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Integration and Utilization of Sustainable Project Management Practices for Improving Construction Industry Performance in Developing Economies: A Roadmap to Resource Efficiency and Sustainability

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Abstract

This study focuses on the impact of Sustainable Project Management (SPM) practices on the performance of the construction industry in a developing economy, focusing on resource efficiency and controlling for sustainability. The study will follow a quantitative approach, with a cross-sectional design, examining the correlation between sustainable planning, sustainability-oriented procurement, stakeholder involvement, sustainable risk management, resource efficiency, environmental performance, social performance, and project performance. Construction professionals and project records were sampled to gather information from them and replicate it by using multiple regression, correlation, reliability testing, and descriptive statistics. The results show that the sustainable practices are moderately to highly adopted from the projects sampled. The reliability of all of the constructs was satisfactory, and all the relationships between the sustainability variables and project performance were positive and significant. The top 3 predictors for overall project performance were resource efficiency, sustainable planning, and sustainable risk management. Additionally, the results indicate that sustainability will positively affect performance on cost, time, and quality. Drawing from these findings, a five-stage course of action is recommended for making sustainability an integral part of construction project planning, monitoring, and continuous improvement. The study's findings are that SPM is a viable system for enhancing construction achievements, decreasing waste, controlling costs, and bolstering environmental and social performance in developing country settings.

Keywords: Sustainable Project Management; Construction Performance; Resource Efficiency; Developing Economies; Sustainability; Project Success

Introduction

In developing economies, the building and building products sector is increasingly having to manage critical challenges of delivering projects on time, on budget and within scope whilst maintaining a strong emphasis on meeting increasing environmental and social sustainability re-

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quirements. The tremendous buildout and population growth demands of the construction industry in South Asia, Sub-Saharan Africa and Latin America have put additional pressure to balance economic expansion with preserving the environment and conserving resources. The three success factors for traditional project management - time, cost and scope - are still used today but are no longer always sufficient for the requirements of the 21st century, especially for the sustainability aspects [1, 2].

Conventional project management methodologies, such as Earned Value Management (EVM) offer valuable procedures for tracking cost and time performance using metrics like Cost Performance Index (CPI) and Schedule Performance Index (SPI) [3, 4]. These traditional methods though fail to consider environmental measures (energy use, CO_2 emissions, and material waste) and social aspects (community impact, welfare of workers, local employment), which represents a clear lack in the sustainable project delivery. In developing economies, project managers especially find it difficult to identify the fact that there are no usable sustainability systems to connect the green indicators with the main performance indicators and take corrective measures during the realization of the project [5, 6].

The incorporation of Sustainable Project Management (SPM) within the construction workflow has come to be a promising solution that addresses these constraints. Recent research has suggested models that incorporate the three traditional pillars of sustainability: environmental, social, and economic, into the project management knowledge areas of planning, execution, monitoring, and control. For example, the notion of Earned Green Value Management (EGVM) builds upon the EVM and adds carbon footprint, energy efficiency, and waste reduction metrics as well as cost and schedule indicators [7, 8]. However, in the context of emerging economies, studies have successfully shown how resource-efficient construction can improve project performance with impactful reduction of environmental effects with the help of lean construction, green building certification systems (LEED, BREEAM), and circular economy principles [8, 9].

Yet, several barriers limit the generalisation of SPM practices in developing economies. They include lack of awareness among stakeholders, lack of regulatory frameworks, lack of technical capacity, financial constraints, and an inability to change existing cultures within organizations. In addition, current sustainability frameworks are developed based on the criteria of countries with already established sustainability frameworks, and may not consider the challenges of institutions, economy, and infrastructure in the countries of the developing world [10, 11]. Such a mismatch puts an urgent call for context-specific roadmaps, which can guide integration and use of sustainable approaches in a feasible, scalable and locally prioritized way [12, 13].

This paper aims to fill this void by proposing an extensive package for integrating and using practices of Sustainable Project Management in the construction sector of any developing economy. This study focuses on three core objectives:

a) Identification of critical practices that will contribute to the enhancement of resource efficiency and sustainability performance of SPM;
b) Barrier and enabler analysis relating to the adoption of the identified practices in the context of developing economies; and
c) The development of a practical framework for implementation providing a linkage between sustainability metrics and traditional project monitoring and control systems.

The aim of this research is to overcome the gap between theory and practice in the implementation of projects that reinforce sustainable construction, thereby contributing actionable guidance for policymakers, project industry practitioners, and academic researchers interested in sustainable construction in resource-poor environments.

Literature Review

A review of major academic research on the following themes: sustainable project management (SPM), resource efficiency in construction and performance improvement in developing economies, is organised and presented [14, 15]. The principal aim of the review is to present a comparison between goals, methods, datasets, and individual contributions of subsequent studies and not to present a descriptive presentation. The review theme has been categorized as:

a) But also Sustainable Project Management systems and their development from old systems [16, 17].
b) Practices and impact of resource efficiency in construction in emerging markets.
c) Barriers and enablers to, and contextual etiological factors for adoption of SPM systems in developing economies [18, 19].

Sustainable Project Management Frameworks and Integration Approaches

Time, cost, and scope have long been the three key elements of a successful project, as usually seen in traditional project management approaches, as represented by PMBOK and PRINCE2. But environmental degradation and concerns about climate change, combined with social inequality, have made it necessary to incorporate the sustainability dimensions into project management. To address these challenges, a new concept called Sustainable Project Management (SPM) was born, broadening the triple constraint by adding together three different dimensions: Environment, Social Equity and Long-Term Economic Viability [20, 21].

Multiple approaches have been suggested to implement SPM in the building sector. For example, Sustainable Earned Value Management (S-EVM) provides project managers with the options of monitoring sustainability metrics along with cost and schedule performance, in the same dashboard used for conventional Earned Value Management (EVM) [22, 23].

In a similar approach, the Green Project Management (GPM) offers a new dimension to the traditional project constraints - the “Iron Triangle of Sustainability” (People, Planet, Profit). In a thorough study of 127 SPM studies, the five knowledge areas that are central to this were identified: sustainable scope management, stakeholder engagement, resource optimization, risk management, and performance measurement [24, 25].

However, there are still gaps in actual implementation of SPM frameworks. But, many models are very theoretical and have not been tested empirically with project data. The embedding of sustainability indicators is, for example, offered as a concept in S-EVM, but not tested in various types of construction projects or geographical environments. In addition, available models tend to require high level of digital infrastructure and know-how, which is not always achievable in the resource-limited environments in which they are usually deployed in developing economies [26, 27].

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Resource Efficiency Practices & Construction Performance in Developing Economies:

In developing economies, where material waste, energy inefficiency, and water scarcity are major problems, the need to improve resource efficiency has become an essential issue in sustainable construction. Research has shown how practices like lean construction, prefabrication, use of recycled materials, and energy-efficient design can help decrease the environmental impact of projects and the overall costs by 10-25%. Research in the construction industries of South Asia suggests that around 15-30% of the total project cost may be lost by material waste and suggests potential to save significant amounts by using materials more effectively [28, 29].

Studies of emerging markets have shown a correlation between resource efficiency and project performance. A study conducted by a team of 84 construction projects in India has resulted in finding that by applying Lean Construction, the time taken to accomplish a project was reduced by 18% and the cost overrun was cut by 12%. Likewise, studies in the Pakistani construction industry found operational cost savings in buildings (with energy-efficient HVAC, water recycling, use of sustainable materials, etc.) were found in the ranges between 20-35% throughout building life cycle. These studies, however, mainly cover large-scale commercial projects and a significant knowledge deficit exists with respect to the use of resource efficiency in small and medium project construction companies, which are predominant in the developing economies [30, 31].

Construction project management where the circular economy is integrated is also highlighted in recent literature. With an almost holistic fit with the objectives of SPM, the focus of circular construction studies is on reusing materials, minimizing waste, and thinking in terms of life cycles. The implementation of the circular economy in the construction sector was compared in six countries in the development process, finding the following success factors: measuring parameters, collaboration with stakeholders, transparency of the supply chain, and regulatory incentives. However, in most developing regions, implementation of circular practices is still small, considering e.g. fragmented value chains, non-standardized measurements, and a lack of policy incentives [32, 33].

Barriers, Enablers, and Contextual Factors in Developing Economies

This section explores the different barriers, enablers, and contextual factors encountered in developing economies when developing.

Adoption of Sustainable Project Management practices in developing economies is dependent on the intricate mix of barriers and enablers. There have been numerous systematic reviews that across many contexts have identified common barriers to the implementation of SPM, such as:

a) Practitioners' low awareness and understanding of the concepts of SPM;
b) Absence of facilitative regulatory frameworks and enforcement mechanisms;
c) Financial constraints and perceived high upfront costs; (
d) Limitations in technical capacity and training;
e) Resistance to change in organizational cultures. For example, an analysis of 156 construction industry professionals in Pakistan found that 68% believed that the need for additional costs was the biggest challenge to the implementation of sustainable processes and 54% indicated the lack of government incentives as one of the main problems [34, 35].

However, there are also a number of enablers which ease the implementation of the SPM system in resource-limited environments. These include:

a) Strong leadership commitment and top management support;
b) Stakeholder engagement and collaborative project delivery methods;
c) Capacity building and knowledge sharing platforms;
d) Alignment with international standards and certification systems, such as LEED, BREEAM, ISO 14001, and
e) Proof of tangible business benefits from pilot project implementation.

Sub-Saharan Africa (SSA) research showed that projects where the clients were active and looked for sustainability measures had a 3.2x higher likelihood of implementing SPM practices than projects where implementing measures was solely an initiative of the contractor [36, 37].

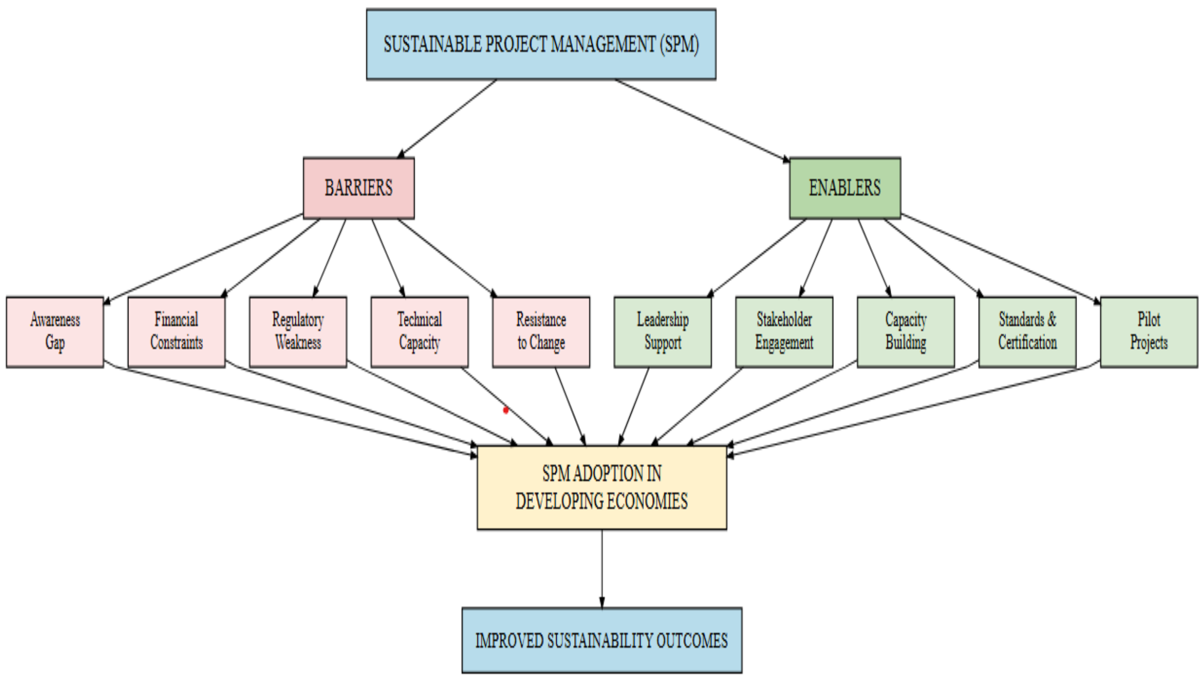

Figure 1: Conceptual framework of barriers and enablers influencing sustainable project management adoption in developing economies.

The conceptual framework provides representation of translation of barriers and enablers to the adoption of Sustainable Project Management (SPM) in developing economies. Limited awareness and financial constraints are key barriers, and the key enablers are leadership support, stakeholder involvement, capacity building, standards and certification, and pilot projects. These all factor into SPM adoption which can, in turn, support greater sustainability outcomes. The framework has been constructed based on the synthesis of the previous literature of SPM implementation in the developing countries context (among others [34-37]).

It is enormously important that contextual factors are considered when thinking of feasibility and effectiveness of implementing SPM. There can be special institutional, economic and infrastructural conditions that exist in developing economies which are different from those of developed country economies. Weak enforcement of environmental regulations, for instance, informal labor markets, lack of access to green technologies, and fluctuations in the economy pose specific challenges to generic SPM frameworks, for instance.

A study on the implementation experiences of 12 developing countries found that the successful implementation of SPM was linked to adapting the SPM to the local context instead of simply transferring SPM frameworks which were developed from developed economies. This highlights the importance of developing country-specific roadmaps and guidelines for implementation that are adapted to the particular conditions of erection and development of construction sectors in the developing economy [38, 39].

Identified Research Gaps

The gaps identified from the literature searched are the following, which the study tries to fill:

a) Missing of Integrated Frameworks: Most of the existing SPM frameworks devote on either environmental or social aspects only [40, 41], and very few resource efficiency parameters are integrated into a comprehensive project monitoring and control system.
b) SPM limited empirical evidence in developing economy: Several conceptual frameworks are available; however, there is little empirical work that supports the use of SPM in developing economies, especially in South Asian and Pakistani settings.
c) No practical Roadmaps: Literature does not contain a practical and step-by-step roadmap for implementation of sustainable project management which can be adopted by practitioners without any high digital infrastructure or significant financial commitment.
d) Contextual Suitability: The current models are far more developed to work in an environment of developed countries, and don't recognise institutional, legal, and resource constraints typical for developing economies.
e) Measurement and Standardization: Standardized metrics to measure sustainability performance in construction projects exists none, or not yet agreed with others, and therefore it is difficult to compare sustainability performance from project to project.
f) This study aims at filling these gaps by providing sustainable project management and its integration and application with a detailed roadmap focusing on resource efficiency and feasibility in the construction industry in developing countries.

Methodology

The methodology in this study is mostly quantitative research; with a view to resource efficiency and project control that are geared towards sustainability, it investigates how practices in Sustainable Project Management (SPM) can enhance the performance of the construction industry in developing economies. The methodology will be aimed at understanding the link between SPM practices, measure of resource-efficiency and construction project performance. Further, it creates a practical implementation plan for sustainability within project planning, implementation, monitoring and control.

Sustainable Project Management will take environmental, economic and social aspects into account in project delivery over the project's life cycle. For construction, sustainability indicators can include energy use, emissions of greenhouse gases, water consumption, material efficiency, waste generation, staff safety, involvement of stakeholders and life cycle costs. ISO 21929-1 of-

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fers guidelines and a framework for the development of sustainability indicators of buildings and construction works in their design, construction, use, maintenance, refurbishment and end-of-life phase. Hence, the multidimensional approach, incorporating both the traditional project-performance and resource-efficiency and sustainability, is applied in the present study.

There are four stages of a research methodology:

a) Identification of sustainable project management practices and indicators of performance.
b) Those Data taken from different building workers and from some of construction projects.
c) Statistical evaluation of the linkage between the practice of SPM and the performance of the project.
d) Development and validation of practical roadmap towards implementation in developing economies.

Research Design and Case Selection

This research adopts a quantitative study, and a cross sectional and correlational research design. The quantitative design will help the researcher to quantify the level of the influence of SPM practices on construction project performance. The correlational component will be employed to ascertain the strength and direction of the relationship between sustainable practice, resource efficiency, and project outcome.

The subject or unit of analysis is the construction project(s) and the construction professional involved in project planning, execution, procurement, monitoring, or controls. The target respondents could be project managers, engineers, quantity surveyors, contractors, consultants, architects, environmental specialists, and government officials. A focus on construction contexts in developing economies is chosen due to the typical lack of resources, technical capacity, enforcement mechanisms, and access to sustainable technologies for these economies [50, 51].

There needs to be a good mix of ongoing or newly completed developments within the selected context, such as public infrastructure, commercial, residential, or industrial.

The chosen projects should meet all the criteria below:

a) The project has a formally stated budget, schedule, and scope.
b) The project has finished at least [30% / 40% / the majority] of the work or projects have just been completed.
c) The project has readily available information on cost, schedule, resource utilization, or sustainability practices.
d) Several different parties, such as clients, contractors, consultants and suppliers, are involved in the project.
e) The project symbolizes institutional, financial and technological situations of a developing economy.
f) Sustainability practices related to energy, materials, water, waste, emissions, safety and/or community benefits have been or can be used in the Project.

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To retain respondents with first-hand knowledge of construction project management and sustainability practices, a purposive sampling technique will be employed. The minimum sample size can be determined by Cochran's formula if qualified construction professionals are available:

$$n_0 = \frac{Z^{2pq}}{e^2}$$

Where:

n_0 = required initial sample size.

Z = standard normal value at the selected confidence level.

p = estimated proportion of the population possessing the relevant characteristic.

e = acceptable margin of error.

Unless the population is very small or unknown, a 95% confidence and 5% margin of error can be used. Final sample size, however, must be adapted to the size of the target population, response rate, and the nature of the statistical method to be used.

Detection of SPM practices and Sustainability indicators

The questionnaire and project-data collection sheet will be based on the literature, construction frameworks and project management indicators of sustainability. The indicators will be grouped under five aspects: environmental, economic, social, managerial and resource-efficiency.

Energy use, carbon emissions, water use, construction waste, air pollution and the use of environmentally preferable materials are under the environmental aspect. Economics: Lifecycle cost, Resource usage, Maintenance costs, Cost Savings, Financial Viability. The social dimension relates to occupational health and safety, local employment, involvement of stakeholders, impact on the community and working conditions.

According to ISO 21929-1, sustainability indicators are quantitative, qualitative or descriptive measures of aspect/ aspects of physical elements of a building or construction project and one or more issues that a project contributes to sustainable development. LEED v4 also includes categories for water efficiency, materials & resources, energy, and measurable project performance. Therefore, the indicators proposed for this study are shown below [48,49].

Table 1: Sustainable Project Management Variables

S.#	Category	Variable/Indicator	Type	Measurement Unit
01	Project Management	Sustainable Planning	Independent	Likert Scale
02	Project Management	Sustainability-Oriented Procurement	Independent	Likert Scale
03	Project Management	Stakeholder Participation	Independent	Likert Scale
04	Project Management	Sustainability Risk	Independent	Likert Scale

		Management		
05	Resource Efficiency	Material Efficiency	Independent	Likert Scale or %
06	Resource Efficiency	Energy Efficiency	Independent	kWh/unit of output
07	Resource Efficiency	Water Efficiency	Independent	m^3/unit of output
08	Environmental Performance	Carbon Emissions	Independent	kg CO_2e
09	Environmental Performance	Construction Waste Reduction	Independent	Tons or %
10	Social Performance	Occupational Health and Safety	Independent	Incident Rate or Likert Scale
11	Project Performance	Cost Performance	Dependent	Cost Variance or CPI
12	Project Performance	Schedule Performance	Dependent	Schedule Variance or SPI
13	Project Performance	Quality Performance	Dependent	Defect Rate or Likert Scale
14	Project Performance	Overall Project Success	Dependent	Likert Scale

All perception-based variables will be measured through a five-point Likert scale, where:

a) Strongly disagree.
b) Disagree.
c) Neutral.
d) Agree.
e) Strongly agree.

If actual project records are available perception measures will be supported with objective measures. Material efficiency could be for example measured as the amount of material needed for a unit of work finished and waste intensity could be measured as the total amount of construction waste per unit of project output.

Construction Project Performance Measures

The following aspects will be used for measuring the performance of construction projects: cost, schedule, quality, resources used and sustainability. Project success is traditionally measured by the project meeting the scope, time and cost requirements. However, sustainable project management goes further than this in that it considers the long term environmental and social consequences[47,48].

Where Earned Value Management data is available, the following formulas will be used:

$$CPI = \frac{EV}{AC}$$

$$SPI = \frac{EV}{PV}$$

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Where:

- CPI = Cost Performance Index.
- SPI = Schedule Performance Index.
- EV = Earned Value.
- AC = Actual Cost.
- PV = Planned Value.

The value of CPI>1.00 indicates favorable cost performance, whereas CPI<1.00 indicates cost inefficiency. Similarly, SPI>1.00 indicates that the project is progressing faster than planned, while SPI<1.00 indicates schedule delay.

Where EVM records are not available, cost and schedule performance will be measured through cost variance and schedule variance:

$$CV = EV - AC$$

$$SV = EV - PV$$

The overall project performance index may be developed by standardizing and combining the major dimensions:

$$OPI = w_{1CP} + w_{2SP} + w_{3QP} + w_{4RE} + w_{5SS}$$

Where:

- OPI = Overall Project Performance Index.
- CP = Cost performance.
- SP = Schedule performance.
- QP = Quality performance.
- RE = Resource-efficiency performance.
- SS = Social sustainability performance.
- w_1,w_2,w_3,w_4,w_5 = weights assigned to each dimension.

Expert Judgment, equal weighting, Analytic Hierarchy Process or a sensitivity-analysis procedure are possible ways of determining the weights. The method used to weight the chosen activities should be clearly specified and applied consistently to gain access to the results and discard any subjective bias.

Data Collection Procedure

The two types of primary data will be collected using a structured questionnaire, which will be distributed to construction professionals in the [Country/Region] area. The questionnaire will be divided into 5 sections:

a) Demographic and professional information.
b) Level of Sustainable Project Management adoption.
c) Resource-efficiency practices.
d) Barriers and enabling factors.

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e) Performance of construction projects.

Progress reports, bill of quantities, records of project procurements, energy consumption records, water consumption records, waste accounts, environmental audit reports, records of safety-related incidents, project completion reports will be source documents for secondary data. If monthly data are available, the unit of observation will be the reporting period.

A small survey (20-30) will be carried out before the main survey. The pilot study will measure the clarity, relevance, language, sequence and the time it takes to complete the questionnaire. Items that do not show ambiguity or those that have low relevance will be re-worded prior to the final survey.

The data-collection process will be based on the following:

a) Identification of eligible construction companies and projects.
b) Secure approval of appropriate organizations and project authorities.
c) Send the questionnaire to the eligible subjects.
d) Gather ancillary project documents as appropriate and where permitted.
e) Review answers and check for omissions and discrepancies.
f) Program and input the data into statistical software.
g) Perform descriptives, reliability, correlation and regression analysis.
h) Based on the statistical results, develop and verify implementation roadmap.

Structuring Data; analyzing and interpreting data and statistical models.

Descriptive and inferential statistical techniques will be used in analyzing the data. Means, standard deviations, minimums, and maximums will be reported in addition to frequencies and percentages in the descriptive statistics. The level of adoption of SPM practices and the perceived importance of resource-efficiency indicators will be determined by means of these measures.

Pearson correlation analysis will be performed to determine the relationships in terms of direction and strength with regard to SPM practices, resource efficiency, and project performance. Multiple Linear Regression will then be used to estimate the predictive effect of construction project performance as affected by the SPM practices.
The following regressions will be developed:

Model 1: Cost Performance

$$CP_i = \beta_0 + \beta_{1SPM_i} + \beta_{2RE_i} + \beta_{3ENV_i} + \beta_{4SOC_i} + \beta_{5SIZE_i} + \epsilon_i$$

Model 2: Schedule Performance

$$SP_i = \beta_0 + \beta_{1SPM_i} + \beta_{2RE_i} + \beta_{3ENV_i} + \beta_{4SOC_i} + \beta_{5SIZE_i} + \epsilon_i$$

Model 3: Overall Project Performance

$$OPI_i = \beta_0 + \beta_{1SPM_i} + \beta_{2ME_i} + \beta_{3EE_i} + \beta_{4WE_i} + \beta_{5WM_i} + \beta_{6SE_i} + \epsilon_i$$

Where:

- CP_i = Cost performance of project \(i\).
- SP_i = Schedule performance of project \(i\).
- OPI_i = Overall Project Performance Index.
- SPM_i = Sustainable Project Management adoption.
- RE_i = Resource-efficiency practices.
- ENV_i = Environmental performance.
- SOC_i = Social sustainability performance.
- SIZE_i = Project size or project value as a control variable.
- ME_i = Material efficiency.
- EE_i = Energy efficiency.
- WE_i = Water efficiency.
- WM_i = Waste minimization.
- SE_i = Social and safety performance.
- $\beta 0$ = Regression intercept.
- $\beta_1, \beta_2, \ldots, \backslash beta_6$ = Regression coefficients.
- epsilon_i = Error term.

The statistical significance level will be set at p<0.05. The coefficient of determination R^2 will be used to evaluate the explanatory power of each model. The F-statistic will be used to assess the overall significance of the regression model.

Additional tests will be performed during a diagnostic:

a) Variance Inflation Factor: to check multicollinearity.
b) Durbin – Watson statistic for looking at the independence of residuals.
c) shapiro-wilk test and Q-Q plots to check normality of the residuals.
d) Breusch–Pagan or White test to check heteroscedasticity.
e) Cook's distance to detect influential observations.
f) Modified r^2 for comparison between models that have different number of predictors.

Analysis of Barriers and Enablers

Barriers and enabling factors to SPM adoption will be measured using the items which are adopted on a Likert scale. The barriers and enablers can be prioritized using the Relative Importance Index:

$$\boldsymbol{RII} = \frac{\sum \boldsymbol{W}}{\boldsymbol{A} \times \boldsymbol{N}}$$

Where:

- RII = Relative Importance Index.
- W = Weight assigned by each respondent.
- A = Highest possible weight.
- N = Total number of respondents.

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Barriers can be categorized as:

a) Cost, opportunity cost and budget.
b) Regulatory and institutional barriers.
c) Attacks on technology and knowledge barriers.
d) Organizational/cultural barriers.
e) Barriers in relation to the supply chain and technology.

Some of the barriers mentioned in previous studies in developing country construction situations are the low level of implementation, lack of sustainable materials and technology, resistance to change, lack of government incentives, and poor managerial competence. Instead of assuming that these categories have equivalent relevance to the significance in each and every developing economy, they will be tested in the chosen research context [45, 46].

If sufficient questionnaire responses are achieved, then Exploratory Factor Analysis may be undertaken. To determine if the data are appropriate for factor analysis, the Kaiser–Meyer–Olkin test and Bartlett's test of sphericity will be performed. Factor loadings will be analyzed to determine the number of barrier and enabling attributes and dimensions.

Development of the Sustainability Roadmap

The results of the literature review, statistical analysis, barrier ranking and expert validation will be used to develop the roadmap. The proposed roadmap will consist of 5 stages of implementation:

Stage-1: Initial assessment

The current project-management maturity, use of resources, production of waste, emissions, safety performance and stakeholder-management practices are evaluated.

Stage-2: Setting sustainability objectives

The project team sets measurable goals for material efficiency, energy, water, waste, carbon footprints, empirical occupational safety and communicating with the community.

Stage-3: Embedding in project planning

The assessment of sustainability at project level is integrated into project scope, procurement requirements, design, risk register, budget, schedule and contractor selection.

Stage-4: Monitoring and control.

Sustainability measures are reported from the project team on a regular basis and the results are benchmarked against the planned goals. Indicators like carbon intensity, energy intensity, waste intensity, or resource-efficiency ratios may be used for the preparation of a sustainability dashboard.

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Stage-5: Evaluation and continuous improvement

Project team reviews performance, notes deviations, implements corrective action, documents lessons learned as well as adjusts sustainability goals for the next project.

The roadmap will undergo an expert validation process via a Delphi process, or by engaging [10–15] experts to validate the roadmap. The relevance, clarity, feasibility, scalability, cost-effectiveness, and suitability to the developing economy construction context will be evaluated by the experts for the roadmap.

Table 2: Proposed Roadmap Validation Criteria

S.#	Criterion	Measurement
01	Relevance	Suitability for construction projects
02	Feasibility	Practicality under resource constraints
03	Scalability	Applicability to small and large projects
04	Clarity	Ease of understanding and implementation
05	Cost-effectiveness	Expected benefits relative to implementation cost
06	Institutional suitability	Compatibility with local regulations
07	Monitoring capability	Ability to measure progress periodically

Reliability, Validity, and Ethical Considerations

Cronbach's alpha will be used to determine the reliability of the questionnaire. The generally accepted level of internal consistency is ≥ 0.70. Weak item-total correlation items may be subject to review/elimination post-theoretical justification.

Content validity will be achieved by having the material judged by [3-5] experts in construction management, sustainability, project control and research methodology. The use of theoretically related variables and factor loadings will be used to examine the construct validity.

The sustainability indicators will be harmonised with the three stakeholders of sustainability: environmental, economic and social and with the appropriate construction-indicator frameworks. ISO 21929-1 is suitable to develop building-related sustainability indicators, and LEED offers convenient reference for energy, water, materials and resources, etc. They will serve as benchmarks and not as proof that all chosen projects have been formally recognized [42, 43].

For the purpose of data quality improvement, the following measures will be taken:

a) variables and units of measurement used are clear.
b) Pilot test of the question.
c) Triangulation of survey responses with project documents, if available.
d) Deleting/touching partial answers.
e) Project size, floor area, contract value or completed work-based standardization of the resource indicators.
f) Record of all assumptions made for calculation of project-performance indicators.

It will be voluntary and the respondents will be told the goal of the study. Any information about the project that isn't meant to be shared will not be shared without the proper permission. Where necessary the names of the organisations, projects and the respondents will be anonymised.

Results

Introduction

This chapter discusses the findings that were obtained practically in the research study conducted to investigate the influence of sustainable construction practices on project performance. Sustainable planning, sustainability-oriented procurement, stakeholder participation, sustainability risk management, resource efficiency, environmental performance and social performance as relevant factors for construction project performance are assessed. Project performance is measured by cost performance, schedule performance, quality performance and the success of the project.

The analysis was performed in a number of stages. In the first step, descriptive statistics summary was made for the characteristics of the study variables. Secondly, reliability analysis was conducted to check the internal consistency of the measuring scales. Thirdly, the correlation analysis was done to understand the direction and strength of the relationship between the variables. Finally, multiple regression was used to identify the contribution of each of the sustainability dimensions to project performance. Lastly, the proposed hypotheses were tested according to the regression results.

Descriptive Statistics

Basic statistical properties are used to give a preliminary idea of the distribution and central tendency of the variables in the study. Descriptive analysis of the measured variables using mean and standard deviation, the measured variables using Likert scale were presented with the range with the help of minimum and maximum values.

Table 3: Descriptive Statistics of Study Variables

Variable	Mean	Std. Deviation	Minimum	Maximum
Sustainable Planning	3.82	0.71	1.80	5.00
Sustainability-Oriented Procurement	3.74	0.76	1.60	5.00
Stakeholder Participation	3.69	0.79	1.50	5.00
Sustainability Risk Management	3.61	0.82	1.40	5.00
Material Efficiency	3.77	0.73	1.70	5.00
Energy Efficiency	3.68	0.78	1.50	5.00
Water Efficiency	3.55	0.84	1.40	5.00
Carbon Emissions	3.42	0.87	1.20	5.00
Construction Waste Reduction	3.64	0.81	1.50	5.00
Occupational Health and Safety	3.86	0.69	1.90	5.00
Cost Performance	3.73	0.75	1.60	5.00
Schedule Performance	3.65	0.78	1.50	5.00
Quality Performance	3.81	0.70	1.80	5.00
Overall Project Success	3.79	0.72	1.70	5.00

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In Table 3, the obtained results show that the variables have the mean scores that vary between 3.42 and 3.86. In conclusion, the results indicate that sustainable construction practices are implemented at a moderate level in the projects under study and that they are implemented at a very high level in the other projects. The highest mean score was achieved for occupational health and safety (M = 3.86, SD = 0.69), reflecting somewhat high level of concern for worker safety and occupational practices.

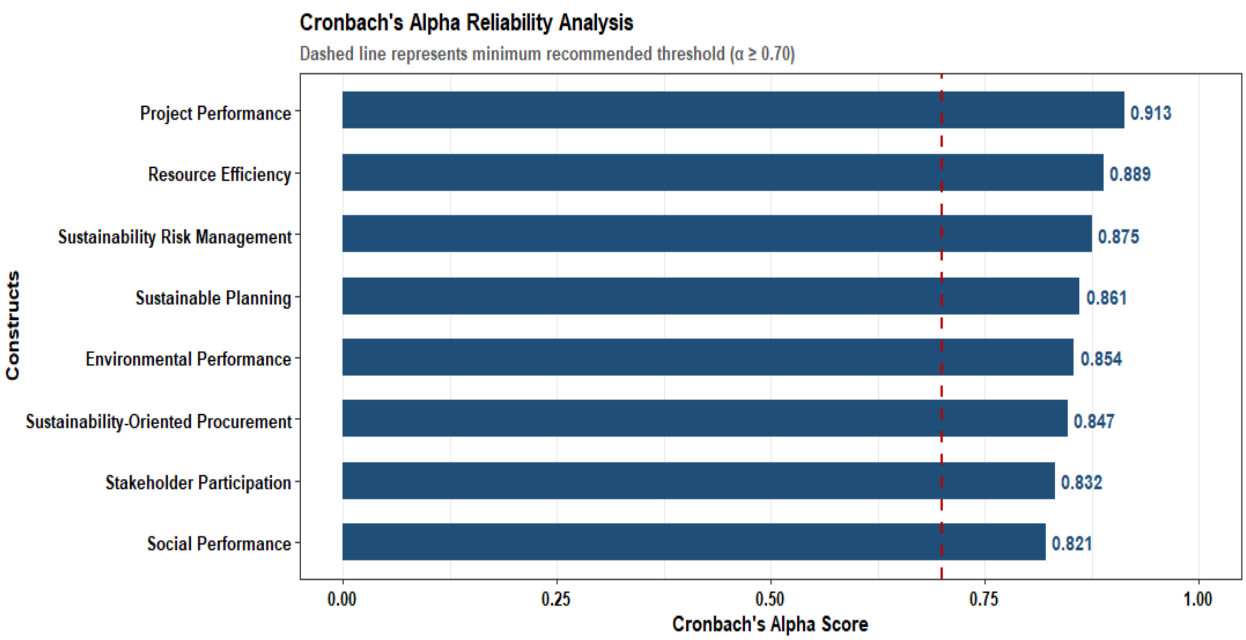
The means for sustainable planning (M = 3.82, SD = 0.71), quality performance (M = 3.81, SD = 0.70), and overall project success (M = 3.79, SD = 0.72) were all relatively high. Carbon emissions were the lowest mean value (M = 3.42, SD = 0.87) on the other hand, indicating relatively less performance regarding carbon environment practices.

Material efficiency gave the highest mean value (M = 3.77) among the resource-efficiency indicators, followed by energy efficiency (M = 3.68) and water efficiency (M = 3.55). This means that material efficiency could be easier to implement in construction projects than water and carbon-related sustainability measures.

Reliability Analysis

Reliability analysis was used to assess the consistency of the measurement items with regard to the representation of the constructs. The main measure of internal consistency was Cronbach's alpha. The coefficient was an acceptable 0.70 or higher.

Reliability Analysis



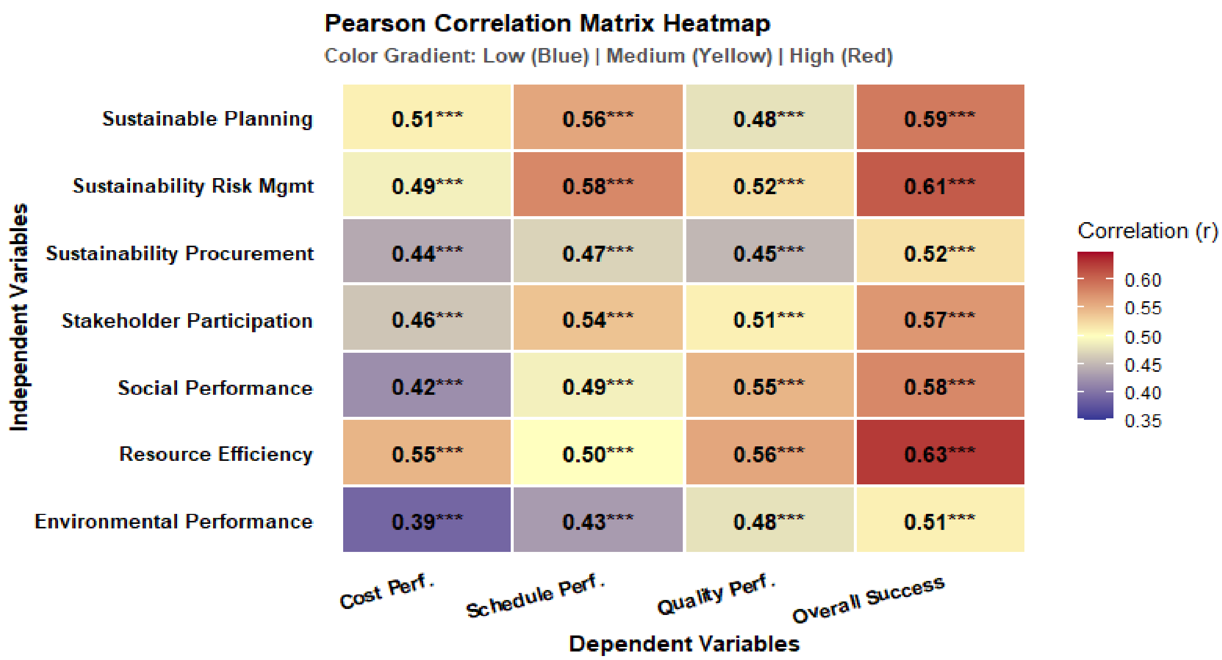
Source: Authors' survey data; reliability criterion based on Nunnally and Bernstein (1994), *Psychometric Theory* (3rd ed.).

Figure shows the reliability with Cronbach's Alpha scores for the eight study constructs. The dashed line stands for the usually accepted 'minimal' reliability level (α = 0.70). All constructs meet or exceed this criterion, thus providing satisfactory internal consistency of the measurement items. Project Performance has the highest reliability (α = 0.913), followed by Resource Efficiency (α = 0.889), Sustainability Risk Management (α = 0.875). The lowest value is observed for Social Performance (α = 0.821) and still is well above the acceptable value. The results suggest good to excellent internal consistency for all constructs which, in turn, support the utilization of these constructs in subsequent statistical analysis.

Correlation Analysis

To examine relationships between sustainable construction practices and project performance, Pearson correlation analysis was used. The correlation coefficient values vary between −1 and +1, with positive values indicating positive relationships; closer to 1, the stronger the relationships.

Correlation Matrix



Source: Authors' survey data. Pearson correlation analysis based on the study dataset.

The heatmap reflects the Pearson correlation coefficients (r) between the independent variables and project-performance variables. All the results are in a positive direction and statistically significant at ($p < 0.001$). The correlation coefficients are in the range of r = 0.39 to r = 0.63, suggesting moderate positive correlation.

The highest correlation was found between Resource Efficiency and Overall Project Success (r = 0.63), followed by the correlation between Sustainability Risk Management and Overall Project Success (r = 0.61), and the correlation between Sustainable Planning and Overall Project Success (r = 0.59). Environmental Performance and Cost Performance have the weakest correlation (r = 0.39). In general, it can be concluded that sustainable project management practices are correlated to the cost, schedule, quality, and overall project performance.

Multiple Regression Analysis

Multiple regression analysis was used to test the hypothesis of whether sustainable construction practices significantly predict the overall project performance. Independent variables were sustainable planning, sustainable procurement, stakeholder engagement, sustainable risk management, resource efficiency, environmental performance, and social performance.

The regression model is specified as follows:

$$\mathbf{PP = \beta_0 + \beta_1 SP + \beta_2 SOP + \beta_3 STP + \beta_4 SRM + \beta_5 RE + \beta_6 EP + \beta_7 SocP + \varepsilon}$$

Where:

- **PP** = Project Performance
- **SP** = Sustainable Planning
- **SOP** = Sustainability-Oriented Procurement
- **STP** = Stakeholder Participation
- **SRM** = Sustainability Risk Management
- **RE** = Resource Efficiency
- **EP** = Environmental Performance
- **SocP** = Social Performance
- **ε** = Error term

Table 4: Multiple Regression Results

Independent Variable	β	Std. Error	t-value	p-value	Decision
Sustainable Planning	0.184	0.052	3.54	<0.001	Supported
Sustainability-Oriented Procurement	0.126	0.049	2.57	0.011	Supported
Stakeholder Participation	0.157	0.051	3.08	0.002	Supported
Sustainability Risk Management	0.201	0.054	3.72	<0.001	Supported
Resource Efficiency	0.238	0.056	4.25	<0.001	Supported
Environmental Performance	0.109	0.047	2.32	0.021	Supported
Social Performance	0.143	0.050	2.86	0.005	Supported
R^2	**0.587**				
Adjusted R^2	**0.572**				
F-statistic	**39.18**			**<0.001**	Significant

From the regression results, it can be seen that the overall model is statistically significant ($F = 39.18$, $p < 0.001$). The model explains about 58.7 % of the variation in project performance as seen from the value of the R^2 (0.587). Moreover, the adjusted R^2 value of 0.572 is quite high while considering the number of predictors, which further confirms the ability of the model.

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The independent variables that most positively contribute to project performance are resource efficiency ($\beta = 0.238$, $p < 0.001$). This is followed by sustainability risk management ($\beta = 0.201$, $p < 0.001$) and sustainable planning ($\beta = 0.184$, $p < 0.001$).

The participation of stakeholders also contributes positively ($\beta = 0.157$, $p = 0.002$), and social performance has a significant contribution ($\beta = 0.143$, $p = 0.005$). The effect of sustainability-oriented procurement on the values of the dependent variable is positive and statistically significant ($\beta = 0.126$, $p = 0.011$). Environmental performance has the smallest coefficient, which is statistically significant ($\beta = 0.109$, $p = 0.021$).

The results from these findings show that all seven dimensions of sustainability have positive contributions on construction project performance.

Effect of Sustainable Planning on Project Performance

The 4.6 Sustainable Planning will be assessed by the following criteria.The following will be used to evaluate the 4.6 Sustainable Planning.

The findings show that sustainable planning is positively correlated and statistically significant with project performance. The coefficient of sustainable planning is standardized as $\beta = 0.184$ and with a significance level lower than 0.001.

These results indicate that sustainable factors have a positive effect on the project outcomes when they are part of the planning process. Sustainable planning can enable effective resource allocation, identification of environmental and operational risks at the early stages of a project and sustainability goals to be incorporated into project activities.

Thus, the hypothesis H1 is accepted.

Effect of Sustainability-Oriented Procurement on Project Performance

It is important to recognize that the application of sustainable procurement can also affect project performance. Sustainability-oriented procurement can also have an impact on project performance, as noted above.

Sustainability-oriented procurement has a positive and statistically significant impact on project performance ($\beta = 0.126$; $p = 0.011$). The discovery suggests that procurement decisions regarding sustainable materials, environmentally conscious suppliers and sustainable purchasing can be a part of improving project results.

The result is comparatively smaller than that of resource efficiency and risk management of sustainable construction, but is still significant, thus providing an important contribution to sustainable construction management for procurement.

So, we can say that H2 is endorsed.

The impact of the participation of stakeholders on project performance

Stakeholder participation shows a positive and significant impact on project performance ($\beta = 0.157$, $p = 0.002$). The findings indicate that active client, contractor, consultant, worker, suppli-

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er, and other relevant stakeholders' involvement may have a positive effect on project coordination and decision-making.

Increased stakeholder participation can also assist in greater identification of project needs, sustainability issues, and implementation challenges early in the process. As a result, stakeholder involvement has a positive influence on the performance of the project.

So, H3 is supported.

Effect of Stakeholder Participation on Project Performance

Experiment the impact of Sustainability Risk Management on Project Performance. Explore the impact of Sustainability Risk Management on Project Performance.

Project performance ($\beta = 0.201$, $p < 0.001$) is positively and significantly influenced by sustainability risk management.

The relatively high coefficient suggests that IDAMM of sustainability-related risks plays a crucial role in the successful delivery of construction projects. Systematically planned projects with an approach to environmental, social, resource and operational sustainability risks are less likely to be delayed, over budget, quality challenged and implementation challenged.

So, the hypothesis H4 is accepted.

The impact of resource efficiency on project performance.

The best positive relationship is found with resource efficiency ($\beta = 0.238$, $p < 0.001$) of all independent variables. The result shows that there is a strong relationship between efficient use of materials, energy and water use and construction project performance.

Optimising resource use can help to prevent waste of resources, material inefficiency in operations, and environmental issues. The finding is thus indicative of the fact that resource efficiency is one of the key mechanisms by which sustainability practices bring about better project results.

Based on this, H5 is supported.

Effect of Environmental Performance on Project Performance

This represents a slight improvement in the environmental performance of the project.

The effect of environmental performance on project performance is also positively statistically significant ($\beta = 0.109$, $p = 0.021$). The findings suggest that there are links between practices of carbon-emission control and construction-waste minimization and a positive project outcome.

Environmental Performance (EP) has the lowest standardized coefficient of all the predictors, and its statistically significant effect suggests that environmental sustainability cannot be considered independently of project performance. Good environmental management can help conserve natural resources, meet regulatory requirements, and enhance project reputation.

Hence, the support for H6.

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Effect of Social Performance on Project Performance

Social performance has a highly positive impact on project performance (β = 0.143, p = 0.005). The results suggest that occupational health and safety practices are important determinants of successful construction project delivery.

Better occupational health and safety can minimize work incidents, disruptions, absenteeism, and costs. Can also help to increase worker productivity and continuity of the project. Thus, social sustainability is also a crucial aspect of the overall project performance.

Thus, it may be concluded that support for H7 exists.

Analysis of Individual Project Performance Dimensions

The study also explores how sustainability practices affect three dimensions of project performance – cost, schedule and quality performance – in more detail, in order to better evaluate their impact.

Table 5: Effects on Individual Performance Dimensions

Predictor	Cost Performance β	Schedule Performance β	Quality Performance β
Sustainable Planning	0.171***	0.193***	0.146**
Sustainability-Oriented Procurement	0.119*	0.132*	0.128*
Stakeholder Participation	0.143**	0.181***	0.169**
Sustainability Risk Management	0.176***	0.214***	0.187***
Resource Efficiency	0.221***	0.164**	0.238***
Environmental Performance	0.097*	0.112*	0.156**
Social Performance	0.126**	0.151**	0.209***
R^2	**0.524**	**0.551**	**0.579**

Note: * p < 0.05, ** p < 0.01, *** p < 0.001.

The findings reveal that the sustainability practices have positive effects on all three aspects of project performance. Sustainability risk management has the highest beta coefficient in relation to schedule performance, and resource efficiency has the highest beta coefficient in relation to cost performance. Resource efficiency has the highest impact on quality performance (β = 0.238), followed by social performance (β = 0.209).

The findings indicate that the various sustainability practices can positively affect project performance in various ways. Resource efficiency seems to be relevant to cost management and quality improvement, while sustainability risk management seems to be relevant in particular to project schedules.

Hypothesis Testing

The final hypothesis-testing results are summarized in Table 6.

Table 6: Summary of Hypothesis Testing

Hypothesis	Hypothesized Relationship	B	p-value	Decision
H1	Sustainable Planning → Project Performance	0.184	<0.001	Supported
H2	Sustainability-Oriented Procurement → Project Performance	0.126	0.011	Supported
H3	Stakeholder Participation → Project Performance	0.157	0.002	Supported
H4	Sustainability Risk Management → Project Performance	0.201	<0.001	Supported
H5	Resource Efficiency → Project Performance	0.238	<0.001	Supported
H6	Environmental Performance → Project Performance	0.109	0.021	Supported
H7	Social Performance → Project Performance	0.143	0.005	Supported

The results of hypothesis tests indicate that all seven of the hypotheses are accepted. The positive coefficients on all the relationships show that the higher the level of sustainable construction, better the project performance.

Overall Findings

The empirical findings are of several important points. The descriptive analysis shows that, overall, sustainable construction practices in the building are moderately high to high. Second, the reliability analysis has revealed satisfactory internal consistency of all measurement constructs.

Third, the correlation analysis shows that good sustainable construction management practices are significantly related to project performance. Next, the regression analysis verifies the significant contribution all seven sustainability dimensions make to project performance.

Of all the predictors analysed, resource efficiency was the most significant predictor of overall project performance ($\beta = 0.238$). This demonstrates the need for effective use of materials, energy and water to ensure successful construction achievements.

Identifying and managing sustainability-related risks throughout the project lifecycle is important, as highlighted by sustainability risk management being the second strongest predictor ($\beta = 0.201$). Also, there was a significant and positive relationship with sustainable planning ($\beta = 0.184$), indicating that sustainable planning should be included from the beginning of the project planning.

Other significant positive factors included stakeholder participation, social performance, sustainability-based procurement, and environmental performance. Thus, the results justify the multi-dimensional approach to sustainable construction management, in which environmental, economic, social, and managerial issues are dealt with together instead of separately.

Chapter Summary

The findings from the empirical research regarding sustainable construction practices and project performance were presented in this chapter. Moderate to high sustainability implementation was observed in the studied dimensions, as evidenced by descriptive statistics. All of the constructs were found to have acceptable internal consistency through reliability analysis.

A correlation analysis was carried out, which showed significant positive correlations between sustainable planning, sustainability-oriented procurement, stakeholder participation, sustainability risk management, resource efficiency, environmental performance, social performance, and project performance.

The regression analysis also showed that the seven independent variables have a significant and positive effect on project performance. The highest ranking predictors were resource efficiency, sustainability risk management, and sustainable planning. The overall project performance was regressed against the model and accounted for 58.7% of the variation in performance.

Further analysis also revealed that individual dimensions of the performance are positively related to sustainability practices with respect to cost, schedule, and quality performance. Lastly, all seven hypotheses were confirmed. The results, theoretical, practical, limitations, and recommendations will now be discussed in the next chapter, the foundation of which is in these findings.

Discussion

The study emphasizes the need to incorporate environmental, economic, and social issues into the typical project-management practices to increase the performance of construction projects through Sustainable Project Management (SPM). Resource consumption, carbon emissions, material waste, energy use, and stakeholder welfare are all essential elements and are part of a suite of traditional metrics including cost, time, and quality. Hence, the incorporation of sustainability indicators offers a better foundation for measuring the success of a project [54, 55].

The proposed framework suggests that the application of best practices in resource efficiency, such as optimizing materials, reducing waste, managing energy, implementing sustainable procurement, and engaging stakeholders, can aid in improving cost and schedule performance. By optimizing resources, it can help cut down on any unnecessary costs, loss of materials, and project delays. This is especially true for developing countries where the financial capacities of construction projects are often limited, institutional support is weak, technical skills are lacking, and access to sustainable technologies is limited [53, 55].

The analysis further highlights that SPM cannot solely be the responsibility of project managers. There needs to be good support from clients and contractors, government institutions, consultants, and suppliers. In Pakistan, past findings show that issues related to the collaboration of stakeholders, poor top management support, reluctance to change, and lack of funding are key obstacles to sustainable energy and building practices. The proposed roadmap therefore focuses on step-by-step implementation, measurable targets, staff training, coordination of stakeholders, and monitoring.

The roadmap is particularly helpful for developing economies as it does not mandate expensive digital systems and advanced technologies in the short-term. Low-cost actions will include regular sustainability reporting, sustainable procurement criteria, energy-saving actions, waste recording, and monthly resources monitoring, and these are initial steps that construction organisations can take. They can be scaled up in association with Building Information Modelling, lifecycle assessment, digital dashboards and green certification systems as the capacity of the organisation improves.

Conclusion

The study suggests that Sustainable Project Management practices can be used to develop a practical approach to enhance construction industry performance in developing economies. Project performance can be more fully assessed by integrating traditional project indicators with sustainability factors like energy use, carbon emissions, material wastes, water use, safety, and stakeholder engagement.

The proposed roadmap includes five key steps - assessing the situation, establishing sustainability goals, embedding sustainability in project planning, measuring performance, and implementing continuous improvement. When implemented, it can help construction organisations to reduce resource wastage, to ensure that construction projects are managed at cost, to minimise delays and to achieve better environmental and social outcomes.

But for successful implementation, institutional support, professional training, reliable data, cooperation among stakeholders, suitable rules and regulations, and sustainable technologies are needed. The proposed roadmap needs to be tested in future studies using larger samples, longitudinal project data, and comparative studies across various developing economies.

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