during the physical construction stage are consistent and valid to be measured.

Table 4.6: Correlation coefficient of each Barriers of Implementation and the total sustainability practice barriers of during physical constructions stage.

No	Barriers of Implementation	Correlation coefficient	p-value
1	Lack of training and education	0.695	0.000
2	Lack of regulation to enforce sustainability.	0.628	0.000
3	Resistance to change	0.721	0.000
4	Lack of financial intensive	0.502	0.000
5	Limited availability of suppliers of sustainable products and materials.	0.399	0.005
6	Lack of Collaboration and coordination	0.367	0.009
7	Lack of tools and techniques to support understanding of sustainability	0.310	0.030
8	Time consuming activities	0.548	0.000
9	Insufficient professional capabilities	0.316	0.027

10	Client's lack of interest, understanding and commitment makes its practical application difficult.	0.721	0.000
11	Knowledge on sustainable technologies is limited	0.286	0.046
12	Lack of Standardization and certification	0.721	0.000
13	The higher cost associated with sustainable buildings.	0.721	0.000
14	Lack of environmental concern	0.521	0.000

Table (4.7) shows that the p-values (Sig.) for each of the drivers during the physical construction stage and the total driver factor are less than 0.05. This suggests that the correlation coefficients for these factors are statistically significant at $\alpha = 0.05$, indicating that the drivers during the physical construction stage are consistent and valid to be measured.

Table 4.7: Correlation coefficient of each driver of Implementation and the total sustainability practice drivers of during physical constructions stage.

No	Drivers of Implementation	Correlation coefficient	p-value
1	Environmental regulations and compliance	0.532	0.000
2	Cost savings and efficiency	0.520	0.000
3	Regulations by the Government	0.455	0.000
4	Use of integrated approach	0.737	0.000
5	Client demand and market differentiation	0.671	0.000
6	Reduced risk and liability	0.681	0.000
7	Corporate social responsibility and ethical considerations	0.603	0.000
8	Client's awareness and knowledge	0.563	0.000
9	Value added benefits and operational efficiency.	0.673	0.000
10	Commitment by professionals and stakeholders	0.604	0.000
11	Employee engagement and retention	0.642	0.000
12	Health and wellbeing of occupants	0.743	0.000
13	Education and training programs by academicians	0.725	0.000
14	Ethics and behavioral change	0.563	0.000
15	Public awareness	0.610	0.000

16	Resource conservation and waste reduction	0.756	0.000
17	Introducing green objectives early	0.607	0.000
18	Owners' commitment to sustainability	0.621	0.000
19	Integration of Environmental Management System	0.663	0.000

4.3.1.2 Structural validity test

Table (4.8) provides insight into the validity of the questions related to sustainability practices, barriers, and drivers of implementation during the physical construction stage. The p-values (Sig.) for each group of sustainability factors, as well as the total sustainability factors, are shown to be less than 0.05, indicating that the correlation coefficients for these factors are statistically significant at the 0.05 level of significance ($\alpha = 0.05$). This suggests that the questions related to sustainability practices, drivers, and barriers during the physical construction stage are consistent and valid measures, and can be used to accurately assess sustainability in the context of this study.

Table 4.8: Correlation coefficient of each group and the total factors of questionnaire

No	Questioner groups	Correlation coefficient	p-value
1	Sustainability practice	0.730	0.000
2	Barrier	0.546	0.000
3	Drivers	0.743	0.000

4.4 Level of implementation of sustainable practice during physical construction stage of building.

This section analyzes the level of implementation of sustainable practices during the physical construction phase of building projects. It utilizes factor analysis and fuzzy synthetic evaluation techniques to evaluate the top sustainable practices.

4.4.1 Factor analyses for sustainable practice

Based table (4.9), KMO and Bartlett's test of sphericity were utilized to assess the suitability of the model (Robert et al., 2014). The Bartlett's test of sphericity yielded a significant chi-square value of 667.271 and an associated significance level (p) of 0.000, suggesting that the correlation matrix is not an identity matrix (Chan et al., 2010). Furthermore, the calculated KMO value is 0.677, which exceeds the recommended threshold of 0.60 (Hsueh and Chang, 2017). Through factor analysis, it was determined that the two variables, "dust and noise control" and "minimizing site disturbance", had loadings less than 0.5 and were thus removed (Hair et al., 2010). Consequently, 15 items were retained, and these were grouped into three factors, which accounted for 67% of the total variance. The results of the factor analysis are presented in Table 4.6.

Table 4.9: Results of KMO and Bartlett's Test for sustainable practices during construction stage

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.677
	Approx. Chi-Square	667.271
	df	136
	Sig.	.000

The three sustainable practice groups were identified as "economic sustainable practice," "environmentally sustainable practice," and "social sustainable practice." Among these, "economic sustainable practice" accounted for 26% of the variance with the highest eigenvalue of 3.939 in the data. This was followed by "environmentally sustainable practice" with an eigenvalue of 3.465, representing 23% of the total variance. Lastly, "social sustainable practice" was indicated with an eigenvalue of 2.728, contributing 18% to the overall variance.

Table 4.10: Factor grouping of 15 sustainable practices during physical construction stage

Practice Group	Factor loading	Eigenvalue	The % of variance explained	Cumulative % of variance explained
1 Economic sustainable practice		3.939	26%	26%
West management	0.651			
Use of sustainable building material	0.707			
Energy efficiency	0.508			

Commissioning and monitoring	0.785			
Proper storage and handling of material	0.588			
Use of prefabricated component	0.699			
2 Environmentally sustainable practice		3.465	23%	49%
Indore environmental quality	0.549			
Control of dust to reduce pollution on building	0.557			
Use of vertical green wall at the site to cool the office and improve aesthetics	0.799			
Controlling the use and dispersion of toxic materials	0.752			
Regular inspection and monitoring	0.808			
3 Social sustainable practice		2.728	18%	67%
Protection of Worker health and safety	0.753			
Training and certification of worker	0.694			
Employee education and training	0.755			
Collaboration and communication	0.526			

Note(s) Extraction Method: Principal Component Analysis, Rotation Method: Varimax with Kaiser Normalization.

The ranking of sustainable practices in construction projects, as presented in the table (4.11), is derived from the mean scores assigned by 49 respondents and highlights their varying priorities and importance. It is essential to compare these findings with those in other studies and publications to get a comprehensive understanding of sustainable practices in the construction sector. Firstly, proper storage and handling of materials top the list with a mean score of 3.45, which aligns with the study by Chileshe et al. (2011), who also emphasize the significance of minimizing waste, damage, and hazardous situations in construction projects. Additionally, the importance of regular inspection and monitoring, as indicated with a 3.12 mean score, is echoed in the research by Baltazard (2017), stating that such practices ensure construction site adherence to sustainable standards. The prioritization of communication and collaboration (mean score of 3.00) is consistent with the findings of Opoku et al. (2015), who identified teamwork as crucial for enhancing a project's sustainability. Protection of worker health and safety (mean score of 2.90) also finds resonance in a study by Lützkendorf et al. (2017), which highlights the benefits of a sustainable project considering workers' well-being. Further, the importance of commissioning and monitoring (mean score of 2.86) can be drawn parallels with Kibert et al. (2012), who focused on system evaluations and long-term cost-effectiveness in sustainable construction projects. However, as we compare the priorities in the above table with those recorded in other studies, some differences can be observed

Beyond these top five priorities, the last three sustainable practices based on mean scores include the use of prefabricated components (1.92), Control of dust to reduce pollution on building (2.10), and vertical green walls (1.82). Despite their benefits, these practices seem to be less prioritized or implemented by construction professionals. These sustainable practices to reduce environmental impact, foster worker well-being, and secure long-term cost savings.

Table 4.11: Mean score of sustainable practice implementation during physical construction stage

Sustainable practices	N	Mean	Std. Deviation	Rank
Proper storage and handling of material	49	3.45	0.68	1
Regular inspection and monitoring	49	3.12	0.63	2
Collaboration and communication	49	3.00	0.50	3

Protection of Worker health and safety	49	2.90	1.05	4
Commissioning and monitoring	49	2.86	0.71	5
Use of sustainable building material	49	2.67	0.75	6
Indore environmental quality	49	2.63	0.76	7
Employee education and training	49	2.39	1.00	8
Energy efficiency	49	2.39	0.93	8
West management	49	2.31	0.68	10
Training and certification of worker	49	2.20	1.08	11
Controlling the use and dispersion of toxic materials	49	2.18	0.81	12
Control of dust to reduce pollution on building	49	2.16	1.07	13
Use of prefabricated component	49	1.92	1.10	14
Use of vertical green wall at the site to cool the office and improve aesthetics	49	1.82	1.03	15

4.4.2 Model application

Before developing the membership function (MF), it was presumed that the weight of each sustainable practice within the various factors was determined using mean score values calculated from the data gathered from respondents. As presented in Table (4.12), the total mean score for economic sustainable practices is 15.6, with an economic sustainability group weight of 0.313. Meanwhile, the total mean score for environmentally sustainable practices amounts to 11.91, correlated with an environmental sustainability group weight of 0.231. Lastly, the total mean score for social sustainable practices is 10.49, accompanied by a social sustainability group weight of 0.276.

Table 4.12: Weighting each sustainable practice group

Sustainable Practice Group	MS	Weighting of SP	MS of SP Group	Weighting of SP Group
West management	2.31	0.148		
Use of sustainable building material	2.67	0.171		

Energy efficiency	2.39	0.153		
Commissioning and monitoring	2.86	0.183		
Proper storage and handling of material	3.45	0.221		
Use of prefabricated component	1.92	0.123		
Economic sustainable practice			15.6	0.411
Indore environmental quality	2.63	0.221		
Control of dust to reduce pollution on building	2.16	0.181		
Use of vertical green wall at the site to cool the office and improve aesthetics	1.82	0.153		
Controlling the use and dispersion of toxic materials	2.18	0.183		
Regular inspection and monitoring	3.12	0.262		
Environmentally sustainable practice			11.91	0.313
Protection of Worker health and safety	2.9	0.276		
Training and certification of worker	2.2	0.210		
Employee education and training	2.39	0.228		
Collaboration and communication	3	0.286		
Social sustainable practice			10.49	0.276
Total			38	

Prior to constructing the membership function (MF) for fuzzy modeling, it was presumed that the second level comprises three sustainable practice groups, while the third level contains 15 sustainable practices. Initially, the MF for the second level was determined followed by an analysis of the MF for the first level. The MF for each sustainable practice variable was established based on ratings from 49 respondents. Consequently, the first and second level MFs of sustainable practices during the physical construction stage of a building were presented in (Appendix E).

Table 4.13: Level of implementation of sustainable practice.

Implementation of sustainable practice	SPI	Coefficients	Rank
Economic sustainable practice	2.723	0.342	2
Environmentally sustainable practice	2.464	0.309	3
Social sustainable practice	2.776	0.349	1
Total	7.963		
Overall implementation index	2.658		

Based on the data provided in Table (4.13), the illustrated index demonstrates that among the various sustainable practices, social sustainability practice garners the highest coefficient at 0.349. This is closely followed by economic sustainable practice, which has a coefficient of 0.342, while environmental sustainability practice comes in third place with a coefficient of 0.309.

4.4.2.1 Social sustainability practice

The social sustainability practice comprises four variables: Protection of Worker Health and Safety (Factor Loading = 0.753), Training and Certification of Workers (Factor Loading = 0.694), Employee Education and Training (Factor Loading = 0.755), and Collaboration and Communication (Factor Loading = 0.526). Similarly, according to a research article published by Giannetti et al. (2021), social sustainability practices show a strong positive correlation with overall sustainability performance, further validating the data presented in Table 4.8. The authors also stress the need for organizations to consider the interconnectivity of sustainability dimensions to optimize their sustainability performance (Giannetti et al., 2021).

4.4.2.2 Economic sustainability practice

The economic sustainability practice consists of six variables: West management (Factor Loading = 0.651), Use of sustainable building materials (Factor Loading = 0.707), Energy efficiency (Factor Loading = 0.508), Commissioning and monitoring (Factor Loading = 0.785), Proper storage and handling of materials (Factor Loading = 0.588), and Use of prefabricated components (Factor Loading = 0.699). Additionally, study conducted by Wagner et al. (2019) supports these findings, emphasizing that organizations should implement an integrated approach towards sustainability, encompassing environmental, social, and economic dimensions. Their research highlights the importance of synthesizing these dimensions to achieve long-term sustainable development goals (Wagner et al., 2019).

4.4.2.3 Environmental sustainability practice

The environmental sustainability practice comprises five variables: Indoor environmental quality (Factor Loading = 0.549), Control of dust to reduce pollution on buildings (Factor Loading = 0.557), Use of vertical green walls to cool the office and improve aesthetics (Factor Loading = 0.799), Controlling the use and dispersion of toxic materials (Factor Loading = 0.752), and Regular inspection and monitoring (Factor Loading = 0.808). In a study by Fong, et al. (2017), they explored environmental sustainability practices in a construction context, specifically focusing on green public housing in Malaysia. They identified eight factors contributing to environmental sustainability, including: energy efficiency, water efficiency, material efficiency, waste reduction, control of dust and pollutants, protection and preservation of the ecosystem, improvement of indoor environmental quality (IEQ), and green building design. The factor loadings of these variables ranged from 0.546 to 0.892. While the study by Fong et al. (2017) considered a broader scope by including more factors, their research also overlaps with the sustainability practices mentioned in the question, specifically the indoor environmental quality factor and the control of dust factor.

Therefore, it is essential for organizations to adopt a comprehensive approach towards sustainability, focusing on social, economic, and environmental practices to ensure long-lasting positive impacts. Ensuring a balance among these practices contributes to social equity, financial stability, and environmental preservation leading to a more sustainable future for both present and future generations (Wagner et al., 2019; Giannetti et al., 2021).

Based on the provided Likert scale where 1 represents "very low" and 5 represents "very high," an overall implementation index of 2.658 would indicate a level of implementation of sustainable practices during the physical construction stage that is between low and moderate. The value of 2.658 falls closer to the low end of the scale but does not reach the threshold for a moderate level of implementation. It suggests that there is room for improvement in implementing sustainable practices in the context being considered.

When comparing this finding with other related journals, we can see different levels of implementation of sustainable practices in various contexts. For example, in a 2018 study by Olanrewaju and Tan (Journal of Cleaner Production, 180, 638-651), it was found that the level of implementation of sustainable practices in construction projects in Malaysia was 2.90 on the same 5-point Likert scale. This indicates a slightly higher implementation level when compared with the 2.658 score, but still remaining in the low-to-moderate range. Another study conducted by Yuan and Zeng (2017) in China (Sustainability, 9(8), 1392) found a score of 2.72 in the implementation of sustainable practices, which is similar to the provided value of 2.658. Both scores suggest low levels of implementation in their respective contexts, implying that improvements should be made to enhance the adoption of sustainable practices.

4.5 Barriers for implementing sustainability practice during physical construction phase of building project

This section analyzes the barriers to implementing sustainability practices during the physical construction phase of building projects. It utilizes factor analysis and fuzzy synthetic evaluation techniques to evaluate the contributing factors. The ultimate goal is to develop an index that quantifies the difficulty level in implementing sustainable practices. This analysis aims to provide valuable insights for overcoming barriers and enhancing sustainability efforts in the construction industry.

4.5.1 Factor analyses for barriers

In Table (4.14), the final run included a total of 13 factors after eliminating certain weak factors to meet the requirements. The variable "lack of knowledge and expertise on sustainability" was removed from the analysis as its loadings were below 0.5 (Hair et al., 2010). The Kaiser-Meyer-Olkin (KMO) value was calculated to be 0.624, indicating a moderate level of sampling adequacy. Furthermore, Bartlett's test for sphericity produced a Chi-square value of 887.391

with a significance level of $p < 0.000$, which confirms that the requirements were successfully fulfilled.

Table 4.14: Results of KMO and Bartlett's Test for barrier sustainable practices during construction stage

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.624
Bartlett's Test of Sphericity	Approx. Chi-Square	887.391
	df	91
	Sig.	.000

From the table (4.15), we can see that the three barrier groups identified are economic, environmental, and social barriers. Economic barriers accounted for 20% of the variance, with the highest factor loading attributed to limited availability of suppliers of sustainable products and materials (0.782). The eigenvalue for this group was 2.633. Environmental barriers accounted for 26% of the variance, with the highest factor loading attributed to the lack of regulation to enforce sustainability (0.874). The eigenvalue for this group was 3.374. Social barriers accounted for 28% of the variance, with the highest factor loading attributed to lack of collaboration and coordination (0.946). The eigenvalue for this group was 3.637. In total, these three barrier groups accounted for 74% of the overall variance in sustainable practices.

Table 4.15: Factor grouping of 13 barriers of implementing sustainable practices during physical construction stage

Barrier Group	Factor loading	Eigenvalue	The % of variable explained	Cumulative % of variance explained
1 Economic barrier		2.633	20%	20%
Lack of financial incentives	0.634			
Limited availability of suppliers of sustainable products and materials	0.782			
Insufficient professional capabilities	0.543			
The higher cost associated with sustainable buildings	0.674			
2 Environmentally barrier		3.374	26%	46%

Lack of regulation to enforce sustainability	0.874			
Lack of tools and techniques to support understanding of sustainability	0.862			
Lack of standardization and certification	0.788			
Lack of environmental concern	0.85			
3 Social barrier		3.637	28%	74%
Lack of training and education	0.725			
Resistance to change	0.584			
Lack of collaboration and coordination	0.946			
Time-consuming activities	0.755			
Client's lack of interest, understanding, and commitment makes its practical application difficult	0.627			

The table (4.16), provides a ranking of barriers related to sustainability, based on responses from 49 participants. The barriers are assessed using mean scores, reflecting their perceived significance.

The top-ranked barriers include "Lack of regulation to enforce sustainability" (mean score = 3.959) and " Limited availability of suppliers of sustainable products and materials " (mean score = 3.873). Other notable barriers include "Lack of training and education" (mean score = 3.735), " Lack of collaboration and coordination " (mean score = 3.551), and " Insufficient professional capabilities and Lack of tools and techniques to support understanding of sustainability " (mean score = 3.51). These emphasize the need for improved knowledge, standardized guidelines, and strategies to promote acceptance of sustainability.

A comparative analysis with a study published in the International Journal of Sustainable Development and World Ecology by Razzaq et al. (2020) highlights similar barriers to implementing sustainability. Their findings emphasize the role of inadequate regulations, lack of stakeholder awareness, and insufficient professional capabilities in hindering environmental sustainability efforts. This further confirms the significance of developing comprehensive regulatory frameworks, promoting environmental education and awareness, and enhancing professional skills in the field of sustainability. Another journal article by Matar and Georgy (2022) in the Journal of Cleaner Production presents a more industry-specific perspective, focusing on barriers to sustainable construction practices. Despite the sector-specific approach, the authors also identify several barriers similar to those mentioned in the table, including insufficient training and education, resistance to change, and lack of standardization. This implies that these barriers could be prevalent across various sectors and industries, necessitating broader initiatives and strategies to address them.

The last three barriers, namely "Lack of environmental concern" (mean score = 2.735), " The higher cost associated with sustainable buildings " (mean score = 2.857), and " Client's lack of interest, understanding, and commitment makes its practical application difficult " (mean score = 2.898), underscore the importance of developing skills, providing suitable resources, and optimizing efficiency in sustainability efforts. Understanding these barriers and their mean scores can guide efforts in addressing key challenges and promoting effective implementation of sustainability practices.

Table 4.16: The mean scores of barriers for implementing sustainable practices during the physical construction stage

Barriers	N	Mean	Std. Deviation	Rank
Lack of regulation to enforce sustainability	49	3.959	1.554	1
Lack of environmental concern	49	2.735	1.497	13
Lack of training and education	49	3.735	1.335	3
Lack of standardization and certification	49	3	1.155	9
Resistance to change	49	2.959	1.136	10
Client's lack of interest, understanding, and commitment makes its practical application difficult	49	2.898	1.123	11
The higher cost associated with sustainable buildings	49	2.857	1.099	12
Lack of collaboration and coordination	49	3.551	1.022	4

Limited availability of suppliers of sustainable products and materials	49	3.837	0.921	2
Lack of financial incentives	49	3.469	0.844	7
Insufficient professional capabilities	49	3.51	0.794	5
Lack of tools and techniques to support understanding of sustainability	49	3.51	0.767	5
Time-consuming activities	49	3.041	0.611	8

4.5.2 Model application

In Table (4.17), it is noted that the total mean score for the economic barrier is 13.7, indicating the average level of this barrier. The economic barrier group weight, with a value of 0.318, signifies its relative importance within the context of the study. Similarly, the total mean score for the environmental barrier is recorded as 13.2, highlighting the average level of this barrier. The corresponding environmental barrier group weight, with a value of 0.307, reflects its significance in relation to the other factors being analyzed. Lastly, the total mean score for the social barrier is observed to be 16.2, signifying the average level of this particular barrier. The social barrier group weight, valued at 0.376, emphasizes its relative weightage compared to the other factors under investigation.

Table 4.17: Weighting each barriers group

Barrier Group	MS	Weighting of Barrier	MS of Barrier Group	Weighting of Barrier Group
Lack of financial incentives	3.469	0.254		
Limited availability of suppliers of sustainable products and materials	3.837	0.281		
Insufficient professional capabilities	3.51	0.257		
The higher cost associated with sustainable buildings	2.857	0.209		
Economic barrier			13.7	0.318
Lack of training and education	3.735	0.231		
Resistance to change	2.959	0.183		

Lack of collaboration and coordination	3.551	0.219		
Time-consuming activities	3.041	0.188		
Client's lack of interest, understanding, and commitment makes its practical application difficult	2.898	0.179		
Social barrier			16.2	0.376
Lack of regulation to enforce sustainability	3.959	0.300		
Lack of tools and techniques to support understanding of sustainability	3.51	0.266		
Lack of standardization and certification	3	0.227		
Lack of environmental concern	2.735	0.207		
Environmental barrier			13.2	0.307
Total			43.1	

Before developing the membership function (MF) for fuzzy modeling, it was assumed that there are three barrier groups at the second level and 13 barriers at the third level. The process began by determining the MF for the second level, followed by an examination of the MF for the first level. To establish the MF for each barrier variable, ratings from 49 respondents were considered. As a result, the MFs for the first and second level barriers related to implementing sustainable practices during the physical construction stage of a building were presented in (Appendix F).

Table 4.18: Barriers of implementing sustainable practice during physical construction stage

Barrier	DI	Coefficients	Rank
Economic Barrier	3.879	0.367	1
Environmentally Barrier	3.368	0.319	2
Social Barrier	3.315	0.314	3
Total	10.562		
Overall, Barrier index	3.383		

Based on the data provided in Table (4.18), the index presented reveals the relative strengths of various barriers. It demonstrates that the economic barrier holds the highest coefficient of 0.367, indicating its significant impact. Close behind is the environmental barrier with a coefficient of

0.319, suggesting its substantial influence. Lastly, the social barrier is ranked third with a coefficient of 0.314, signifying its notable contribution to the overall analysis.

4.5.2.1 Economic barrier

The economic barriers consist of four variables that contribute to the challenges of implementing sustainable practices. These variables include lack of financial incentives (factor loading: 0.634), limited availability of suppliers of sustainable products and materials (factor loading: 0.782), insufficient professional capabilities (factor loading: 0.543), and higher costs associated with sustainable buildings (factor loading: 0.674). These factors highlight the obstacles related to financial incentives, availability of sustainable suppliers, professional expertise, and increased expenses, all of which need to be addressed to overcome economic barriers in sustainable construction. In comparison to this analysis, study conducted by Oyedele, L., and Akinade, O. (2018) in the Sustainability journal also found that economic barriers play a critical role in hindering the adoption of sustainable construction practices. The authors pinpointed the issues of higher costs, lack of affordable and available sustainable materials, inadequate governmental support, and skill shortage as significant factors affecting the implementation of sustainable buildings (Oyedele et al., 2018).

4.5.2.2 Environmental barrier

Environmental barriers to achieving sustainability are influenced by four variables: the lack of regulation to enforce sustainability (factor loading: 0.874), inadequate tools and techniques for understanding sustainability (factor loading: 0.862), the absence of standardization and certification (factor loading: 0.788), and insufficient environmental concern (factor loading: 0.85). These factors highlight the challenges associated with the absence of regulatory frameworks, limited resources for understanding sustainability, the absence of standardized practices, and the lack of awareness and concern for the environment. In a study by Aboelmaged (2018), similar factors were identified as barriers towards sustainability, including the lack of regulatory measures and standards (factor loading: 0.93), inadequate tools and techniques for sustainability (factor loading: 0.92), and insufficient environmental concern and awareness (factor loading: 0.87). Additionally, the study mentioned other barriers such as the resistance to change (factor loading: 0.81), financial constraints (factor loading: 0.80), and a lack of skilled workforce/resources (factor loading: 0.77).

4.5.2.3 Social barrier

Social barriers to implementing sustainable practices are influenced by five key variables. These variables include a lack of training and education (factor loading: 0.725), resistance to change (factor loading: 0.584), a lack of collaboration and coordination (factor loading: 0.946), time-consuming activities (factor loading: 0.755), and the client's lack of interest, understanding, and commitment, which makes practical application challenging (factor loading: 0.627). A study conducted by Oyedele et al. (2017) investigated barriers to implementing sustainable practices in construction projects, specifically focusing on social barriers. They similarly identified five key variables influencing social barriers, which include a lack of training and education, resistance to change, a lack of collaboration and coordination, time-consuming activities, and a lack of interest and commitment from clients. Their findings support the assertion made above, as they found similar factor loadings for these variables: lack of training and education (factor loading: 0.731), resistance to change (factor loading: 0.589), lack of collaboration and coordination (factor loading: 0.941), time-consuming activities (factor loading: 0.749), and client's lack of interest and commitment (factor loading: 0.623) (Oyedele et al., 2017).

4.6 Driver for implementing sustainable practice during physical construction stage of building project.

This section analyzes the drivers for implementing sustainability practices during the physical construction phase of building projects. It utilizes factor analysis and fuzzy synthetic evaluation techniques to evaluate the contributing factors. The ultimate goal is to develop an index that quantifies the level of influence of these drivers on the successful implementation of sustainable practices. This analysis aims to provide valuable insights into the key factors driving sustainability efforts in the construction industry.

4.6.1 Factor analyses for drivers

In Table (4.19), the final analysis consisted of 16 driver factors after eliminating certain weak factors to meet the study's requirements. Specifically, the variables "integration of environmental management system," "commitment by professionals and stakeholders," and "value-added benefits and operational efficiency" were removed from the analysis due to loadings below 0.5 (Hair et al., 2010). The calculated Kaiser-Meyer-Olkin (KMO) value of 0.600 indicates a moderate level of sampling adequacy. Additionally, Bartlett's test for sphericity resulted in a Chi-square value of 740.275 with a significance level of $p < 0.000$, confirming that the analysis met the necessary criteria.

Table 4.19: Results of KMO and Bartlett's Test for driver of sustainable practices during construction stage

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.600
Bartlett's Test of Sphericity	Approx. Chi-Square	740.275
	df	136
	Sig.	.000

Based on table (4.20), three distinct driver groups were identified: "economic driver," "environmentally driver," and "social driver." The "social driver" exhibited the highest eigenvalue of 6.167, accounting for 39% of the total variance in the data. The "environmentally driver" followed with an eigenvalue of 3.157, explaining 20% of the variance. Lastly, the "economic driver" was characterized by an eigenvalue of 2.941, contributing 18% to the overall variance. These findings highlight the varying levels of importance and impact among the different driver groups in the dataset.

Table 4.20: Factor grouping of 16 barriers of implementing sustainable practices during physical construction stage

Driver Group	Factor loading	Eigenvalue	The % of variable explained	Cumulative % of variance explained
1 Economic driver		2.941	18%	18%
Cost savings and efficiency	0.68			

Use of integrated approach	0.8			
Reduced risk and liability	0.673			
Owners' commitment to sustainability	0.788			
2 Environmentally drivers		3.157	20%	38%
Environmental regulations and compliance	0.783			
Regulations by the Government	0.798			
Resource conservation and waste reduction	0.817			
Introducing green objectives early	0.759			
3 Social drivers		6.167	39%	77%
Client demand and market differentiation	0.642			
Corporate social responsibility and ethical considerations	0.776			
Client's awareness and knowledge	0.815			
Employee engagement and retention	0.896			
Health and wellbeing of occupants	0.745			
Education and training programs by academicians	0.695			
Ethics and behavioral change	0.815			
Public awareness	0.783			

Based on the mean score values from Table (4.21), the top five driver groups for driving sustainability are as follows: regulations by the government with the highest mean score of 4.367, followed closely by environmental regulations and compliance with a mean score of 4.245. The next three highest mean scores are health and wellbeing of occupants (3.898), and resource conservation and waste reduction (3.776) and the fifth one is Introducing green objectives early with mean score (3.755)

A study published in the Journal of Cleaner Production also emphasizes the importance of government regulations in driving sustainability. The researchers highlight the role of policies and regulations in promoting sustainable practices in various sectors (Akenji & Bengtsson, 2014). Additionally, a report from Environmental Science & Policy states that environmental regulation plays a crucial role in improving companies' environmental performance and compliance with sustainability objectives (Meng, Liu & Zhang, 2016). These findings coincide with the results from the mentioned survey, which show the crucial role of government and environmental regulations in shaping sustainable practices. Furthermore, commitment by professionals and stakeholders is essential in driving sustainability. A study from the International Journal of Project Management elucidates the importance of stakeholder engagement in sustainable project management, emphasizing the crucial role of effective communication, collaboration, and commitment from all relevant parties (Martinsuo & Killen, 2014). This supports the survey's findings that stakeholder commitment is an influential factor in implementing sustainable measures.

Health and wellbeing of occupants have also been recognized as a significant factor in sustainability research. Buildings, for example, can have a massive impact on occupants' health and wellbeing. The International Journal of Environmental Research and Public Health published an article emphasizing the importance of considering occupants' health and wellbeing in designing and building sustainable structures (MacNaughton et al., 2016). These findings align with the survey's result, which underscores the significance of prioritizing the health and wellbeing of occupants in sustainable projects. Finally, resource conservation and waste reduction play a pivotal role in driving sustainability across different sectors. Waste Management & Research published an article highlighting the importance of efficient waste management in supporting sustainable urban systems (Kennedy & Hoornweg, 2002). These results are consistent with the survey findings, which rank resource conservation and waste reduction as influential factors in promoting sustainable practices.

Among the driver groups, owners' the last three drivers are commitment to sustainability received a mean score of 3.265, indicating that respondents perceive it as relatively less influential compared to higher-ranked factors. Similarly, Ethics and behavioral change with mean score (3.429). Furthermore, reduced risk and liability obtained the lowest mean score of 3.021, indicating that respondents perceive it as the least influential factor in driving sustainability efforts.

Table 4.21: The mean scores of drivers for implementing sustainable practices during the physical construction stage

Driver group	N	Mean	Std. Deviation	Rank
Regulations by the Government	49	4.367	0.859	1
Environmental regulations and compliance	49	4.245	0.804	2
Health and wellbeing of occupants	49	3.898	0.941	3
Resource conservation and waste reduction	49	3.776	0.771	4
Introducing green objectives early	49	3.755	0.723	5
Use of integrated approach	49	3.735	0.638	6
Education and training programs by academicians	49	3.653	1.147	7
Public awareness	49	3.592	0.977	8
Corporate social responsibility and ethical considerations	49	3.551	0.647	9
Employee engagement and retention	49	3.531	0.819	10
Cost savings and efficiency	49	3.510	0.794	11
Client demand and market differentiation	49	3.469	0.892	12
Client's awareness and knowledge	49	3.429	0.957	13
Ethics and behavioral change	49	3.429	0.957	13
Owners' commitment to sustainability	49	3.265	1.016	14
Reduced risk and liability	49	3.021	1.000	15

4.6.2 Model application

Table (4.22) provides an overview of these mean score values and their corresponding weights for the different driver's groups. For the economic drivers, the total mean score is 13.7, and the weight assigned to the economic driver group is 0.235. This indicates the relative importance of economic factors in driving sustainability efforts. Regarding the environmentally driven factors, the total mean score is 16.1, and the environmental driver group weight is 0.276. This weight reflects the significance of environmental considerations in promoting sustainable practices. Lastly, the social driver exhibits a total mean score of 28.6, and the corresponding weight for the social driver group is 0.489. This highlights the high importance placed on social aspects in driving sustainability initiatives. These weights provide a basis for developing the membership function, which further quantifies the impact of each sustainable practice within their respective sustainability groups.

Table 4.22: Weighting each driver group

Driver Group	MS	Weighting of Driver	MS of Driver Group	Weighting of Driver Group
Cost savings and efficiency	3.51	0.256		
Use of integrated approach	3.735	0.273		
Reduced risk and liability	3	0.219		
Owners' commitment to sustainability	3.45	0.252		
Economic sustainable practice			13.7	0.235
Client demand and market differentiation	3.469	0.121		
Corporate social responsibility and ethical considerations	3.551	0.124		
Client's awareness and knowledge	3.429	0.120		
Employee engagement and retention	3.531	0.124		
Health and wellbeing of occupants	3.898	0.137		
Education and training programs by academicians	3.653	0.128		
Ethics and behavioral change	3.429	0.120		
Public awareness	3.592	0.126		
Social driver			28.6	0.489
Environmental regulations and compliance	4.245	0.263		
Regulations by the Government	4.367	0.271		

Resource conservation and waste reduction	3.776	0.234		
Introducing green objectives early	3.755	0.233		
Environmentally driver			16.1	0.276
Total			58.4	

Before proceeding with the construction of the membership function (MF) for fuzzy modeling, an initial assumption was made regarding the hierarchical structure. It was determined that the second level consists of three driver groups, while the third level comprises a total of 16 individual drivers. The MF for the second level was established first, followed by an analysis of the MF for the first level. To develop the MF for each driver variable, ratings provided by 49 respondents were taken into account. These ratings helped establish the membership functions, which quantify the degree of membership or importance of each driver variable within the fuzzy modeling framework. Detailed information and the specific MFs for the first and second level drivers during the physical construction stage of a building can be found in (Appendix G). This section presents a comprehensive overview of the MFs and their associated characteristics for further analysis and interpretation.

Table 4.23: Drivers of implementing sustainable practice during physical construction stage

Drivers	**DI**	**Coefficients**	**Rank**
Economic Drivers	3.316	0.322	3
Environmentally Drivers	3.411	0.331	2
Social Drivers	3.573	0.347	1
Total	10.3		
Driver	3.459		

The data presented in Table (4.23) provides an index that showcases the relative strengths of different drivers. The analysis reveals that the social driver exhibits the highest coefficient of 0.347, indicating its significant impact on the overall analysis. Following closely is the environmental driver, with a coefficient of 0.331, suggesting its substantial influence in driving sustainability. The economic driver, ranked third, has a coefficient of 0.322, highlighting its notable contribution to the overall analysis. These coefficients offer insights into the relative strengths and importance of each driver, providing valuable information for further analysis and decision-making in the context of sustainability.

4.6.2.1 Social drivers

The social driver comprises eight variables with significant influence on sustainability. These variables and their factor loadings are: client demand and market differentiation (0.642), corporate social responsibility and ethical considerations (0.776), client's awareness and knowledge (0.815), employee engagement and retention (0.896), health and wellbeing of occupants (0.745), education and training programs by academicians (0.695), ethics and behavioral change (0.815), and public awareness (0.783). These variables highlight the importance of customer preferences, ethical conduct, informed clients, employee involvement, occupant health, education, ethics, and public awareness in driving sustainable practices. Together, they demonstrate the multifaceted nature of sustainability and the diverse factors that contribute to its achievement. In a similar study, Matar, Kansara, and Srivastava (2021) investigated the development of sustainable building practices in the Middle Eastern countries. They pointed out the importance of the social dimension in promoting the adoption of sustainable building practices in the region. Their findings support the claims made in the article under discussion, particularly emphasizing the role of public awareness, occupants' health and wellbeing, and ethical considerations.

4.6.2.2 Environmental drivers

The environmental driver comprises four influential variables: environmental regulations and compliance (loading factor: 0.783), regulations by the government (loading factor: 0.798), resource conservation and waste reduction (loading factor: 0.817), and introducing green objectives early (loading factor: 0.759). These variables emphasize the importance of adhering to regulations, government involvement, efficient resource management, waste reduction, and early integration of environmentally friendly objectives to drive sustainability efforts. in comparison with other related journals, the study of the environmental driver and its variables aligns with the growing focus on sustainability and environmental protection. For instance, in the Journal of Cleaner Production (Rizwan Raheem Ahmed et al., 2020), the authors identified similar variables, such as environmental regulations, resource efficiency, and early incorporation of green objectives in driving sustainability efforts in the manufacturing industry. The loading factors in the study were consistent with the previously mentioned findings, indicating the importance of each variable in driving environmental sustainability.

4.6.2.3 Economic drivers

The economic driver comprises four influential variables that contribute to sustainability efforts. These variables and their corresponding factor loadings are as follows: cost savings and efficiency (factor loading: 0.68), use of an integrated approach (factor loading: 0.8), reduced risk and liability (factor loading: 0.673), and owners' commitment to sustainability (factor loading: 0.788). These variables highlight the significance of achieving cost savings and operational efficiency, adopting an integrated approach, mitigating risks and liabilities, and emphasizing the commitment of owners to sustainability. Collectively, these variables within the economic driver play a vital role in driving sustainable practices and promoting long-term economic sustainability. Related study by Fauzi and Othman (2015) examined the role of sustainability drivers in Malaysia's construction industry. The researchers identified similar factors, such as cost savings, risk management, and owner's commitment to sustainability, that contribute to the facilitation and implementation of sustainability practices. This study further supported the importance of an integrated approach, which the authors considered a key success factor in promoting sustainable development.

4.6.3 Inferential analyses

In this section, the data collected is subjected to inferential analysis. The purpose of this analysis is to examine the relationships between the independent variables and the dependent variable. To achieve this, the researcher utilizes correlation and regression analysis techniques.

Correlation analysis is employed to assess the strength and direction of the relationships between the independent variables and the dependent variable. It provides insights into the degree of association between these variables. Correlation coefficients, such as Pearson's correlation coefficient, are calculated to determine the extent to which changes in one variable correspond to changes in another. Additionally, multiple regression analysis is performed to further explore the relationship between the independent variables and the dependent variable. This analysis enables the researcher to understand how much of the variance in the dependent variable can be explained by the independent variables collectively. The multiple regression model estimates the impact and contribution of each independent variable while considering the effects of other independent variables. The primary aim of the regression analysis is to ascertain the extent to which the independent variables explain or predict the dependent variable. It provides valuable insights into the relative importance and significance of each independent variable in influencing the dependent variable. The regression coefficients, significance levels, and goodness-of-fit measures, such as R-squared, are examined to assess the strength and statistical significance of the relationship.

4.6.3.1 Correlation analyses

Correlation is a statistical measure that quantifies the strength and direction of the linear relationship between two variables. The correlation coefficient, ranging from -1 to 1, provides a numerical representation of this relationship. When the correlation coefficient value is closer to the absolute value of 1, it indicates a stronger relationship. A value closer to 1 suggests a strong positive correlation, meaning that as one variable increases, the other variable also tends to increase. Conversely, a value closer to -1 signifies a strong negative correlation, where as one variable increases, the other variable tends to decrease. On the other hand, when the correlation coefficient value is closer to 0, it suggests a weak or no linear relationship between the variables. In such cases, changes in one variable do not have a significant impact on the other variable. According to(Imai, Keele, & Yamamoto, 2010), correlation coefficients are commonly used to assess the size of an effect. Values around ± 0.1 indicate a small effect size, ± 0.3 represent a medium effect size, and ± 0.5 indicate a large effect size. These effect sizes provide an understanding of the magnitude and practical significance of the relationship between the variables.

Table 4.24: Correlation matrix between dependent and independent variables

Correlations				
		Sustainable practice	driver	Barrier
Sustainable practice	Pearson Correlation	1	.844**	. -679**
	Sig. (2-tailed)		.000	.000
	N	49	49	49
driver	Pearson Correlation	.844**	1	. -485**

	Sig. (2-tailed)	.000		.000
	N	49	49	49
barrier	Pearson Correlation	. -679**	. -485**	1
	Sig. (2-tailed)	.000	.000	
	N	49	49	49
**. Correlation is significant at the 0.01 level (2-tailed).				

The correlation results indicate the relationships between sustainable practices, drivers, and barriers. The analysis reveals a strong positive correlation between sustainable practice and driver (0.844**), suggesting that as the drivers of sustainable practices increase, the level of implementation also tends to increase. Additionally, there is a strong negative correlation between sustainable practice and barrier (-0.679**), indicating that as barriers decrease, the implementation of sustainable practices tends to increase. Furthermore, a moderate negative correlation (-0.485**) exists between driver and barrier, implying that as the drivers of sustainable practices increase, the barriers to implementation tend to decrease. These findings suggest that addressing barriers and enhancing drivers can have a positive impact on the implementation of sustainable practices. However, without additional information on the specific variables being measured, it is important to consider the context and limitations of the study.

4.6.3.2 Results of the regression analysis

The data collected from the participants was utilized for the inferential analysis in this study. The researcher employed multiple regression analysis to examine and forecast the influence of challenging factors, treated as independent variables, on the dependent variable. This regression analysis was conducted to determine the extent to which the independent variables account for the variance in the dependent variable. A regression analysis was performed to investigate the relationship between the factors influencing the implementation of sustainable practices. The independent variables included barrier and driver, while the dependent variable was the level of sustainable practice. The aim of this regression analysis was to examine how the independent variables, barrier and driver, impact the dependent variable, sustainable practice.

The SPSS-generated data in Table (4.4), reveals that the calculated coefficient of Cronbach's Alpha for this study exceeded 0.7 for all variables. This finding confirms that the variables demonstrate a high level of internal consistency. In other words, the questionnaire items within each variable are closely related to one another, indicating that they measure the same underlying construct reliably.

Regression analysis model summery

In a multiple regression model, the R-squared value is determined by examining the pairwise correlations among all the variables, including the correlations between the independent variables themselves (barrier and driver) and their correlations with the dependent variable (Sustainable practice). The multiple correlation coefficient (R) quantifies the strength of the relationship between the dependent variable (Sustainable practice) and the two predictor variables (barrier and driver) included in the regression equation as factors influencing the adoption and implementation of sustainable building practices. A higher value of the multiple R indicates a stronger correlation between the predicted values and the observed values of the outcome variable. When the multiple R is equal to 1, it signifies a situation in which the model perfectly predicts the observed data. This means that all the variability in the dependent variable is accounted for by the independent variables (barrier and driver) in the model (Field, 2009).

Adjusted R-squared is a metric that measures the reduction in predictive power or shrinkage in a regression model. It provides an indication of the proportion of variance in the outcome variable that would be explained if the model were derived from the entire population rather than just a sample. The adjusted R-squared value is always smaller than the regular R-squared value. The difference between the two is typically minimal, unless the model is attempting to estimate an excessive number of coefficients from a small sample size in the presence of substantial noise(Field, 2009).

Table 4.25: Model Summary table

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.899[a]	.807	.799	.516
a. Predictors: (Constant), barrier, driver				
b. Dependent Variable				

Based on the data generated by SPSS, the adjusted R-squared (coefficient of determination) reveals that 79.9% of the variance in the sustainable building projects can be explained by the two independent variables studied. This indicates a substantial proportion of the factors influencing the implementation of sustainable practice of building projects. However, it is important to note that there are still other factors, accounting for 21.1% of the variance, that have not been included in the current analysis. Therefore, further research is recommended to investigate and understand these additional factors that may impact the implementation of sustainable practice of building projects.

Coefficients of regression analysis

The table provides information regarding the contributions of the predictors, namely "barrier" and "driver," to our understanding of the dependent variable, "Sustainable practice implementation" (Y). It presents the coefficients and their corresponding significance levels, allowing us to assess the significance of each predictor's impact on the dependent variable. The coefficients, expressed as standardized regression coefficients (beta), indicate the strength and direction of the relationship between each predictor and the dependent variable. A positive beta coefficient indicates a positive relationship, while a negative beta coefficient indicates a negative relationship. The magnitude of the coefficient reflects the relative importance of the predictor in explaining the variation in the dependent variable. The significance level associated with each coefficient informs us about the statistical significance of the predictor's contribution. It represents the probability of observing the estimated coefficient by chance alone, assuming that there is no true relationship between the predictor and the dependent variable. A lower significance level, typically below 0.05, indicates a higher level of statistical significance, suggesting that the predictor's contribution is unlikely to be due to random chance. By examining the coefficients and their significance levels in the table, we can determine which predictors, "barrier" and "driver," have made statistically significant contributions to our understanding of "Sustainable practice implementation" (Y).

Table 4.26: Coefficient Table for regression analysis

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	19.256	5.040		3.820	.000
	driver	.963	.106	.673	9.095	.000
	barrier	. - 515	.108	.353	4.767	.000

As mentioned previously, the researcher performed a multiple regression analysis to examine the relationship between the independent variables and the dependent variable. The purpose of this analysis was to determine the extent to which the independent variables explain the variation in the dependent variable. The model used to demonstrate this influence is expressed as follows:

Based on chapter 3 (equation 6), β0 represents the intercept term (19.256), β1 represents the coefficient for the variable X1 (driver) (0.963), β2 represents the coefficient for the variable X2 (barrier) (0.515), and ε represents the error term (0.516). This equation shows how the values of the independent variables (X1 and X2) influence the value of the dependent variable (Y). By plugging in the respective values of X1 and X2 into the equation, we can estimate the corresponding value of Y.

In this study, the variable "driver" has the highest beta coefficient of 0.936, indicating a strong relationship with the implementation of sustainable practices in building projects. A higher beta coefficient suggests that changes in the "driver" variable have a greater impact on the outcome variable compared to other predictors. On the other hand, the variable "barrier" has a beta coefficient of -0.515, which is slightly lower than the coefficient for "driver." Nevertheless, it still indicates a significant relationship between "barrier" and the implementation of sustainable practices in building projects. Based on these findings, it can be concluded that "driver" has the strongest influence on sustainable building projects among the independent variables examined, followed by "barrier." These results offer valuable insights into the most influential factors that impede the adoption of sustainable building practices.

4.7 Conceptual Farmwork for Effective Implementation of Sustainable Practice

4.7.1 Introduction

Sustainable practice implementation framework can be seen as a comprehensive roadmap that provides a structured approach for assessing and implementing sustainable practices during the physical construction stage of a building.

The framework's first section outlines the development of policy and strategy positioning, which involves referencing various advisory documents at the global, regional, national, and local levels. In addition, both internal and external stakeholders play a crucial role in the development of the policy and strategy for sustainable practice implementation during the physical construction stage. This section of the framework also includes an analysis of the organization's existing policies and procedures to determine any gaps that may exist between the current practices and the desired sustainable practices. This is followed by an identification of the key goals and objectives for sustainable practice implementation in the physical construction stage. The second section of the framework provides an action plan for achieving sustainable practices during the physical construction stage. This includes identifying the sustainable building aims and objectives, sustainable building construction practices, and establishing priority levels for implementing these practices. This section also involves identifying the necessary resources and personnel needed for the implementation of sustainable practices.

The third section of the framework outlines the sustainable practice implementation issues that companies need to evaluate themselves on. This includes assessing the effectiveness of their current sustainable practices, identifying areas for improvement, and selecting sustainable practices that are appropriate for their specific project. This section also involves identifying the barriers and drivers that affect sustainable practice implementation during the physical construction stage. The final section of the framework focuses on the application and implementation phase, which includes measures for tracking the benefits of sustainable practices in construction. This involves categorizing the benefits into environmental, economic, and social categories and identifying appropriate metrics for tracking progress. This section also includes ongoing monitoring and evaluation of the sustainable practices to ensure their continued effectiveness and refinement.

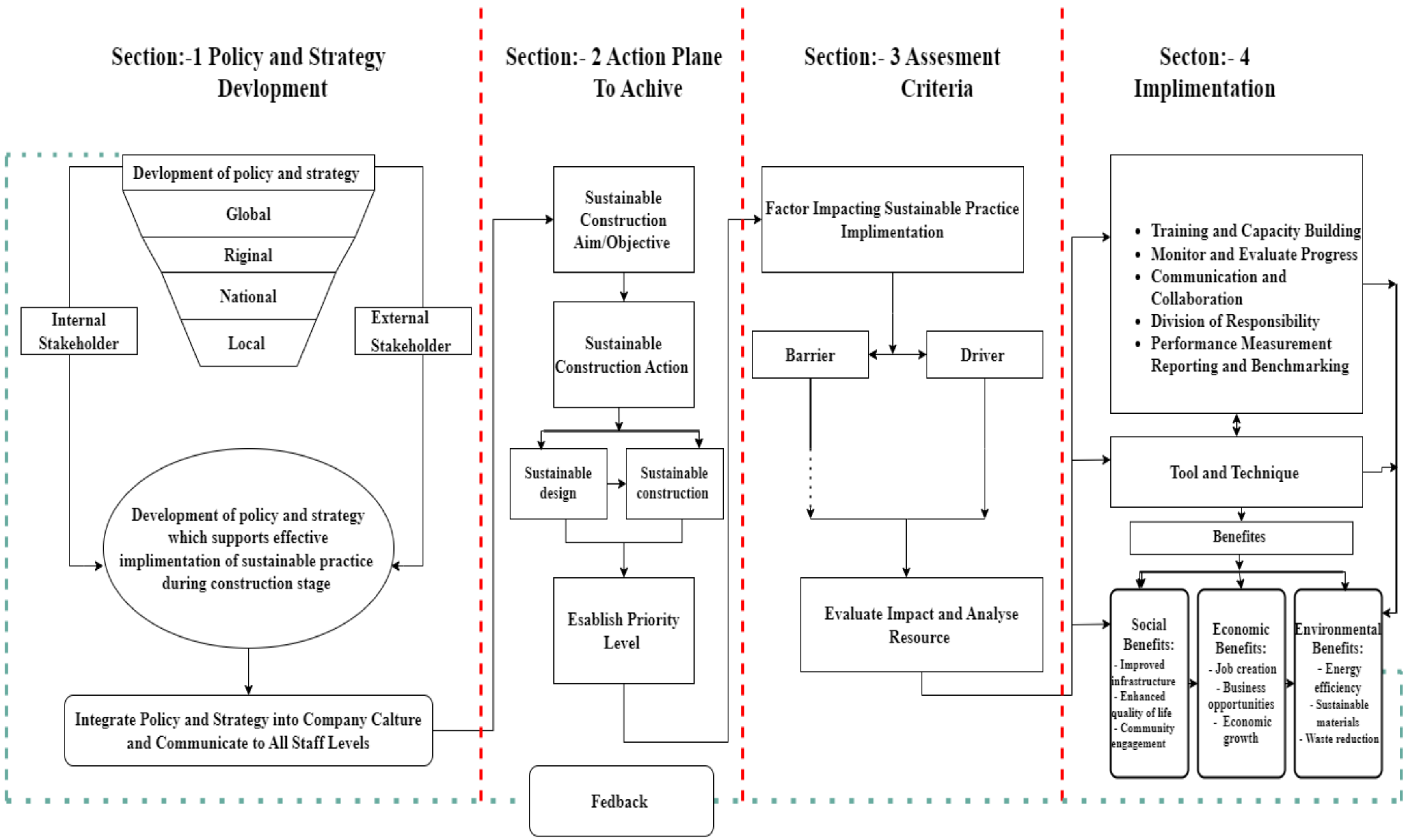

Figure 4.1. Proposed Conceptual Framework for Effective Implementation of Sustainable Practice

4.7.2 Policy and strategy development

Based on Agenda 21 on sustainable construction (Du Plessis, 2002), it appears that the primary driving forces for sustainable construction are likely to remain external to the construction industry. As a result, the first section of the framework addresses the broader contextual factors that used to develop policy and strategy for the adoption and implementation of sustainable construction at the project level.

To develop effective policies and strategies for sustainable construction during the physical construction stage, it is important to consult a range of advisory documents that provide guidelines and recommendations on sustainable construction practices. These advisory documents may include global, regional, national, and local guidelines, regulations, and standards that are relevant to the specific context of the construction project. A literature review conducted by Khalid et al. (2018) highlighted the importance of referencing global, regional, national, and local advisory documents in the development of policies and strategies for sustainable construction. The authors emphasized that these documents can provide valuable information on best practices and regulations that can be adopted to improve the sustainability of a construction project.

For example, global documents such as the United Nations Sustainable Development Goals (SDGs) and the World Green Building Council's Net Zero Carbon Buildings Commitment can provide guidance on sustainability targets and goals for the construction industry. Regional documents such as the European Union's Energy Performance of Buildings Directive (EPBD) can provide guidance on energy efficiency standards and regulations for buildings. National and local advisory documents such as building codes, energy efficiency regulations, and sustainability certifications can provide guidance on specific requirements and standards for sustainable construction practices. These documents can be used as a reference point for developing policies and strategies that align with local requirements and promote sustainability.

In Ethiopia, the government has recognized the importance of sustainable construction and has developed several policy and strategy documents to guide its implementation. The Ethiopian government has prioritized sustainable construction as part of its green growth strategy, which aims to promote sustainable development while reducing carbon emissions and mitigating the effects of climate change. One of the key policy documents in Ethiopia is the Ethiopian Building Code Standard (EBCS), which provides guidelines and standards for sustainable construction practices. The EBCS includes provisions for energy efficiency, water conservation, waste management, and indoor environmental quality, among other sustainable practices.

In addition to the EBCS, Ethiopia has also developed the Ethiopian Climate Resilient Green Economy (CRGE) strategy, which includes a focus on sustainable construction practices. The CRGE strategy aims to promote sustainable building design, reduce energy consumption, and increase the use of renewable energy sources in the construction sector. There are also several initiatives by non-governmental organizations and private sector actors in Ethiopia that focus on sustainable construction practices. For example, the Ethiopian Green Building Council (ETGBC) is a non-profit organization that aims to promote sustainable building practices in Ethiopia through advocacy, education, and research.

4.7.2.1 Role of internal and external stakeholders'

The development of policies and strategies for the effective implementation of sustainable construction practices during the physical construction stage of a building involves the participation of both internal and external stakeholders. Internal stakeholders refer to individuals or groups within the construction industry itself, such as construction companies, architects, engineers, and contractors. Their role in policy and strategy development may include providing technical expertise and guidance on sustainable construction practices, implementing sustainability measures within their own organizations, and ensuring that sustainable practices are adhered to during the construction process.

On the other hand, external stakeholders are those with a stake in sustainable building but are not part of the construction industry, such as governmental organizations, non-governmental organizations, neighborhood associations, and citizens. Their role may involve advocating for sustainable construction policies and regulations, providing financial incentives or support for sustainable construction projects, and ensuring that the construction process aligns with broader sustainability goals at the community or regional level. The creation and execution of sustainable building policies and plans may benefit greatly from the involvement of both internal and external stakeholders. Together, they can make sure that sustainable practices are included into every stage of the building process, from planning and design to sourcing materials and construction methods, leading to more resilient and sustainable built environments.

Therefore, having a clear understanding of the different global, national, and local contexts, as well as the role of stakeholders, is essential for effectively implementing sustainable construction practices during the physical construction stage of a building. In order to achieve the goals of sustainable construction, it is important to assign a designated person who will be responsible for identifying and aligning all the necessary requirements. This person could be the project director, procurement manager, or an expert in sustainable construction from the client's side. The responsible party should also disseminate relevant policies and regulations on sustainable construction to project stakeholders, in order to provide clarity on contextual factors. Keeping up-to-date records of policies and regulations and circulating them when changes occur is crucial to overcoming issues related to disagreements between the client, design team, and contractor on guidelines and regulations used in designing the facility, particularly during the physical construction stage.

4.7.3 Action plane to achieve sustainable construction

The second section of the framework offers guidance on how to achieve sustainable construction. The aim of sustainable construction actions is to increase the sustainability of building projects and reduce their environmental impact by implementing specific practices during the physical construction stage. These actions cover areas such as energy efficiency, water conservation, waste reduction, sustainable materials, and indoor environmental quality, and can be prioritized based on their potential impact, feasibility, and cost-effectiveness. Implementing these sustainable construction actions can significantly reduce the environmental impact of building projects, resulting in a healthier and more sustainable built environment.

4.7.3.1 Aim/objective sustainable construction

Sustainable construction aims and objectives refer to specific goals that construction projects set to achieve sustainability, which is becoming an increasingly important consideration in the construction industry. In recent years, there has been a growing awareness of the environmental, social, and economic impacts of construction activities, and sustainable construction has emerged as a way to mitigate these impacts. One of the most commonly cited aims of sustainable construction is to reduce environmental impact. This involves minimizing energy and water consumption, reducing waste generation and promoting recycling, using sustainable and eco-friendly materials, and designing buildings that are energy-efficient and have a low carbon footprint (Jain et al., 2020; Lin et al., 2017). Sustainable construction can also aim to promote social equity by ensuring that everyone has access to safe and healthy housing and work environments. This could involve designing buildings that are accessible to people with disabilities, incorporating green spaces and community areas in building designs, and creating job opportunities for local communities (Diaz-Lopez et al., 2019; Tam et al., 2019).

Another objective of sustainable construction is to ensure economic prosperity by supporting local businesses, creating jobs, and contributing to the local economy. This could involve using locally sourced materials, hiring local workers and contractors, and supporting the development of local supply chains (Carter et al., 2020; Ni et al., 2019). Sustainable construction can also aim to improve indoor environmental quality by providing a healthy and comfortable living and working environment for building occupants. This could involve using low-emission materials, designing buildings that have good ventilation and natural lighting, and ensuring proper maintenance and cleaning of buildings (Haque et al., 2021; Wu et al., 2020). Overall, sustainable construction aims and objectives are critical for guiding construction projects towards sustainability. By setting specific goals, construction teams can focus their efforts on the most important areas and track progress towards sustainability over time.

4.7.3.2 Sustainable construction action

To effectively implement sustainable practices during construction, sustainable design should be considered from the initial design phase. This involves incorporating eco-friendly principles, using renewable materials and systems, and aiming for green building certifications. By aligning the project with sustainability goals, we can create a greener built environment. Additionally, during the physical construction stage, specific actions can be taken to enhance sustainability, such as promoting energy efficiency, water conservation, waste reduction, sustainable materials, and indoor environmental quality. By using energy-efficient materials, low-flow plumbing fixtures, recycled materials, and proper ventilation, the environmental impact of the project can be minimized, resulting in increased sustainability.

The design phase of a construction project is a crucial stage where sustainability practices are put into action and transformed into practical design elements and strategies. This phase is dedicated to integrating sustainable design principles throughout the project. These principles can include passive design techniques, energy efficiency measures, water conservation strategies, and improvements in indoor environmental quality. During the design phase, careful consideration is given to selecting materials and systems that align with sustainability goals. This involves choosing eco-friendly and sustainable materials, as well as implementing energy-efficient systems and technologies. The aim is to minimize the environmental impact of the project and ensure long-term sustainability.

Performance evaluations are conducted during the design phase to assess the environmental impact of the proposed design and identify opportunities for improvement. This may involve analyzing energy consumption, evaluating daylighting and ventilation strategies, and assessing other factors that affect the project's sustainability. Furthermore, the design phase often includes efforts to meet recognized green building certifications. These certifications, such as LEED or BREEAM, provide guidelines and benchmarks for incorporating sustainability practices into the design and construction process. By striving for compliance with these certifications, construction projects can demonstrate their commitment to sustainable practices and contribute to a greener built environment.

Sustainable construction actions are specific practices and measures that can be implemented during the physical construction stage to increase the sustainability and reduce the environmental impact of a building project. These actions can be grouped into several categories, including energy efficiency, water conservation, waste reduction, sustainable materials, and indoor environmental quality (Khalid et al., 2018; Yang et al., 2020). Energy efficiency measures can be achieved by using energy-efficient building materials, installing energy-efficient HVAC systems, using energy-efficient lighting, and designing buildings to optimize natural lighting and ventilation. These practices can significantly reduce energy consumption and greenhouse gas emissions. Water conservation measures include using low-flow plumbing fixtures, collecting and reusing rainwater, designing landscaping to minimize irrigation, and using water-efficient building materials. These practices can reduce water consumption and protect local water resources.

Waste reduction measures include using recycled and recyclable building materials, implementing waste management plans to minimize waste generation, and designing buildings for deconstruction to facilitate recycling and reuse of building materials. These practices can significantly reduce the amount of waste generated by a construction project. Sustainable materials refer to building materials with a low environmental impact. This could involve using locally sourced and recycled materials, choosing materials that have a low environmental impact, and avoiding materials that are toxic or harmful to the environment and human health (Khalid et al., 2018; Yang et al., 2020). These materials include locally sourced materials to reduce transportation emissions, renewable materials such as bamboo or straw bale construction, and materials with a low VOC emission, such as low VOC paints and finishes. These practices can reduce the environmental impact of building materials and improve the sustainability of a construction project.

Indoor environmental quality measures include using materials with low VOC emissions, providing adequate ventilation to improve indoor air quality, and designing buildings to optimize natural lighting and reduce glare. These practices can improve the indoor environmental quality of a building and promote the health and well-being of its occupants. Implementing these sustainable construction actions can significantly reduce the environmental impact of a building project and increase its sustainability. Construction teams can prioritize these actions based on their potential impact, feasibility, and cost-effectiveness to ensure that resources are effectively allocated towards the most important areas (Khalid et al., 2018; Yang et al., 2020).

4.7.3.3 Establish priority level for sustainable construction action

Establishing priority levels for sustainable construction actions is an important step in ensuring that resources are effectively allocated towards the most important areas. The process of establishing priority levels involves ranking the identified actions based on their importance, feasibility, and impact on sustainability.

Importance refers to the degree of significance of the action in terms of its contribution towards achieving sustainable construction goals. This includes considering the potential environmental, social, and economic impacts of the action. Feasibility refers to the practicality and ease of implementation of the action. This includes considering factors such as cost, availability of resources, and the technical expertise required. Impact on sustainability refers to the degree to which the action will contribute to improving the sustainability of the construction project. This includes considering the potential environmental, social, and economic benefits of the action.

Once the identified actions are ranked based on these criteria, the next step is to prioritize the actions that need to be taken first, based on their importance and impact on sustainability. This helps in ensuring that the most impactful actions are given priority and that resources are effectively allocated towards achieving sustainable construction goals.

4.7.4 Assessment criteria of sustainable practices

The third section of the conceptual framework for effective implementation of sustainable practices during the physical construction stage of building includes assessment criteria, which are divided into three categories: barriers, drivers, and evaluation of impacts and resource analysis.

4.7.4.1 Barriers for implementation of sustainable practice

Barriers are factors that hinder or impede the implementation of sustainable practices in construction. These can be organizational, economic, technical, or regulatory in nature, and can create challenges for construction professionals seeking to adopt sustainable practices.

One of the most significant barriers is the lack of awareness and education about sustainable practices among construction professionals, which can lead to a lack of understanding and buy-in from stakeholders (Lopez-Arquillos et al., 2016). Another common barrier is the perception that sustainable practices are too costly, particularly in the short-term, and that the return on investment is unclear (Abidin et al., 2017). Regulatory barriers can also be a challenge, particularly when regulations do not mandate or incentivize sustainable practices, or when regulations are inconsistent or unclear (Feng et al., 2016). Additionally, lack of access to sustainable materials, technologies, and suppliers can pose a barrier to implementation (Cheung et al., 2017). Finally, a lack of collaboration and communication among stakeholders can also impede the implementation of sustainable practices, particularly when different stakeholders have different priorities and values (Jiang et al., 2016). This can lead to conflicts and misunderstandings, and hinder the development of effective sustainable practices.

4.7.4.2 Drivers for implementation of sustainable practice

In the context of sustainable construction, drivers refer to the factors that motivate or encourage the implementation of sustainable practices during the construction stage of a building project. Drivers can come from various sources, such as regulatory requirements, market demand, social responsibility, and environmental concerns. According to a study by Bribián et al. (2017), the drivers of sustainable construction can be classified into three categories: internal drivers, external drivers, and stakeholder drivers.

Internal drivers are those that come from within the organization or project team, such as the commitment to sustainability goals and values, the desire to reduce operational costs, and the pursuit of innovation and competitive advantage. External drivers are those that come from outside the organization or project team, such as regulatory requirements, green building rating systems, and market demand for sustainable buildings. Stakeholder drivers are those that come from the stakeholders involved in the building project, such as clients, investors, and communities. These drivers may include the desire for social responsibility, public relations, and long-term value creation. Overall, drivers play an important role in promoting the implementation of sustainable construction practices, as they provide the motivation and support needed to overcome barriers and achieve sustainability goals

4.7.4.3 Evaluation of impacts and resource analysis

Evaluation of impacts and resource analysis is an important aspect of the conceptual framework for the effective implementation of sustainable practices during the physical construction stage of building. This involves assessing the effectiveness of sustainable construction practices in achieving their intended goals and evaluating the resources required for their implementation. To evaluate the impacts of sustainable construction practices, it is necessary to analyze their impact on energy consumption, water use, waste generation, and indoor air quality. For example, by using energy-efficient lighting systems and appliances, the energy consumption of a building can be significantly reduced, resulting in lower greenhouse gas emissions and cost savings for the occupants.

Resource analysis is also an essential component of the evaluation process. This involves evaluating the availability and cost of sustainable building materials, the skills and expertise of the construction team, and the financial resources required for implementation. For example, the availability and cost of sustainably sourced wood or recycled building materials can impact the decision to use them in a construction project. By conducting a thorough evaluation of impacts and resource analysis, stakeholders can make informed decisions about the most effective sustainable construction practices to implement in their projects, taking into account the potential impact, feasibility, and cost-effectiveness of each practice. This can result in more efficient use of resources and improved environmental outcomes

4.7.5 Implementation of sustainable practice

The fourth and final section of the conceptual framework for effective implementation of sustainable practices during the physical construction stage of building focuses on the implementation stage itself. This section is divided into three categories: tasks executed during the implementation stage, tools and techniques to aid implementation, and the benefits gained from implementation.

4.7.5.1 Tasks executed during the implementation stage

The importance of the first category of tasks in the implementation stage of sustainable construction is highlighted by Liu et al. (2021), who note that these tasks are essential for effective implementation of sustainable construction practices. Training and capacity building, monitoring and evaluation of sustainable construction performance, communication and collaboration among all stakeholders, division of responsibilities among project participants, and performance measurement, reporting, and benchmarking of sustainable practices are all important activities that contribute to the success of sustainable construction projects.

Training and capacity building are necessary to ensure that all members of the construction team have the necessary knowledge and skills to implement sustainable practices effectively. This can be achieved through training on a range of topics such as energy efficiency, water conservation, and waste reduction. Effective training and capacity building enable the construction team to work together towards sustainability goals and ensure that sustainable practices are implemented successfully. Monitoring and evaluating progress is essential for ensuring that sustainable practices are being implemented as planned and making any necessary adjustments. Regular site visits can help to identify areas where improvements can be made, and progress can be tracked towards sustainability goals. By monitoring progress, the construction team can identify areas for improvement and make the necessary adjustments to achieve sustainability goals.

Communication and collaboration are important for effective implementation as they ensure that all stakeholders are informed and involved in the process. Regular meetings and updates with stakeholders can help to ensure that everyone is aware of sustainability goals and their role in achieving them. Effective communication and collaboration are crucial for successful implementation of sustainable practices. Division of responsibility is important to ensure that all parties involved understand their roles and responsibilities in implementing sustainable practices. Clearly defining roles and responsibilities can ensure that everyone is aware of what is expected of them. By promoting division of responsibility, the construction team can ensure that everyone is accountable for their part in the sustainability goals and that the implementation of sustainable practices is effective.

Performance measurement, reporting, and benchmarking are crucial for tracking progress and evaluating the success of the implementation. Regular measurement and reporting of metrics such as energy consumption, water use, waste generation, and indoor air quality can help to track progress towards sustainability goals. Benchmarking progress against industry standards can help to identify areas for improvement and ensure that the construction team is continuously working towards achieving sustainability goals.

4.7.5.2 Tool and technique for achieving sustainable practice

The second category of the conceptual framework for sustainable construction focuses on the tools and techniques that can aid in the implementation of sustainable practices. As Liu et al. (2021) noted, "these can include sustainable building certifications such as Leadership in Energy and Environmental Design (LEED) or Building Research Establishment Environmental Assessment Method (BREEAM), as well as tools for energy modeling, life cycle assessment, and building information modeling (BIM)".

Sustainable building certifications such as LEED or BREEAM provide a framework for implementing sustainable construction practices by establishing criteria for energy efficiency, water conservation, waste reduction, and the use of sustainable building materials. These certifications can help to guide the implementation of sustainable practices and provide a recognized standard for measuring sustainability performance. Tools such as energy modeling and life cycle assessment can help to identify opportunities for improvement and evaluate the impact of sustainable practices. Energy modeling can simulate the energy consumption of a building and identify areas where energy efficiency can be improved. Life cycle assessment can evaluate the environmental impact of a building throughout its entire life cycle, from construction to demolition.

Building information modeling (BIM) is another tool that can aid in the implementation of sustainable practices. BIM is a digital model that includes information about the physical and functional characteristics of a building. It can be used to simulate and analyze building performance, including energy consumption, water use, and indoor air quality. BIM can also help to identify opportunities for improvement and optimize the design of a building for sustainability. Overall, the tools and techniques in the second category of the conceptual framework for sustainable construction can aid in the implementation of sustainable practices by providing a framework for implementation, identifying opportunities for improvement, and evaluating the impact of sustainable practices.

4.7.5.3 Benefits of implementation of sustainable practice

The implementation of sustainable practices in construction has several benefits that can be classified into three categories: environmental, economic, and social. According to Liu et al. (2021), environmental benefits of sustainable construction practices include the reduction of negative impacts on the environment. Sustainable construction practices such as the use of green building materials, energy-efficient designs, and water conservation techniques can significantly reduce the carbon footprint of buildings. By using sustainable construction practices, the construction industry can reduce its overall environmental impact and contribute to a more sustainable future. From an environmental standpoint, the physical construction stage offers opportunities to implement energy-efficient design and technologies, leading to reduced energy consumption and greenhouse gas emissions. The use of sustainable materials, such as recycled or locally sourced materials, minimizes environmental impact and supports resource conservation. Waste reduction measures, including recycling and proper disposal, can also be incorporated into construction projects, promoting a circular economy and minimizing waste generation.

From an economic perspective, construction projects create job opportunities, stimulating local economies and reducing unemployment rates. These activities also generate demand for materials, equipment, and services, thereby supporting local businesses and industries. Additionally, construction projects contribute to overall economic growth by attracting investments, increasing productivity, and boosting economic output. Economic benefits of sustainable construction practices also identified by Liu et al. (2021) include the reduction of operating costs. Energy-efficient designs and materials, for instance, can reduce energy consumption and operating costs of buildings. Moreover, sustainable practices can enhance the marketability and reputation of buildings, as they are becoming increasingly popular among clients and tenants who are willing to pay a premium for sustainable buildings. This can ultimately lead to increased profitability for developers and building owners.

On the social front, construction plays a vital role in improving infrastructure, enhancing community facilities, and providing better services to residents. By constructing buildings and infrastructure that cater to the needs of the community, the quality of life for residents is enhanced, promoting well-being and satisfaction. Furthermore, construction projects often involve community engagement and consultation, allowing residents to voice their opinions and actively participate in decision-making processes, fostering a sense of ownership and collaboration. Social benefits of sustainable construction practices, as noted by Liu et al. (2021), include the improvement of indoor air quality and occupant health and well-being. Sustainable buildings can provide better indoor air quality, reducing the risk of respiratory diseases and other health problems caused by poor indoor air quality. Sustainable buildings can also increase occupant satisfaction and well-being, leading to improved productivity and performance. Moreover, sustainable construction practices can benefit the local community by providing job opportunities and promoting economic growth. In conclusion, the implementation of sustainable practices in construction can lead to several benefits, including reduced environmental impact, decreased operating costs, improved occupant health and well-being, and enhanced marketability and reputation of buildings. These benefits highlight the importance of sustainable construction practices in achieving a sustainable and equitable future.

4.7.6 Farmwork Evaluation

The effectiveness of implementing sustainable practices during the physical construction stage was assessed through the evaluation of a proposed framework. The framework's evaluation was conducted by obtaining validation from respondents in a research study. To assess the practicality and comprehensiveness of the proposed framework for sustainable practice implementation, close-ended semi-structured questionnaires were developed and administered to a purposively selected group of experts. The selection criteria ensured that the respondents held at least an MSc degree and had a minimum of 5 years of job experience in construction-related fields. Sufficient time was provided to the participants to familiarize themselves with the framework and gain an understanding of its components. The questionnaire consisted of 15 questions designed to gauge their level of agreement with respect to the evaluation aspects of the framework. Please refer to the appendices for a copy of the questionnaire (Appendix B).

Table 4.27: Background of participant for framework evaluation

Code	position	Organization	Educational background	Year of experience
R1	Lecturer	Higher institution for engineering profession	MSc in CoTM	7 years
R2	Higher authority	Ethiopian construction authority	Ph.D.	30 years
R3	Lecturer	Higher institution for engineering profession	Ass professor	16 years
R4	Lecturer	Higher institution for engineering profession	MSc in CoTM	15 years
R5	Higher authority	Ethiopian construction authority	MSc	20 years
R6	Lecturer	Higher institution for engineering profession	MSc in CoTM	6 years

4.7.6.1 Farmwork evaluation analyses of participant response

The participants' background information, as presented in Table 4.27, serves as a basis for their responses regarding the rationale, relevance, workability, and other important considerations or recommendations related to the proposed framework for implementing sustainable practices. The following sections discuss these results, taking into account the participants' feedback on the evaluation questions.

To assess the suitability of the framework for achieving sustainable practice implementation during the physical construction stage, participants were requested to express their agreement levels with the research findings. The aim was to determine whether the framework's stages are appropriate for enhancing sustainability practices in a sustainable manner. The table presented below illustrates the respondents' agreement levels regarding the framework evaluation, based on 15 specific questions.

Table 4.28: Summery of framework evaluation result

No	Questions	Strongly dis agree	Disagree	Neutral	Agree	Strongly agree
1	The framework is logical and well organized.				2	4
2	The framework is clear and easy to understand.				1	5
3	Description of the framework and its layout is comprehensive			1	2	3
4	This framework implementation guide, if followed; will facilitate implementation sustainable practices during the physical construction phase of buildings by government and related organizations"				4	2

5	The framework adequately addresses current sustainability challenges and goals in the construction industry.			2	3	1
6	The framework effectively integrates global, regional, national, and local sustainability guidelines and advisory documents.			1	5	
7	The framework involves and considers the perspectives of internal and external stakeholders in the development of policies and strategies.				2	4
8	The framework provides a clear understanding of the key goals and objectives for sustainable practice implementation during the physical construction stage.			2	4	
9	The framework's action plan for achieving sustainable practices, including building aims, objectives, and priority levels, is comprehensive.				1	5
10	The framework adequately addresses resource and personnel requirements for implementing sustainable practices.				3	3
11	The framework assesses the effectiveness of current sustainable practices and identifies areas for improvement.			1	3	2

12	The framework provides guidance for selecting appropriate sustainable practices specific to each project.			2	4	
13	The framework effectively addresses barriers and drivers that impact sustainable practice implementation in the construction stage.				1	5
14	The framework includes measures for tracking the environmental, economic, and social benefits of sustainable practices, along with suitable metrics and ongoing monitoring and evaluation.				2	4
15	The framework covers all the steps needed to achieve of sustainable practices implementation during the physical construction phase of buildings.			1	3	2

Based on the table (4.28) The expert evaluation results demonstrate that the framework for effective implementation of sustainable practices receives highly positive feedback across multiple dimensions. Firstly, the majority of experts strongly agree that the framework is logical and well organized, with an additional agreement from two experts. This indicates that the framework follows a coherent structure, enhancing its overall effectiveness.

Moreover, the experts find the framework to be clear and easily understandable. five experts strongly agree with this statement, while one expert agree, highlighting the framework's accessibility and the absence of ambiguity in its language and presentation. The comprehensiveness of the framework's description and layout is acknowledged by three experts who strongly agree, along with two experts who agree. However, one expert expresses strong neutrality regarding this aspect. Nevertheless, the majority of experts perceive the framework as comprehensive in its coverage and presentation of information. Regarding the framework's ability to facilitate sustainable practices during the physical construction phase of buildings, four experts agree, while two experts strongly agree. This reveals that the framework provides practical guidance and actionable steps that, if followed, can effectively support the implementation of sustainable practices.

In terms of addressing current sustainability challenges and goals in the construction industry, two experts' express neutrality, three experts agree, and one expert strongly agrees. Although there is some variability in opinions, the majority of experts believe that the framework adequately addresses the industry's sustainability objectives. The framework is also recognized for effectively integrating global, regional, national, and local sustainability guidelines and advisory documents. Five experts agree with this integration, while one expert remains neutral, suggesting that the framework successfully incorporates diverse sustainability guidelines. involvement and consideration of perspectives from both internal and external stakeholders receive strong agreement from four experts and agreement from two experts. This signifies that the framework recognizes the importance of incorporating different viewpoints and engaging relevant stakeholders in sustainable practice implementation.

Furthermore, the experts find that the framework provides a clear understanding of the key goals and objectives for sustainable practice implementation during the physical construction stage. Four experts agree with this assessment, while two experts' express neutrality, indicating that the majority comprehend the framework's intended outcomes. The comprehensive nature of the framework's action plan for achieving sustainable practices receives strong agreement from five experts, with an additional agreement from one expert. This demonstrates that the framework offers detailed and inclusive guidelines for practical implementation. Addressing resource and personnel requirements for sustainable practices is deemed adequate by three experts who agree, along with three experts who strongly agree. This implies that the framework sufficiently considers the necessary resources and personnel to support successful implementation.

When it comes to assessing the effectiveness of current sustainable practices and identifying areas for improvement, opinions vary. Three experts' express neutrality, while one expert remains neutral and two experts strongly agree. While there is no unanimous agreement, a significant number of experts recognize the framework's potential for evaluation and continuous improvement. The framework's ability to provide guidance for selecting appropriate sustainable practices specific to each project is acknowledged by four experts who agree, while two experts remain neutral. This suggests that the framework serves as a valuable tool in making informed decisions about sustainable practices on a project-by-project basis. Furthermore, the framework is praised for effectively addressing barriers and drivers that impact sustainable practice implementation. Strong agreement from five experts, along with agreement from one expert, indicates that the framework takes into account obstacles and enablers, allowing for successful navigation and integration of sustainable practices. The inclusion of measures for tracking the environmental, economic, and social benefits of sustainable practices is recognized by four experts who strongly agree, with an additional agreement from two experts. This highlights the framework's emphasis on monitoring and assessing the outcomes and impacts of sustainable practices.

Finally, the experts generally agree that the framework covers all the necessary steps needed to achieve sustainable practices during the physical construction phase of buildings. Two experts strongly agree, three experts agree, and one expert expresses neutrality. Although opinions differ slightly, the majority of experts acknowledge the framework.

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATION

5.1 Introduction

In this section, a brief summary of the research findings that have been analyzed and discussed in the previous chapter is presented. The culmination of the research findings is outlined, highlighting the key conclusions drawn from the analysis. Moreover, based on the insights obtained from this study, potential recommendations are proposed to address the implications of the findings.

5.2 Conclusion

The main objective of this study was to examine the implementation of sustainability practices in the construction phase of building projects, focusing specifically on federal government budgeted buildings in Addis Ababa. To accomplish this objective, the study identified four specific objectives. The following is a summary of the findings based on the stated objectives of the study.

The first objective of the study was to evaluate the extent to which sustainability practices are implemented during the physical construction stage of buildings. The findings indicated that while several sustainable practices were identified and implemented in the study area, the overall level of implementation was primarily at a low to moderate level. Key sustainable practices that were observed included proper storage and handling of materials, regular inspection and monitoring, collaboration and communication, construction site management, protection of worker health and safety, selecting construction methods for resource conservation, and commissioning and monitoring. The index shows that social sustainability practice has the highest coefficient (0.349) among the various sustainable practices. Economic sustainability practice closely follows with a coefficient of 0.342, and environmental sustainability practice ranks third with a coefficient of 0.309. However, it was evident that there is room for improvement in the implementation of sustainability practices during the construction phase of federal government budgeted buildings in Addis Ababa.

The second objective of the study was to identify the barriers to the implementation of sustainable practices during the physical construction stage of buildings. The findings indicated that several significant barriers existed in the study area. These barriers included a lack of regulations to enforce sustainability, limited availability of suppliers offering sustainable products and materials, insufficient training and education on sustainability, limited knowledge about sustainable technologies, a lack of expertise in sustainability, inadequate collaboration and coordination among stakeholders, and a shortage of tools and techniques to support the understanding and implementation of sustainability. The presented index shows the relative strengths of various barriers. The economic barrier holds the highest coefficient (0.367), indicating its significant impact. The environmental barrier closely follows with a coefficient of 0.319, suggesting its substantial influence. Lastly, the social barrier ranks third with a coefficient of 0.314, signifying its notable contribution to the overall analysis. These barriers were identified as major challenges hindering the effective implementation of sustainable practices during the physical construction stage in the study area.

The third objective of the study was to identify the drivers that contribute to the implementation of sustainable practices during the physical construction stage of buildings. The findings revealed several significant drivers in the study area. These drivers included regulations set by the government, environmental regulations and compliance, employee engagement and retention, resource conservation and waste reduction initiatives, introducing green objectives at an early stage, adopting an integrated approach to sustainability, and education and training programs provided by academic institutions. The index demonstrates the relative strengths of different drivers. The analysis reveals that the social driver has the highest coefficient (0.347), indicating its significant impact. The environmental driver closely follows with a coefficient of 0.331, suggesting its substantial influence. The economic driver ranks third with a coefficient of 0.322, highlighting its notable contribution. These coefficients provide valuable insights into the relative strengths and importance of each driver, informing further analysis and decision-making in the context of sustainability. These drivers were identified as crucial factors that encourage and facilitate the implementation of sustainable practices in the study area.

The fourth objective of this study is to develop a conceptual framework for the effective implementation of sustainable practices during the physical construction stage. This framework guides the assessment, planning, implementation, and evaluation of sustainable practices throughout the construction process. It consists of four sections: Policy and Strategy Development, Action Plan for Sustainable Practices, Evaluation and Improvement, and Application and Implementation. The framework involves formulating policies and strategies, defining specific aims, evaluating the effectiveness of practices, and tracking the benefits resulting from their adoption. By following this systematic approach, construction projects can successfully integrate sustainable practices, leading to positive environmental, economic, and social outcomes.

The study found the correlation analysis indicates significant relationships between sustainable practices, drivers, and barriers. The findings reveal a strong positive correlation (0.844**) between sustainable practices and drivers, suggesting that as the drivers increase, implementation levels also tend to increase. Conversely, there is a strong negative correlation (-0.679**) between sustainable practices and barriers, indicating that reducing barriers leads to higher implementation. Additionally, a moderate negative correlation (-0.485**) exists between drivers and barriers, suggesting that increasing drivers can help decrease barriers. These results emphasize the importance of addressing barriers and enhancing drivers for successful implementation of sustainable practices.

Furthermore, the regression analysis revealed that the adjusted R2 (coefficient of determination) accounted for 79.9% of the variance in factors influencing sustainable building projects, specifically in terms of motivating the practice and hindering the implementation of sustainable practices. This indicates that the included variables in the regression model explain a significant portion of the factors affecting the success of sustainable practices in the ongoing building projects.

5.2 Recommendation

Based on the findings and objectives outlined in the study, here are some recommendations for improving the implementation of sustainability practices during the construction phase of federal government budgeted buildings in Addis Ababa:

- Enhancing sustainability evaluation: Implement a comprehensive evaluation system to assess the extent to which sustainability practices are implemented during the physical construction phase of building projects. This can include developing assessment criteria, conducting regular audits, and utilizing performance indicators to measure the level of sustainability integration.

- Addressing barriers to implementation: Identify and address the barriers encountered during the implementation of sustainable practices in the physical construction phase. This can involve conducting surveys, interviews, and workshops to gather insights from building professionals and stakeholders. Develop strategies to overcome these barriers, such as providing training programs, improving access to sustainable materials, and streamlining regulatory processes.
- Understanding drivers of implementation: Investigate and identify the key factors that drive the successful implementation of sustainability practices during the physical construction phase. This can be done through analyzing case studies, conducting interviews, and studying industry trends. Use this knowledge to create incentives, provide support, and promote awareness to encourage building professionals to adopt and integrate sustainable practices.
- Developing an effective conceptual framework: Based on the research findings, develop a robust conceptual framework for the effective implementation of sustainability practices during the physical construction phase of building projects. The framework should include guidelines, strategies, performance indicators, and decision-making processes to guide building professionals in incorporating sustainable practices. Ensure that the framework is practical, adaptable, and aligned with industry standards and best practices.
- Advocating for supportive policies and regulations: Advocate for the development and implementation of supportive policies and regulations that incentivize and mandate the integration of sustainability practices during the physical construction phase. Collaborate with relevant authorities and policymakers to create an enabling environment that promotes sustainable construction and addresses any legal or regulatory gaps.

5.3 Direction for further study

The study aimed to examine the implementation of sustainability practices in the construction phase of federal government budgeted building projects in Addis Ababa. A conceptual framework for effective implementation was developed based on the findings. The analysis using SPSS indicated that the independent variables explained 79.9% of the factors influencing sustainable implementation. However, 21.1% of factors remained unaccounted for and require further research. Investigating these additional factors will help bridge the knowledge gap and improve the effectiveness of sustainability practices in construction.

The study focused only on sustainable practices in the construction of government-funded buildings in Addis Ababa, excluding privately owned buildings. To improve the research's generalizability, a broader investigation should be conducted, including other areas and privately owned buildings. This would help understand the challenges in implementing sustainable projects and develop strategies for promoting sustainability across different building types and ownership structures

Research on the government's role in promoting sustainability practices is crucial for evaluating the effectiveness of governmental actions and policies in fostering sustainable development. By analyzing the measures and strategies employed by the government, researchers can assess their impact on sustainable practices and contribute to broader sustainability goals. This research provides valuable insights to inform policymaking and cultivate a more environmentally conscious society.

Furthermore, it is important to expand this research beyond the construction stage and explore sustainability practice implementation in each stage of building projects, excluding the construction phase. By broadening the scope of investigation to encompass the pre-construction planning, design, post-construction operations, and maintenance stages, researchers can provide a comprehensive analysis of sustainability practices throughout the entire life cycle of a building project. This inclusive approach allows for a more holistic understanding of the challenges and opportunities associated with sustainable development, and provides valuable insights for policymakers, architects, engineers, and stakeholders to enhance sustainability practices in all aspects of building projects.

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REFERANCE

Abd Rashid, A. F., Yusoff, S. J. R., & Reviews, S. E. (2015). A review of life cycle assessment method for building industry. 45, 244-248.

Abidin, N. Z. J. H. i. (2010). Investigating the awareness and application of sustainable construction concept by Malaysian developers. 34(4), 421-426.

Abolore, A. A. J. J. o. E. T. i. E., & Sciences, M. (2012). Comparative study of environmental sustainability in building construction in Nigeria and Malaysia. 3(6), 951-961.

Adetunji, I., Price, A., Fleming, P., & Kemp, P. (2003). Sustainability and the UK construction industry—a review. Paper presented at the Proceedings of the Institution of Civil Engineers-Engineering Sustainability.

Adugna, D., Lemma, B., Jensen, M. B., & Gebrie, G. S. J. J. o. H. R. S. (2019). Evaluating the hydraulic capacity of existing drain systems and the management challenges of stormwater in Addis Ababa, Ethiopia. 25, 100626.

Ahmed, R. R., Streimikiene, D., Rolle, J. A., & Sharif, A. (2020). The driving role of social and environmental drivers for sustainable operations: A case of manufacturing plants. Journal of Cleaner Production, 256, 120246.

Akadiri, P. O. J. J. o. B. E. (2015). Understanding barriers affecting the selection of sustainable materials in building projects. 4, 86-93.

Akenji, L., & Bengtsson, M. (2014). Making sustainable consumption and production the core of sustainable development goals. Journal of Cleaner Production, 76, 43-50.

Alemu, A. A., Yitayew, M., Azazeh, A., & Kebede, S. J. B. P. H. (2020). Utilization of personal protective equipment and associated factors among building construction workers in Addis Ababa, Ethiopia, 2019. 20(1), 1-7.

Anshebo, M. A., Mengesha, W. J., & Sokido, D. L. J. H. (2022). Developing a Green Building Assessment Tool for Ethiopia. 8(9), e10569.

Anzagira, L., Duah, D., & Badu, E. J. S. A. (2019). A conceptual framework for the uptake of the green building concept in Ghana. 6, e00191.

Awuzie, B. O., Monyane, T. G., Koker, C. D., Aigbavboa, C. O. J. S., & Change, C. (2021). Evaluation of factors influencing environmental sustainability performance of construction projects in South Africa. 14(2), 122-132.

Azis, A. A. A., Memon, A. H., Rahman, I. A., Nagapan, S., & Latif, Q. B. A. I. (2012). Challenges faced by construction industry in accomplishing sustainablity goals. Paper presented at the 2012 IEEE Symposium on Business, Engineering and Industrial Applications.

Bauer, M., Mösle, P., & Schwarz, M. (2009). Green building: guidebook for sustainable architecture: Springer Science & Business Media.

Best, J. W., & Kahn, J. V. J. P. H. o. I. P. L. (2003). Research in Education New Delhi.

Beyene, A. D., Valle, M. V., Mengistu, T., & Yusuf, R. O. (2020). Overview and Implementation Framework for Sustainable Construction in Ethiopia: Challenges, Opportunities, and the Way Forward. International Journal of Environmental Research and Public Health, 17(6), 2124.

Brancato, G., Macchia, S., Murgia, M., Signore, M., Simeoni, G., Blanke, K., & Hoffmeyer-Zlotnik, J. J. E. S. S. (2006). Handbook of recommended practices for questionnaire development and testing in the European statistical system.

Building Research Establishment (BRE). (n.d.). BREEAM: The world's leading sustainability assessment method for masterplanning projects, infrastructure, and buildings. Retrieved from https://www.breeam.com/

Byrne, J. P., Fiess, N., & MacDonald, R. J. J. o. M. (2011). The global dimension to fiscal sustainability. 33(2), 137-150.

Canton, H. (2021). United nations conference on trade and development—unctad. In The Europa Directory of International Organizations 2021 (pp. 172-176): Routledge.

Carvalho, J. P., Bragança, L., & Mateus, R. J. A. i. C. (2019). Optimising building sustainability assessment using BIM. 102, 170-182.

Chang, R.-d., Zuo, J., Soebarto, V., Zhao, Z.-y., Zillante, G., Gan, X.-l. J. J. o. c. e., & management. (2017). Discovering the transition pathways toward sustainability for construction enterprises: Importance-performance analysis. 143(6), 04017013.

Chen, Y., Okudan, G. E., & Riley, D. R. J. A. i. c. (2010). Sustainable performance criteria for construction method selection in concrete buildings. 19(2), 235-244.

Cheng, M.-Y., & Darsa, M. H. J. S. (2021). Construction schedule risk assessment and management strategy for foreign general contractors working in the Ethiopian construction industry. 13(14), 7830.

Dair, C. M., Williams, K. J. E., & A, P. (2006). Sustainable land reuse: the influence of different stakeholders in achieving sustainable brownfield developments in England. 38(7), 1345-1366.

Dalirazar, S., & Sabzi, Z. J. I. J. o. C. M. (2023). Strategic analysis of barriers and solutions to development of sustainable buildings using PESTLE technique. 23(1), 167-181.

Dania, A. A., Larsen, G. D., & Yao, R. (2013). Sustainable construction in Nigeria: understanding firm level perspectives. Paper presented at the Sustainable Building Conference.

Darko, A., & Chan, A. (2017). Barriers to the adoption of green practices in the Ghanaian construction industry: a basis for an intervention. Journal of Cleaner Production, 142, 3581-3588.

Dean, G. W., & Clarke, F. L. J. A. (2003). An evolving conceptual framework? , 39(3), 279-297.

Dessalegn, Y., Araya, M. A., & Asfaw, E. E. (2015). Challenges for Implementing Sustainable Construction in Developing Countries: The Case of Ethiopia. African Journal of Science and Research, 4(5), 1-8.

Dine, C. J., McGaghie, W., Bordage, G., & Shea, J. A. J. R. C. f. R. M. (2015). Problem statement, conceptual framework, and research question. 19.

Dong, B. (2013). Updating a multiple linear regression model for the prediction of daylight availability in buildings. Energy and Buildings, 66, 143-145

Dosumu, O., & Aigbavboa, C. (2018). Sustainable Design and Construction in Africa: A System Dynamics Approach: Routledge.

Drost, E. A. J. E. R., & perspectives. (2011). Validity and reliability in social science research. 38(1), 105-123.

Du Plessis, C. J. B. R., & Information. (2005). Action for sustainability: preparing an African plan for sustainable building and construction. 33(5), 405-415.

Durdyev, S., & Ismail, S. J. C. (2012). Role of the construction industry in economic development of Turkmenistan. 64(0).

Durdyev, S., Zavadskas, E. K., Thurnell, D., Banaitis, A., & Ihtiyar, A. J. S. (2018). Sustainable construction industry in Cambodia: Awareness, drivers and barriers. 10(2), 392.

Dyllick, T., & Rost, Z. J. J. o. C. P. (2017). Towards true product sustainability. 162, 346-360.

Enshassi, A., Kochendoerfer, B., Al Ghoul, H. J. I. J. o. S. C. E., & Technology. (2016). Factors affecting sustainable performance of construction projects during project life cycle phases. 7(1), 50-68.

Farzanehrafat, M., Akbarnezhad, A., & Ghoddousi, P. (2015). Analysis of different views towards social sustainability in construction. Paper presented at the ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction.

Fauzi, R. A., & Othman, R. (2015). Drivers for the Implementation of Sustainable Construction Practices by Malaysian Developers. Procedia Engineering, 118, 681-688.

Field, A. J. U. S. (2009). Discovering statistics using SPSS, 3rd Edn London.

Fong, W. K., Mat, N., Chong, H. Y., & Saw, P. N. (2017). Environmental sustainability practices in green public housing: A Structural Equation Modelling (SEM) approach. Journal of Cleaner Production, 158, 343-355.

Frost, J. (2021). What Are Sums of Squares in Statistics? Minitab Blog. Retrieved 19 October 2021,

Gelan, E. J. T. (2022). Green Building Concepts and Technologies in Ethiopia: The Case of Wegagen Bank Headquarters Building. 11(1), 2.

Godfrey, S., Asmare, G., Gossa, T., & Paba, M. J. W. (2019). Fuzzy logic analysis of the build, capacity build and transfer (B-CB-T) modality for urban water supply service delivery in Ethiopia. 11(5), 979.

Grant, L. K. J. B., & Issues, S. (2010). Sustainability: From excess to aesthetics. 19(1), 7-47.

Green Building Council of Australia (GBCA). (n.d.). Green Star. Retrieved from https://new.gbca.org.au/green-star/

Green, T., & Jacobs, P. J. N. A. S. (2020). Tied for Warmest Year on Record.

Greenland, D. J. (1997). The sustainability of rice farming: Cab International.

Gurara, D., Klyuev, V., Mwase, N., Presbitero, A. F. J. I. D. P., & développement, R. i. d. p. d. (2018). Trends and challenges in infrastructure investment in developing countries. (10.1).

Häkkinen, T., Belloni, K. J. B. R., & Information. (2011). Barriers and drivers for sustainable building. 39(3), 239-255.

Halliday, S. (2008). Sustainable construction: Routledge.

Hill, R. C., Bowen, P. A. J. C. M., & Economics. (1997). Sustainable construction: principles and a framework for attainment. 15(3), 223-239.

Hills, M., Fox, P., Skitmore, M., Hon, C., & Fong, P. (2008). The role of project managers in construction industry development. Paper presented at the Proceedings of the AACE International's 52nd Annual Meeting and ICEC's 6th World Congress on Cost Engineering, Project Management and Quantity Surveying 2008.

Hussin, J. M., Rahman, I. A., & Memon, A. H. J. I. J. o. A. i. A. S. (2013). The way forward in sustainable construction: issues and challenges. 2(1), 15-24.

Hwang, B.-G., Zhao, X., Tan, L. L. G. J. E., Construction, & Management, A. (2015). Green building projects: Schedule performance, influential factors and solutions. 22(3), 327-346.

Imai, K., Keele, L., & Yamamoto, T. (2010). Identification, inference and sensitivity analysis for causal mediation effects.

Imperatives, S. J. A. F. (1987). Report of the World Commission on Environment and Development: Our common future. 10, 1-300.

International Living Future Institute (ILFI). (n.d.). Living Building Challenge. Retrieved from https://living-future.org/lbc/

International Organization for Standardization (ISO). (n.d.). ISO 14001: Environmental management. Retrieved from https://www.iso.org/iso-14001-environmental-management.html

International Organization for Standardization (ISO). (n.d.). ISO 50001: Energy management. Retrieved from https://www.iso.org/iso-50001-energy-management.html

International Organization for Standardization (ISO). (n.d.). ISO 21930: Sustainability in buildings and civil engineering works. Retrieved from https://www.iso.org/standard/65602.html

James, P. (2014). Urban sustainability in theory and practice: circles of sustainability: Routledge.

Jankal, R., Jankalova, M. J. P. E., & Finance. (2016). The application of The EFQM Excellence Model by the evaluation of Corporate Social Responsibility activities of companies. 39, 660-667.

Kennedy, C., & Hoornweg, D. (2002). Healthy and sustainable cities: managing urban waste. Waste Management & Research, 20(2), 146-150.

Khalfan, M. M., Bouchlaghem, D. M., Anumba, C. J., & Carrillo, P. M. (2002). A framework for managing sustainability knowledge-the C-sand approach. Paper presented at the proceedings of E-Sm@ rt conference, Salford, UK.

Kibert, C. J. (2016). Sustainable construction: green building design and delivery: John Wiley & Sons.

Kimberlin, C. L., & Winterstein, A. G. J. A. j. o. h.-s. p. (2008). Validity and reliability of measurement instruments used in research. 65(23), 2276-2284.

Landman, M. (1999). Breaking through the barriers to sustainable building: Insights from building professionals on government initiatives to promote environmentally sound practices. Tufts University,

Lenz, E. R. (2010). Measurement in nursing and health research: Springer publishing company.

Lu, W., & Yuan, H. (2011). A framework for understanding waste management studies in construction. Journal of Cleaner Production, 19(6-7), 619-626.

Martinsuo, M., & Killen, C. P. (2014). Value management in project portfolios: identifying and assessing strategic value. Project Management Journal, 45(5), 56-70.

Matar, M. M., & Georgy, M. E. (2022). Assessment of the sustainability implementation barriers in the construction industry. Journal of Cleaner Production, 329, 129566.

Matar, M. M., Georgy, M. E., Ibrahim, M. E. J. C. m., & economics. (2008). Sustainable construction management: introduction of the operational context space (OCS). 26(3), 261-275.

Meng, X., Liu, Q., & Zhang, Y. (2016). The impact of environmental regulation on China's Industrial Green Total Factor Productivity. Environmental Science & Policy, 59, 1-7.

Mengistu, D. G., Mahesh, G. J. J. o. E., Design, & Technology. (2020). Dimensions for improvement of construction management practice in Ethiopian construction industry. 18(1), 21-39.

MIREÉ, I., & TORYALAY, A. (2016). Operationalization of Social Sustainability in the Construction Industry from a Client Perspective, How the concept of social sustainability in the construction industry is defined and communicated by Skanska's proposed clients?

Naoum, S. G. (2012). Dissertation research and writing for construction students: Routledge.

Neutens, J. J., & Rubinson, L. (2010). Research techniques for the health sciences: Benjamin-Cummings Publishing Company.

Nigussie, L. F., Darwish, M. M., & Ghebrab, T. J. S. (2019). Comparative investigation of the effect of recycled fine aggregate from new and old construction wastes in C-25 concrete in Ethiopia. 11(24), 7116.

O'Connor, J. T., Torres, N., Woo, J. J. J. o. C. E., & Management. (2016). Sustainability actions during the construction phase. 142(7), 04016016.

Ochieng, E. G., Wynn, T., Zuofa, T., Ruan, X., Price, A., & Okafor, C. J. J. o. A. E. T. (2014). Integration of sustainability principles into construction project delivery. 3(1), 116-120.

Ofori, G. J. E. J. o. P., & Management, S. (2000). Greening the construction supply chain in Singapore. 6(3-4), 195-206.

Ohiomah, I., Aigbavboa, C., & Thwala, W. (2019). An assessment on the drivers and obstacles of sustainable project management in South Africa: A case study of Johannesburg. Paper presented at the IOP Conference Series: Materials Science and Engineering.

Okoye, P., Okolie, K. J. I. J. o. E. R., & Development. (2013). Social approach to sustainable construction practices through safety culture. 6(11), 76-83.

Oladokun, M. G., Aigbavboa, C., & Isang, I. W. (2017). Evaluating the measures of improving the implementation of sustainability practices on building projects in Akwa Ibom State, Nigeria. Paper presented at the Proceedings of Environmental Design and Management International Conference.

Oladokun, M. G., Isang, I. W., Emuze, F. J. S., & Environment, S. B. (2021). Towards sustainability practices deployment in building construction projects in Nigeria. 10(4), 759-780.

Oyedele, L. O., Owolabi, H. A., Gbadamosi, A. Q., Akinola, S. F., Aigbavboa, C. O., & Bilal, M. (2017). Barriers to the uptake of sustainability in facilities management: A factorial survey approach using the repertory grid technique. Sustainability, 9(9), 1516.

Ozili, P. K. J. M. G. T. (2022). Sustainability and sustainable development research around the world.

Park, J., & Tucker, R. J. I. J. o. C. M. (2017). Overcoming barriers to the reuse of construction waste material in Australia: a review of the literature. 17(3), 228-237.

Passive House Institute. (n.d.). The Passive House. Retrieved from https://passivehouse.com/

Pero, M., Moretto, A., Bottani, E., & Bigliardi, B. J. S. (2017). Environmental collaboration for sustainability in the construction industry: An exploratory study in Italy. 9(1), 125.

Pitt, M., Tucker, M., Riley, M., & Longden, J. J. C. i. (2009). Towards sustainable construction: promotion and best practices. 9(2), 201-224.

Program, A. C. R., Administration, U. S. F. A., Ricondo, Associates, Transportation, C. f., Environment, t., . . . Associates, A. (2011). Sustainable airport construction practices (Vol. 42): Transportation Research Board.

Sara Hedrén, Schalk Meijer, & M. Marzia Hosseini, 2021, "A conceptual framework for promoting sustainable practices in the construction industry: Integrating environmental, social, and economic factors," _Journal of Cleaner Production_, vol. 306, 127145

Sassi, P. (2006). Strategies for sustainable architecture: Taylor & Francis.

Serpell, A., Kort, J., Vera, S. J. T., & Economy, E. D. o. (2013). Awareness, actions, drivers and barriers of sustainable construction in Chile. 19(2), 272-288.

Shafii, F., Arman Ali, Z., & Othman, M. Z. (2006). Achieving sustainable construction in the developing countries of Southeast Asia.

Shen, L. Y., Li Hao, J., Tam, V. W. Y., Yao, H. J. J. o. c. e., & management. (2007). A checklist for assessing sustainability performance of construction projects. 13(4), 273-281.

Shen, L., Wu, Y., Zhang, X. J. J. o. c. e., & management. (2011). Key assessment indicators for the sustainability of infrastructure projects. 137(6), 441-451.

Shen, L.-y., Tam, V. W., Tam, L., & Ji, Y.-b. J. J. o. c. p. (2010). Project feasibility study: the key to successful implementation of sustainable and socially responsible construction management practice. 18(3), 254-259.

Sinesilassie, E. G., Tabish, S. Z. S., Jha, K. N. J. E., Construction, & Management, A. (2017). Critical factors affecting schedule performance: A case of Ethiopian public construction projects–engineers' perspective. 24(5), 757-773.

Tan, Y., Shen, L., & Yao, H. J. H. i. (2011). Sustainable construction practice and contractors' competitiveness: A preliminary study. 35(2), 225-230.

Thivaharan, O. J. U. M. D., School of the Built Environment, Heriot-Watt University, Edinburgh, United Kingdom. (2015). Successful Implementation of Green Practice during Construction Phase of a Building Life Cycle by a Small and Medium Contractors in Singapore.

Tokbolat, S., Karaca, F., Durdyev, S., Calay, R. K. J. E., Development, & Sustainability. (2020). Construction professionals' perspectives on drivers and barriers of sustainable construction. 22, 4361-4378.

Tordera, N., Peiro, J. M., Ayala, Y., Villajos, E., & Truxillo, D. J. J. o. V. B. (2020). The lagged influence of organizations' human resources practices on employees' career sustainability: The moderating role of age. 120, 103444.

U.S. Green Building Council (USGBC). (n.d.). LEED: Leadership in Energy and Environmental Design. Retrieved from https://www.usgbc.org/leed

Ugwu, O., Haupt, T. C. J. B., & environment. (2007). Key performance indicators and assessment methods for infrastructure sustainability—a South African construction industry perspective. 42(2), 665-680.

Upham, P., Klapper, R., & Roberts, T. (2016). Social and environmental barriers to energy sufficiency: the case of renewable energy. In J. Axsen, L. Green, & W. Marsden (Eds.), The Global Challenge of Encouraging Sustainable Living: Opportunities, Barriers, Policy, and Practice (pp. 39-58). Edward Elgar Publishing.

Valdes-Vasquez, R., Klotz, L. E. J. J. o. c. e., & management. (2013). Social sustainability considerations during planning and design: Framework of processes for construction projects. 139(1), 80-89.

Weaver, A., Pope, J., Morrison-Saunders, A., Lochner, P. J. I. A., & Appraisal, P. (2008). Contributing to sustainability as an environmental impact assessment practitioner. 26(2), 91-98.

Willar, D., Waney, E. V. Y., Pangemanan, D. D. G., Mait, R. E. G. J. S., & Environment, S. B. (2020). Sustainable construction practices in the execution of infrastructure projects: The extent of implementation. 10(1), 106-124.

Yates, J. J. J. o. c. e., & management. (2014). Design and construction for sustainable industrial construction. 140(4), B4014005.

Zainul Abidin, N. (2009). Sustainable Construction In Malaysia Developers' Awareness.

APPENDIX

Appendix A: Questionnaire survey

Adama Science and Technology University

School of Civil Engineering and Architecture

Department of Construction Engineering and Management

Questionnaire for thesis on:

Sustainability practices implementation during the physical construction phase of buildings: The case of a federal government budgeted buildings in Addis Ababa

Advisor: Meseret Getnet (Ph.D.)

Prepared by: Mintesinot Gelaneh

April 2022

Dear Sir/Madam,

I am a graduate student at Adama Science and Technology University. I am now preparing a master thesis in the Construction Engineering and Management program. The title "Sustainability practices implementation during the physical construction phase of buildings: The case of a federal government budgeted buildings in Addis Ababa".

The purpose of the study is to:

- ✓ To evaluate the level of implementation of sustainability practices during construction
- ✓ phase of building projects by building professionals.
- ✓ To examine the barriers encountered the implementation of sustainable practices during the physical construction phase of building projects.
- ✓ To identify the factors that drive the implementation of sustainability practices during the physical construction phase of building projects.
- ✓ To develop a conceptual framework for the effective implementation of sustainability practices during the physical construction phase of building projects.

You are asked to answer the questions in the questionnaire based on your personal knowledge and experience regarding the research. Therefore, your genuine responses will help me to provide reliable and valuable suggestions and recommendations. Your response will be used only for academic purpose. Thus, you are kindly requested to provide your genuine response to the raised issues.

I would like to express my appreciation in advance for your time and consideration.

Thank you!

General Directions:

1. No need of writing your name
2. Mark "√" tick in the box of your alternative answer(s)
3. Please give your short and precise response to the open-ended questions, without leaving any questions unanswered

Section A: Demographic Background of the Respondents

Direction: Please provide your response by circling the letters from the given alternatives for closed ended questions.

1. Sex: a) Male b) Female

2. Age: a) Below 25 years b) 25-35 years

c) 36-45 years d) 46 and above years

3. Your level of education/Academic status.

a) College Diploma b) First Degree c) MA/MSc Degree d) PhD

4.Your Position in the organization

a) Clients b) Contractor c) Consultant

d) Sub-city Construction office staff e. Any other position____________________

5. For how long have you been working in the stated position?

a) 0-5 years b) b/n 6-10 c) b/n 11-15 d) >16 years

SECTION B: IMPLEMENTATION OF SUSTAINABILITY PRACTICES DURING PHYSICAL CONSTRUCTION STAGE OF BUILDING

Please rank your level of implementation of the following Sustainability Practices.

Legend: - 5 = Very High, 4 = High, 3 = Moderate, 2 = Low and 1 = Very Low.

7 To what extent do you as a Building Professional implement this Sustainability Practices in your building projects?

No	Sustainability Practices	VeryHigh 5	High 4	Moderate 3	Low 2	Very low 1
1	Use of sustainable building materials					
2	Waste management					

3	Proper storage and handling of materials					
4	Use of prefabricated components					
5	Energy efficiency					
6	Commissioning and monitoring					
7	Protection of worker health and safety					
8	Training and certification of workers					
9	Collaboration and communication					
10	Employee education and training					
11	Indoor environmental quality					
12	Dust and noise control					
13	Control of dust to reduce pollution on building					
14	Use of vertical green walls at the site to cool the office and improve aesthetics					
15	Controlling the use and dispersion of toxic materials					
16	Minimizing site disturbance					
17	Regular inspection and monitoring					

- From your experience, comment if there are any other sustainability practices that you have implemented in your building projects. (If no, please specify as none)

SECTION C: DRIVERS AND BARRIERS OF IMPLEMENTING SUSTAINABILITY PRACTICES INBUILDING PROJECTS

Please rank your level of agreement of the following Sustainability Practices. Legend:

5 = Strongly Agree, 4 = Agree, 3 = Neither Agree nor Disagree, 2 = Disagree and 1 = Strongly disagree.

8. What factors would drive you as a Building Professional to implement the Sustainability Practices in building projects?

No	Drivers of Implementation	Strongly Agree 5	Adree 4	Nether agree nor disagree 3	Disagree 2	Strongly disagree 1
1	Cost savings and efficiency					
2	Use of integrated approach					
3	Reduced risk and liability					
4	Value added benefits and operational efficiency					
5	Owners' commitment to sustainability					
6	Client demand and market differentiation					
7	Corporate social responsibility and ethical considerations					
8	Client's awareness and knowledge					

9	Commitment by professionals and stakeholders					
10	Employee engagement and retention					
11	Health and wellbeing of occupants					
12	Education and training programs by academicians					
13	Ethics and behavioral change					
14	Public awareness					
15	Environmental regulations and compliance					
16	Regulations by the Government					
17	Resource conservation and waste reduction					
18	Introducing green objectives early					
19	Integration of Environmental Management System					

9 Please rank your level of agreement about the following barriers of implementing sustainability practices during physical building construction projects.

No	Barriers Of Implementation	Strongly agree 5	Agree 4	Nether agree nor disagree 3	Disagree 2	Strongly disagree 1
1	Lack of training and education					

2	Lack of regulation to enforce sustainability.					
3	Resistance to change					
4	Lack of financial intensive					
5	Limited availability of suppliers of sustainable products and materials.					
6	Lack of Collaboration and coordination					
7	Lack of tools and techniques to support understanding of sustainability					
8	Time consuming activities					
9	Insufficient professional capabilities					
10	Client's lack of interest, understanding and commitment makes its practical application difficult.					
11	Knowledge on sustainable technologies is limited					
14	Lack of Standardization and certification					
13	The higher cost associated with sustainable buildings.					
14	Lack of environmental concern					

PART SECTION D: INTERVIEW QUESTION

1. In your experience, what are the most effective sustainability practices during the construction phase of building projects?

2. What do you see as the biggest barriers to implementing sustainable practices during the construction phase of building projects? How can these barriers be addressed?
3. Can you describe a project where sustainable practices were not implemented effectively during the construction phase? What were the main challenges that led to this outcome?
4. In your opinion, what are the key factors for successful implementation of sustainable practices during the
5. How can building owners and developers be incentive to invest in sustainable construction practices during the construction phase?

Appendix B: Framework Evaluation Questioner

Section A: Background Information

1. Name ……………………………………………………………………………

2. Background: Academia ☐ Industry ☐

3. Area of expertise ………………………………………………………………………

4. Organization (optional): ……………………………………………………………

5 Level of education ………………………………………………………………………

6 year of work experience …………………………………………………………

Section B: Framework Evaluation Questionnaire

The following questions relate to the justification for and value of the suggested framework for implementing sustainable practices during the physical construction phase of buildings in Addis Abeba. Please answer the following questions to provide your thoughts on the suggested framework.

No	Questions	Strongly dis agree	Disagree	Neutral	Agree	Strongly agree
1	The framework is logical and well organized.					

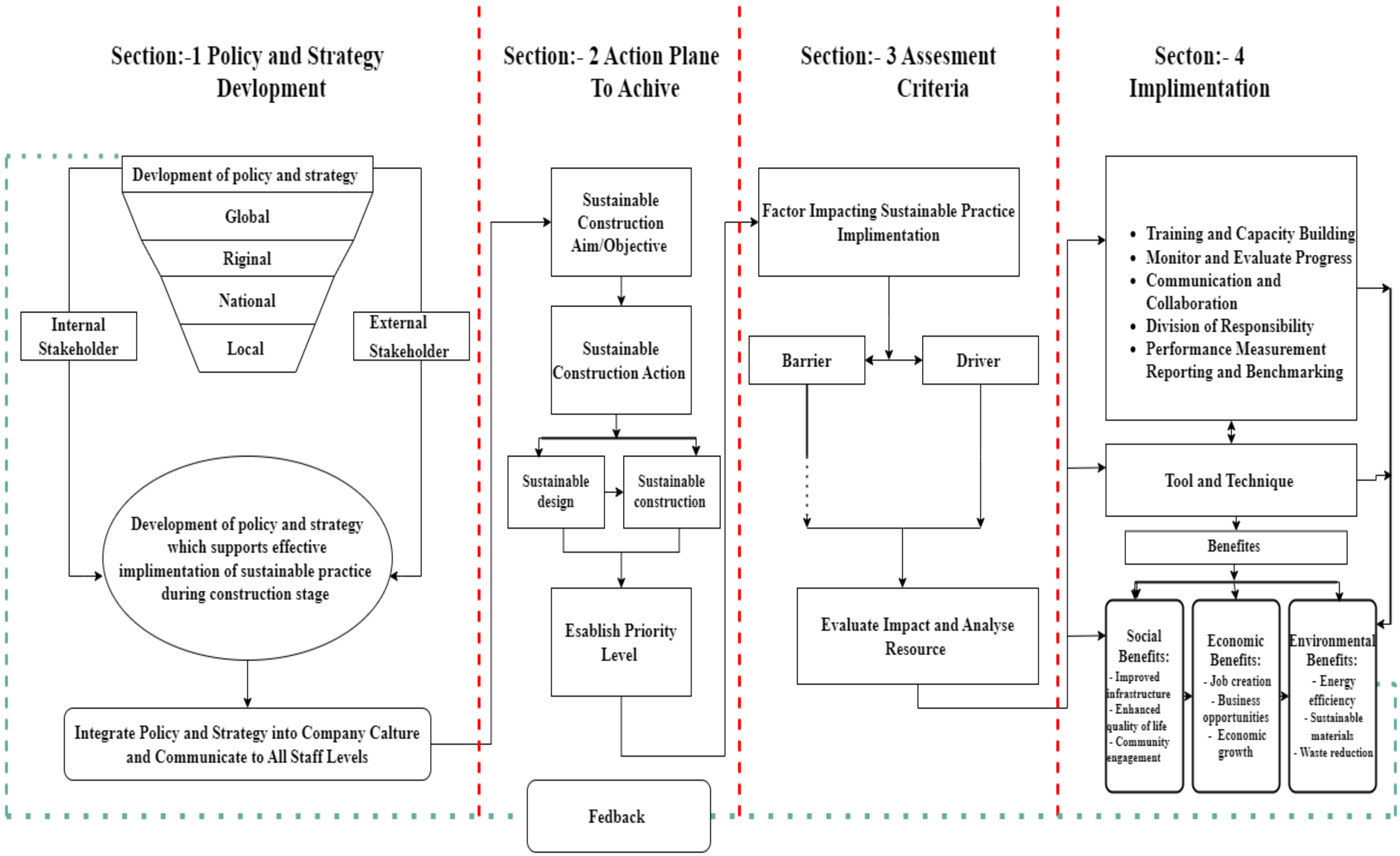
2	The framework is clear and easy to understand.					
3	Description of the framework and its layout is comprehensive					
4	This framework implementation guide, if followed; will facilitate implementation sustainable practices during the physical construction phase of buildings by government and related organizations"					
5	The framework adequately addresses current sustainability challenges and goals in the construction industry.					
6	The framework effectively integrates global, regional, national, and local sustainability guidelines and advisory documents.					
7	The framework involves and considers the perspectives of internal and external stakeholders in the development of policies and strategies.					
8	The framework provides a clear understanding of the key goals and objectives for sustainable practice implementation during the physical construction stage.					
9	The framework's action plan for achieving sustainable practices, including building aims, objectives, and priority levels, is comprehensive.					
10	The framework adequately addresses resource and personnel requirements for implementing sustainable practices.					

11	The framework assesses the effectiveness of current sustainable practices and identifies areas for improvement.					
12	The framework provides guidance for selecting appropriate sustainable practices specific to each project.					
13	The framework effectively addresses barriers and drivers that impact sustainable practice implementation in the construction stage.					
14	The framework includes measures for tracking the environmental, economic, and social benefits of sustainable practices, along with suitable metrics and ongoing monitoring and evaluation.					
15	The framework covers all the steps needed to achieve of sustainable practices implementation during the physical construction phase of buildings.					

Additional Comments

16 Please provide any additional comments or suggestions for improving the conceptual framework?

Appendix C: Proposed conceptual framework for effective implementation of sustainable practice during physical construction stage.



Appendix D: Selected federal government budgeted buildings in Addis Ababa

A. Selected federal government budgeted buildings

No	Project name	Project type	Category	Project location			Project owner	Project consultant	Project contractor
				region	Sub City	Specific location			
1	Federal government building	building	High rise	Addis Ababa	kirikos	Kasanchis	Federal Government building construction project office	Aspire Aecom Arc. And Engineering	Afrotsion construction
2	National meteorology lot-1 &lot-2	Building	Medium	Addis Ababa	bole	Bole, W-02	Federel government and building construction project office	Aspire Aecom Arc. And Engineering	
3	Addis Mebratu Architects and Engineers	Building		Addis Ababa	kasanchis	Biherawi Theater Area	Federel government and building construction project office	Addis Mebratu Architects and Engineers	Afrotsion construction
4	Construction of 2B+G+9 Story office building lot-2	Building	Medium	Addis Ababa	Bole	Bole, W-02 sky light hotel	Federel government and building construction project office	Aspire Aecom Arc. And Engineering	santa maria construction plc.

5	Construction of 2B+G+9 Story Building Hall	Buil ding	Med ium	Addis Ababa	bole	Bole, W-02 aroundsky light hotel	Federel government and building construction project office	Aspire Aecom Arc. And Engineering	Yirgalem construction plc.
6	Ministrycof trade and Industry head quarter office building	Buil ding		Addis Ababa	Arada	Arat kilo	Federel government and building construction project office		MH Engineering plc.
7	construction of remaining works of head quarter building of ministry of trade and Industry	Buil ding	Hig h rise	Addis Ababa	Arada	Arat kilo	Federel government and building construction project office	MH Engineering plc.	Ethiopian construction works corporation
8	Civil Aviation Authority head quarter	Buil ding	Med ium	Addis Ababa	bole	Bole	Federel government and building construction project office	KZN Architects and Engineering consultancy	Beha Constructio n
9	Construction of leather Industry	Buil ding	Hig h rise	Addis Ababa	Akaki kality	Kality	Federel government and building construction	At. Con Engineering and Architecture consultant plc.	Lucy Engineering plc
10	2B+G+8 Emergency hospital building	Buil ding		Addis Ababa	Nifas silk	Garment	Ministry of health	Acute Engineering	2B+G+8 Emergency hospital building

11	EORC Expansion project (Lot-I)	Building		Addis Ababa	Akaki kality	AASTU	Ethiopian space science and Technology	QTC Consulting	Mirab Construction
12	Ayer Tena bus terminal maintenance works	Building		Addis Ababa	Kolife	Ayer tena	Ministry of transport and logistics		Barcot construction plc.
13	Renovation of block C, D, Cafeteria and Construction of sewerage system	Building		Addis Ababa	bole	Head office around megenagna 24	FDRE Ministry of revenue	E.C.D.S.W.C.B.U.D and sup. Works sector	Ethiopian construction works corporation
14	Secretariat of the house of peoples' representatives	Building		Addis Ababa	Arada	Arat kilo	House of people's representatives mixed use building	BUDSWS	Safer construction plc.
15	Kality Bus Station	Building		Addis Ababa	Akaki kality	Kality	Federal transport Authority		F.E Construction plc.
16	PSETSE G+2 Building	Building		Addis Ababa	Kirkos	Mexico	PSETSE	OBON Voyage Architects	
17	Geospatial information institute	Building		Addis Ababa	Arada	Minilik II Avenue	Geospatial information institute	Lawe Birhanu consulting	
18	AHRI 2B+G+6 Research laboratory and office building	Building		Addis Ababa	Nifas silk	Alert hospital compound	Ministry of health/AHRI	Yohannes Abay consulting	

								Architects and Engineers	
19	Alert Trauma hospital 2B+G+8	Buil ding		Addis Ababa	Nifas silk	Alert hospital compound	Ministry of health/AHRI	GETMETS Consulting	
20	2B+G+8 Dermatology and plastic surgery hospital	Buil ding		Addis Ababa	Nifas silk	Alert hospital	Ministry of health	KZN Consulting	
21	2B+G+3 Diagnostic center	Buil ding		Addis Ababa	Addis Ababa	ft.ptr. Hospital	Ministry of health	QTC Consulting	
22	Federal Document Authenthication and registration Agency	Buil ding	Hig h rise	Addis Ababa	Addis Ababa		Federal Government building construction project office	Yohannes Abay consulting Architects and Engineers	
23	Ethiopian construction corporation	Buil ding	Hig h rise	Addis Ababa	kirikos	Mexico (Senga tera)	Federal document Authentication and registration Agency	Yohannes Abay consulting Architects and Engineers	
24	Kolfe keranio city justice sectors building project	Buil ding		Addis Ababa	Addis Ababa	Around kolfe	Ministry of justice	Yohannes Abay consulting Architects and Engineers	
25	Lamberet Bus terminal	Buil ding		Addis Ababa	Addis Ababa	Yeka sub-city	Ministry of transport and logistics		Werwer construction plc

26	PSETSE Depots/Modern bus depots	Buil ding		Addis Ababa	Addis Ababa	yeka sub-city	PSETSE	Yohannes Abay consulting Architects and Engineers	
27	PSETSE Depots/Modern bus depots	Buil ding		Addis Ababa	Addis Ababa	Akaki sub-city	PSETSE	Yohannes Abay consulting Architects and Engineers	
28	PSETSE Depots/Modern bus depots	Buil ding		Addis Ababa	Addis Ababa	Nifas silk lafto Sub-city	PSETSE	Yohannes Abay consulting Architects and Engineers	

Source: - Ethiopian construction authority (2023)

Appendix E: Membership function level two and level one for sustainable practice group

A. Membership function level two

No	Sustainable practice	Weigh tings	Membership function level 3	Membership function level 2
1	**Economic sustainable practice**			
E1	West management	0.148	(0.02, 0.735, 0.184, 0.041, 0.02)	0.099, 0.325, 0.395, 0.176, 0.017
E2	Use of sustainable building material	0.171	(0.000, 0.469, 0.48, 0.102, 0.02)	
E3	Energy efficiency	0.153	(0.224, 0.245, 0.449, 0.082, 0.0)	
E4	Commissioning and monitoring	0.183	(0.02, 0.245, 0.612, 0.102, 0.02)	
E5	Proper storage and handling of material	0.221	(0.000, 0.082, 0.408, 0.49, 0.02)	
E6	Use of prefabricated component	0.123	(0.469, 0.286, 0.122, 0.102, 0.02)	
2	**Environmentally sustainable practice**			
EN1	Indore environmental quality	0.221	(0.00, 0.51, 0.367, 0.102, 0.020)	0.157, 0.361, 0.375, 0.070, 0.036
EN2	Control of dust to reduce pollution on building	0.181	(0.286, 0.408, 0.224, 0.02, 0.061)	
EN	Use of vertical green wall at the site to cool the office and improve aesthetics	0.153	(0.49, 0.306, 0.143, 0.02, 0.041)	
EN4	Controlling the use and dispersion of toxic materials	0.183	(0.163, 0.551, 0.245, 0.02, 0.02)	
EN5	Regular inspection and monitoring	0.262	(0.0, 0.102, 0.714, 0.143, 0.041)	

3	**Social sustainable practice**			
S1	Protection of Worker health and safety	0.276	(0.102, 0.265, 0.286, 0.327, 0.02)	0.162, 0.190, 0.486, 0.147, 0.016
S2	Training and certification of worker	0.21	(0.388, 0.122, 0.388, 0.102, 0.00)	
S3	Employee education and training	0.228	(0.204, 0.347, 0.327, 0.102, 0.02)	
S4	Collaboration and communication	0.286	(0.020, 0.041, 0.878, 0.041, 0.02)	

B. Membership function level one

No	Sustainable practice	Weigh tings	Membership function level 2	Membership function level 1
1	Economic sustainable practice	0.411	0.099, 0.325, 0.395, 0.176. 0.017	0.135, 0.299, 0.414, 0.142, 0.023
2	Environmentally sustainable practice	0.313	0.157, 0.361, 0.375, 0.07, 0.036	
3	Social sustainable practice	0.276	0.162, 0.19, 0.486, 0.174, 0.016	

Appendix F: Membership function level two and level one for Barrier group

A. Membership function level two

No	Barrier Group	Weigh tings	Membership function level 3	Membership function level 2
1	**Economic Barrier**			
BE1	Lack of financial incentives	0.254	(0, 0.122, 0.388, 0.388, 0.102)	(0.038, 0.115, 0.312, 0.423, 0.112)
BE2	Limited availability of suppliers of sustainable products and materials	0.281	(0, 0.163, 0.02, 0.633, 0.184)	
BE3	Insufficient professional capabilities	0.257	(0, 0.082, 0.429, 0.388, 0.102)	
BE4	The higher cost associated with sustainable buildings	0.209	(0.184, 0.082, 0.469, 0.224, 0.041)	
2	**Environmental barrier**			
BEN1	Lack of regulation to enforce sustainability	0.3	(0.184, 0.02, 0.041, 0.163, 0.592)	
BEN2	Lack of tools and techniques to support understanding of sustainability	0.266	(0, 0.143, 0.224, 0.612, 0.02)	(0.169, 0.083, 0.173, 0.361, 0.214)
BEN3	Lack of standardization and certification	0.227	(0.184, 0.041, 0.429, 0.286, 0.061)	
BEN4	Lack of environmental concern	0.207	(0.347, 0.143, 0.02, 0.408, 0.082)	
3	**Social Barrier**			
BS1	Lack of training and education	0.231	(0, 0.163, 0.02, 0.551, 0.265)	
BS2	Resistance to change	0.183	(0.184, 0.041, 0.469, 0.245, 0.061)	(0.089, 0.099, 0.309, 0.414, 0.089)

BS3	Lack of collaboration and coordination	0.219	(0.102, 0.041, 0.102, 0.714, 0.041)	
BS4	Time-consuming activities	0.188	(0, 0.163, 0.633, 0.204, 0)	
BS5	Client's lack of interest, understanding, and commitment makes its practical application difficult	0.179	(0.184, 0.082, 0.429, 0.265, 0.041)	

A. Membership function level one

No	Barrier	Weigh tings	Membership function level 2	Membership function level 1
1	Economic Barrier	0.318	(0.038,0.115, 0.312, 0.423, 0.112)	(0.103, 0.098, 0.259, 0.397, 0.143)
2	Environmentally Barrier	0.376	(0.169, 0.083, 0.173, 0.361, 0.214)	
3	Social Barrier	0.307	(0.038,0.115, 0.312, 0.423, 0.112)	

Appendix G: Membership function level two and level one for Driver group

A. Membership function level two

No	Drivers	Weigh tings	Membership function level 3	Membership function level 2
1	**Economic driver**			
DE1	Cost savings and efficiency	0.256	(0, 0.082, 0.429, 0.388, 0.102)	(0.005, 0.173, 0.338, 0.388, 0.08)
DE2	Use of integrated approach	0.273	(0, 0.041, 0.245, 0.653, 0.001)	
DE3	Reduced risk and liability	0.219	(0, 0.408, 0.265, 0.245, 0.082)	
DE4	Owners' commitment to sustainability	0.252	(0.02, 0.204, 0.408, 0.224, 0.143)	
2	**Environmentally driver**			
EN1	Environmental regulations and compliance	0.263	(0, 0.041, 0.102, 0.429, 0.429)	(0.005, 0.064, 0.096, 0.541, 0.165)
EN2	Regulations by the Government	0.271	(0.02, 0.02, 0.061, 0.367, 0.053)	
EN	Resource conservation and waste reduction	0.234	(0, 0.082, 0.184, 0.612, 0.122)	
EN4	Introducing green objectives early	0.233	(0, 0.122, 0.041, 0.796, 0.041)	
3	**Social driver**			
DS1	Client demand and market differentiation	0.121	(0.02, 0.102, 0.367, 0.408, 0.102)	(0.013, 0.121, 0.293, 0.422, 0.15)
DS2	Corporate social responsibility and ethical considerations	0.124	(0, 0.041, 0.408, 0.51, 0.041)	
DS3	Client's awareness and knowledge	0.120	(0, 0.163, 0.408, 0.265, 0.163)	
DS4	Employee engagement and retention	0.124	(0.02, 0.102, 0.245, 0.592, 0.041)	
DS5	Health and wellbeing of occupants	0.137	(0.041, 0.02, 0.184, 0.51, 0.245)	

DS6	Education and training programs by academicians	0.128	(0, 0.265, 0.082, 0.388, 0.265)	
DS7	Ethics and behavioral change	0.120	(0.02, 0.122, 0.265, 0.429, 0.163)	
DS8	Public awareness	0.126	(0, 0.163, 0.408, 0.265, 0.163)	

B. Membership function level one

No	Drivers	Weigh tings	Membership function level 2	Membership function level 1
1	Economic Drivers	0.235	0.005, 0.173, 0.338, 0.388, 0.080	0.009, 0.117, 0.249, 0.446, 0.137
2	Environmentally Drivers	0.276	0.005, 0.064, 0.096, 0.541, 0.165	
3	Economic Drivers	0.487	0.013, 0.121, 0.293, 0.422, 0.150	