

Volume 7	Issue 2	August (2026)	DOI: 10.47540/ijsei.v7i2.2829	Page: 128 – 136
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Analysis of green construction implementation during the building construction phase: case study in Bandung City

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ARTICLE INFO

Keywords: Construction; Environmental Sustainability; Implementation; Policy.

Received : 19 June 2026

Revised : 21 July 2026

Accepted : 18 August 2026

ABSTRACT

Green construction implementation has become an important approach to reducing environmental impacts generated during building construction activities. However, the implementation of green construction principles during the construction phase still faces various challenges at the project level. This study aims to analyze the implementation of green construction during the building construction phase in Bandung City based on the Regulation of the Minister of Public Works and Housing Number 21 of 2021, identify the factors influencing its implementation, and formulate optimization strategies. The study employed a qualitative-dominant approach with a sequential explanatory mixed methods design, using in-depth interviews supported by quantitative data to strengthen the analysis. The analysis was conducted using George C. Edwards III's policy implementation model, consisting of communication, resources, disposition, and bureaucratic structure dimensions. The findings indicate that green construction implementation has been initiated but remains suboptimal. The main influencing factors include policy understanding, resource availability, implementers' commitment, and stakeholder coordination. Therefore, strengthening implementers' capacity and improving implementation mechanisms are necessary to support more sustainable urban development.

INTRODUCTION

The construction sector is one of the major contributors to environmental pressure through intensive resource consumption, energy use, waste generation, and emissions throughout the development process (Ira, 2021; Ujang et al., 2023; United Nations Environment Programme, 2024). In building construction projects, environmental impacts are not only generated during the operational phase but also during the construction phase through material utilization, water and energy consumption, and construction waste generation (Green Building Council Indonesia, 2021; Habert et al., 2020; Sandanayake, 2022). This condition has encouraged the adoption of green construction as an approach that integrates environmental considerations into construction processes to support sustainable development.

In Indonesia, the implementation of sustainability principles in the construction sector has been strengthened through Regulation of the Minister of Public Works and Housing Number 21 of 2021 concerning Green Building Performance Assessment (Ministry of Public Works and Housing, 2021). This regulation positions green construction as an essential component of building development by promoting efficient resource utilization, reducing environmental impacts, and improving sustainability performance throughout the construction cycle (Praganingrum et al., 2023). During the construction phase, however, successful implementation depends not only on the existence of regulations but also on how effectively these policies are translated into project practices (Persson et al., 2018).

Despite the established regulatory framework, the implementation of green construction in practice continues to face various challenges. Project complexity, limited resources, varying levels of policy understanding among implementers, and coordination among stakeholders may influence the effectiveness of implementation (Arman et al., 2023; Wang et al., 2024). In environmental policy contexts, successful implementation should not only be measured through administrative compliance but also through the extent to which sustainable construction principles are applied in actual project execution (Nurkaidah et al., 2024; Ioannou et al., 2025).

Bandung City, as one of the rapidly developing urban areas in Indonesia and part of the Bandung Basin Urban Area, provides a relevant context for examining green construction implementation (Amalputra et al., 2023). The increasing intensity of building development requires construction practices that place greater emphasis on environmental performance and resource efficiency (Apandi et al., 2023). However, the extent to which green construction principles have been implemented during the construction phase of building projects remains insufficiently explored.

This study adopts George C. Edwards III's policy implementation model, which emphasizes four dimensions: communication, resources, disposition, and bureaucratic structure (Edward III, 1980). Although studies have examined green construction practices and environmental policy implementation (Agnes & Koestoer, 2021; Chen et al., 2024), limited research has specifically investigated implementation effectiveness during the building construction phase using a policy implementation perspective in the context of Bandung City.

Using this framework, the study aims to analyze the implementation of green construction

during the building construction phase in Bandung City, identify the factors influencing its implementation, and formulate recommendations to support more effective implementation toward sustainable urban development.

MATERIALS AND METHODS

Research design

This study employed a qualitative-dominant mixed methods approach using a sequential explanatory design (Wipulanusat et al., 2020). The quantitative phase was conducted to obtain an overview of the implementation level of green construction indicators, while the qualitative phase was used to explain, deepen, and interpret quantitative findings (Creswell & Creswell, 2022). The study focused on the implementation of green construction during the construction phase of building projects in Bandung City based on the provisions outlined in the Regulation of the Minister of Public Works and Housing Number 21 of 2021 (Ministry of Public Works and Housing, 2021).

The study was conducted through two stages. First, quantitative data were collected using questionnaires to evaluate the implementation of green construction indicators. Second, qualitative data were collected through in-depth interviews and document review to identify factors influencing implementation and formulate improvement strategies.

The analysis framework adopted George C. Edwards III's policy implementation model, consisting of four dimensions: communication, resources, disposition, and bureaucratic structure (Edward III, 1980). These dimensions were used to examine how policy implementation influenced the application of green construction practices during project execution.

Table 1. Research Design

Stage	Method	Data Collection	Output
Stage 1	Quantitative	Questionnaire	Description of green construction implementation
Stage 2	Qualitative (dominant)	In-depth interview and document analysis	Explanation of influencing factors and optimization strategies
Integration	Mixed Methods Sequential Explanatory	Data interpretation	Comprehensive implementation analysis

Research location and participants

The study was conducted in Bandung City, Indonesia, focusing on building construction projects implementing green construction principles. Participants were selected using purposive sampling, considering their involvement and understanding of project implementation and green construction practices.

Data collection techniques

This study used primary and secondary data. Primary data were collected through questionnaires

distributed to project stakeholders to assess the implementation level of green construction and through in-depth interviews with key informants to identify factors influencing implementation. Secondary data were obtained from regulations and project-related documents to support analysis and interpretation of the findings.

Research variables and analytical framework

The study used George C. Edwards III's policy implementation dimensions as analytical categories.

Table 3. Analytical Dimension

Variable	Dimension	Indicator
Green Construction Implementation	Communication	Information delivery, policy understanding
	Resources	Human resources, facilities, capability
	Disposition	Commitment and responsiveness
	Bureaucratic Structure	Coordination and implementation procedures

Data analysis

Quantitative data were analyzed descriptively to identify the implementation condition of green construction indicators. Qualitative data were analyzed using interactive analysis, including data

reduction, data display, and conclusion drawing. Findings from both stages were integrated during interpretation to obtain a comprehensive understanding of implementation conditions and the factors affecting green construction practices.

Research Flow

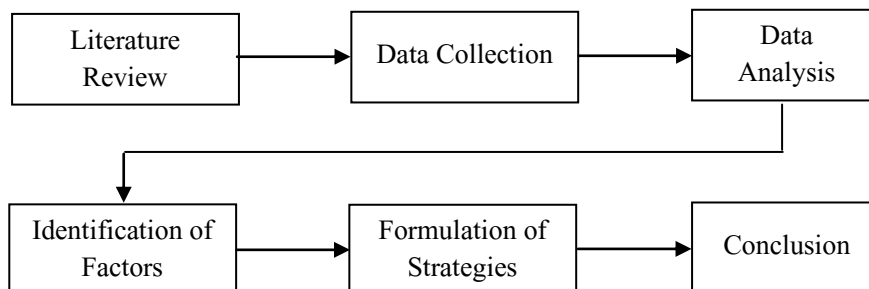


Figure 1. Research Flowchart

Source: Researcher's Analysis (2026)

RESULTS AND DISCUSSION

Overview of green construction implementation during the construction phase

Based on qualitative findings, the implementation of green construction during the building construction phase in Bandung City has generally been carried out in accordance with the principles regulated in the Minister of Public Works and Housing Regulation Number 21 of 2021. However, implementation effectiveness varies depending on project conditions, stakeholder performance, communication effectiveness, and implementation capacity (Ibrahim et al., 2024).

Interview findings indicate that green construction practices have begun to be integrated

into project execution, particularly through environmentally oriented construction procedures, implementation management, and resource efficiency efforts. Nevertheless, implementation has not yet been fully consistent across all projects.

Informants explained that implementation tends to be stronger for activities directly integrated into project operational procedures, while practices requiring behavioral adaptation and broader stakeholder coordination remain more difficult to maintain.

To support these qualitative findings, questionnaire results were used as complementary evidence.

Table 4. Green Construction Implementation Index in Bandung City

Implementation Dimension	Mean	Index (%)	Category
Green Construction Process	3.96	79.25	High
Green Behavior Practices	3.71	74.11	High
Green Supply Chain	3.89	77.78	High
Overall Average	3.85	77.04	High

The quantitative findings support the qualitative interpretation. The overall implementation index reached 77.04% (high category), indicating that green construction principles have generally been implemented during the construction phase.

Among all dimensions, Green Construction Process achieved the highest score (79.25%), indicating that implementation activities integrated into project procedures tend to be more established. Meanwhile, Green Behavior Practices obtained the lowest score (74.11%), suggesting that implementation requiring behavioral and organizational change remains relatively less optimal.

Factors influencing green construction implementation

Qualitative analysis based on George C. Edwards III's implementation framework identified four interconnected factors influencing the effectiveness of green construction implementation during the building construction phase in Bandung City, namely communication, resources, implementers' disposition, and bureaucratic structure (Edward III, 1980).

Interview findings indicate that communication has generally supported policy implementation through dissemination activities and

coordination mechanisms among stakeholders. However, differences in interpretation and understanding of technical implementation requirements remain evident across projects (Pirotti, 2022). As a result, implementation consistency tends to depend on each project's internal interpretation and operational practices.

In addition, resource readiness emerged as one of the determining factors affecting implementation effectiveness. Informants emphasized that successful implementation depends not only on the availability of facilities and operational support but also on stakeholder capability to understand and apply green construction principles in practice. Variations in implementation capacity among project actors contributed to differences in implementation outcomes (Kim et al., 2020; Söderberg & Liff, 2023).

The disposition of implementers also influenced implementation performance. Findings show that project stakeholders generally demonstrate positive attitudes and commitment toward environmentally responsible construction practices. Nevertheless, implementation intensity varies according to project priorities, organizational readiness, and perceived operational burden. This suggests that successful implementation is shaped not only by technical requirements but also by

stakeholder willingness to maintain sustainable practices (Tumpa & Naeni, 2025; Yetunde Adenike Adebayo et al., 2024).

Furthermore, bureaucratic structure plays an important role in ensuring implementation consistency. Informants explained that implementation tends to become more effective when responsibilities, procedures, and coordination mechanisms are clearly established. Conversely, coordination gaps and inconsistencies in implementation arrangements may reduce implementation effectiveness across project stages (Menon, 2024; Stanikzai & Mittal, 2025).

These qualitative findings are supported by questionnaire results, which show that green construction implementation achieved an overall mean score of 3.85 and an implementation index of 77.04%, categorized as high. Among the implementation dimensions, Green Construction Process recorded the highest achievement (79.25%), while Green Behavior Practices showed the lowest score (74.11%). This result indicates that implementation aspects integrated into project procedures tend to perform better than aspects requiring behavioral and organizational adaptation.

Driving and inhibiting factors of green construction implementation

The findings indicate that the effectiveness of green construction implementation during the building construction phase in Bandung City is influenced by the interaction between enabling and constraining factors identified from both qualitative and quantitative findings. These results suggest that implementation outcomes are determined not only by regulatory existence but also by the ability of implementing organizations to translate policy objectives into operational practices (Khan, 2016; Omamo, 2026).

Driving factors were primarily associated with regulatory support, stakeholder commitment, and the integration of environmental considerations into project procedures. The existence of the Regulation of the Minister of Public Works and Housing Number 21 of 2021 has provided institutional direction for the adoption of green construction practices. This finding supports Edwards III (1980), who argues that implementation effectiveness depends on the interaction between policy direction and implementation conditions. In the context of sustainable construction, previous studies also

explain that regulatory frameworks become more effective when supported by organizational commitment and stakeholder engagement, as regulatory provisions alone are insufficient without institutional support and stakeholder alignment (Hernandez Aros et al., 2025; Emere & Oguntola, 2026).

However, the findings also reveal that implementation barriers remain despite the presence of regulatory support. Differences in stakeholder understanding, limited implementation capacity, and variations in technical readiness contributed to inconsistencies in implementation across projects. This condition indicates that policy implementation does not automatically lead to uniform implementation outcomes (Mugambwa et al., 2018). This finding aligns with Røvik (2016), who explains through the concept of policy translation that policies undergo interpretation and adaptation when implemented within organizational settings, resulting in different forms of implementation across actors and contexts (Røvik, 2016).

Furthermore, implementation challenges became more visible in aspects requiring behavioral and organizational change. Questionnaire findings support this interpretation, showing that although the overall implementation index reached 77.04% (high category), Green Behavior Practices achieved the lowest implementation score (74.11%) among all dimensions. This finding is consistent with studies in sustainable construction implementation showing that technical requirements are generally easier to institutionalize than practices requiring long-term behavioral adjustment and organizational transformation (Alrizal et al., 2024; Mufida et al., 2026).

Overall, these findings demonstrate that improving green construction implementation requires not only regulatory intervention but also strengthening organizational capacity, improving coordination mechanisms, and developing institutional commitment to support the internalization of sustainable construction practices (Gu et al., 2023; Firoozi et al., 2025; Imanto & Hardjomuljadi, 2025).

Strategy formulation based on SWOT analysis

Following the analysis of implementation factors using George C. Edwards III's framework, this study further employed SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to

formulate strategic recommendations for improving green construction implementation during the building construction phase in Bandung City (Setiawan & Syukri, 2026).

In this study, SWOT analysis was not used as an alternative implementation model but as a strategic tool to synthesize findings obtained from the implementation analysis. Internal factors

(strengths and weaknesses) were derived from the implementation dimensions identified through Edwards III's framework, including communication, resources, implementers' disposition, and bureaucratic structure. Meanwhile, external factors (opportunities and threats) were identified from broader environmental and institutional conditions affecting implementation.

	Internal Factors	External Factors	
		Opportunities (O)	Threats (T)
Strength (S)	- Regulatory support for green construction implementation. - Integration of environmental considerations into construction procedures. - Stakeholder commitment toward sustainability practices. - Availability of technical guidelines and green construction standards. - Increasing awareness of environmental responsibility among project actors.	- Increasing attention to sustainable development and environmental protection. - Stronger environmental governance and regulatory support. - Growing demand for environmentally responsible construction practices. - Potential for collaboration between government, industry, and academia.	- Variations in project readiness and stakeholder capability. - Coordination complexity among multiple stakeholders. - Resistance to operation adjustments required by green construction practices. - Limited enforcement consistency. - Budget constraints that may affect implementation quality.
Weakness (W)	- Uneven understanding of green construction requirements among stakeholders. - Differences in implementation capability and technical competence. - Limited operational adaptation in applying green construction principles. - Coordination and communication challenges across project stages. - Environmental performance monitoring not yet fully integrated.	SO Strategy (Strengths – Opportunities) - Utilize existing regulatory support and stakeholder commitment to capture opportunities from sustainable development trends. - Strengthen collaboration with government, industry, and academia to promote innovation and green technology adoption. - Leverage integration of environmental considerations to meet growing demand for environmentally responsible construction	ST Strategy (Strengths – Threats) - Use regulatory support and strong commitment to mitigate resistance to operational adjustments. - Strengthen coordination mechanisms to reduce complexity among stakeholders. - Enhance enforcement and monitoring to minimize risks from inconsistent implementation. - Optimize existing standards and guidelines to maintain implementation quality under budget constraints.
		WO Strategy (Weaknesses – Opportunities) - Improve understanding and technical capacity of stakeholders by utilizing training and capacity-building opportunities. - Strengthen communication and coordination to address differences in implementation understanding. - Integrate environmental performance indicators into project monitoring systems to leverage strong environmental governance.	WT Strategy (Weaknesses – Threats) - Improve stakeholder capability and organizational readiness to reduce risks from project readiness variations. - Develop adaptive and flexible implementation mechanisms to address complexity and resistance. - Strengthen internal coordination and standardization to ensure consistency across project stages. - Optimize resource allocation to minimize the impact of budget limitations.

Figure 2. SWOT-Based Strategy Formulation for Green Construction Implementation

Source: Researcher's analysis (2026)

The SWOT analysis indicates that implementation strengths include the existence of regulatory support, stakeholder commitment, and the integration of environmental considerations into project procedures. However, implementation weaknesses remain, particularly related to differences in implementation understanding, limited implementation capacity, and coordination challenges.

From the external environment, opportunities arise from increasing attention toward sustainable development and stronger environmental governance, while threats include implementation complexity, institutional adjustment challenges, and variations in stakeholder readiness (Naseer et al., 2025).

Based on the interaction among these factors, strategic directions were formulated to strengthen implementation effectiveness. These include improving stakeholder capacity, strengthening communication and coordination mechanisms, integrating environmental performance monitoring, and increasing institutional adaptability to support sustainable construction practices (Omoregie & Aigbavboa, 2026).

Therefore, the proposed strategy framework represents a continuation of the implementation analysis rather than a replacement of Edwards III's framework (Edward III, 1980). The framework serves as a practical recommendation derived from empirical findings to support more effective green construction implementation.

CONCLUSION

This study found that green construction implementation during the building construction phase in Bandung City has generally been carried out in accordance with the Regulation of the Minister of Public Works and Housing Number 21 of 2021, with an overall implementation index of 77.04% (high category). The highest performance was found in Green Construction Process (79.25%), while Green Behavior Practices (74.11%) showed the lowest implementation level.

Implementation effectiveness was influenced by communication, resources, implementers disposition, and bureaucratic structure. Regulatory support and stakeholder commitment acted as driving factors, while differences in understanding, limited implementation capacity, and coordination

challenges became the main barriers. Based on these findings, SWOT analysis identified strategies focusing on strengthening stakeholder capacity, improving coordination mechanisms, and enhancing environmental performance monitoring to support more effective green construction implementation.

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