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Analysis of Green Building Implementation at The Planning Stage of Educational Buildings in Badung Regency

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Abstract

The rapid development of educational buildings in Badung Regency, Bali Province, has increased construction, operational, and maintenance costs, raising concerns about environmental sustainability and resource efficiency. This study aims to evaluate the level of green building implementation at the planning stage of elementary and junior high school buildings, identify dominant constraints, and formulate improvement strategies. The research employed a mixed-methods approach with an explanatory sequential design, involving a survey of planning consultant team leaders followed by quantitative and qualitative analyses. Descriptive analysis was used to determine implementation levels, while constraint prioritization and typology classification were conducted to explore key barriers. Qualitative data were obtained through focus group discussions to support strategy formulation. The findings show that the average level of green building implementation at the planning stage is 60.82 percent, indicating a moderate level of application. Higher implementation levels are found in aspects related to regulatory compliance, while lower levels occur in energy efficiency planning and domestic wastewater management. Major constraints include weak regulatory enforcement, limited technical capacity, budget limitations, and organizational culture factors. The study concludes that strengthening leadership commitment, improving technical capacity, and developing pilot green school projects are essential to enhance green building implementation and support sustainable educational infrastructure planning.

Keywords: Green Building, Implementation Assessment, Planning Stage, Educational Buildings, Badung Regency

Introduction

The construction sector plays a crucial role in supporting economic growth and the provision of social infrastructure, yet it is also recognized as one of the largest contributors to global environmental degradation. The building and construction sector accounts for approximately one third of global greenhouse gas emissions and consumes about 34 percent of total global energy use (Elzinga et al., 2015). In Indonesia, this sector is estimated to contribute between 30 and 40 percent of national carbon dioxide emissions. These conditions highlight the urgency of transforming conventional construction practices toward sustainable approaches that integrate technical feasibility, economic efficiency, and environmental responsibility (Kibert, 2016).

Badung Regency, as the primary tourism and economic center of Bali Province, continues to experience rapid infrastructure development, particularly in the education sector. The construction of elementary and junior high school buildings has increased significantly to accommodate population growth and expanding public services. Educational buildings

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typically require high levels of energy and water consumption during daily operation and generate substantial maintenance costs, which place long-term financial pressure on regional budgets. Previous studies indicate that the application of green building principles in educational facilities can reduce life-cycle costs while improving indoor environmental quality and learning comfort (Ibrahim et al., 2023; Vestfal & Seduikyte, 2024; Karimi et al., 2023).

In response to sustainability challenges in public infrastructure, the Ministry of Public Works and Housing issued Regulation No. 21 of 2021 concerning the performance assessment of green buildings, which establishes measurable criteria for the implementation of green building principles in state-owned buildings. Despite the existence of this regulatory framework, implementation at the planning stage has not been consistently evaluated. In Badung Regency, guidance on green building application has been communicated to planning stakeholders; however, systematic assessment of planning outputs, particularly detailed engineering design documents, remains limited. As a result, the actual level of green building implementation and the constraints faced by planning consultants are not clearly understood.

Previous research conducted in Badung Regency reported that the level of green construction implementation reached 53.40 percent; however, the analysis focused primarily on the construction stage rather than the planning phase. Construction management literature emphasizes that decisions made during planning and design stages have the greatest influence on a building's environmental performance and long-term sustainability (Ervianto, 2005). Inadequate integration of green principles at the planning stage often leads to higher corrective costs during construction and operation, reducing overall efficiency and effectiveness (Linggo & Sutandi, 2023).

Based on these conditions, this study aims to evaluate the level of green building implementation at the planning stage of educational buildings in Badung Regency, identify dominant technical, financial, and organizational constraints, and formulate improvement strategies. This research applies an integrated analytical approach by combining quantitative assessment, including the Relative Importance Index and cluster analysis, with qualitative validation through focus group discussions. The findings are expected to provide practical and evidence-based recommendations to support more effective and sustainable green building implementation in the planning of educational facilities.

Methods

The research method explains the implementation methods employed in the study. The method is described clearly and in detail [Times New Roman 12 font, normal] This study was conducted on planning projects for elementary and junior high school buildings in Badung Regency, Indonesia, during the 2025 fiscal year. A mixed-methods approach with an explanatory sequential design was employed to obtain a comprehensive understanding of green building implementation at the planning stage. Quantitative analysis was used to measure the level of implementation and identify dominant constraints, while qualitative analysis was applied to validate findings and formulate improvement strategies. Quantitative data were collected using structured questionnaires with a five-point Likert scale. The respondents consisted of 36 team leaders from planning consultant firms responsible for preparing technical planning documents, including Detailed Engineering Design documents, for educational building projects. Respondents were selected using purposive sampling to ensure that participants had direct involvement and sufficient experience in green building-related planning activities. The sample size exceeded the minimum requirement calculated using the Slovin formula with a margin of error of 10 percent. Prior to data analysis, validity and reliability tests were conducted to ensure the consistency and accuracy of the research instrument. Descriptive statistical analysis was applied to assess the level of green building

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implementation based on criteria stipulated in the Ministry of Public Works and Housing Regulation No. 21 of 2021. The implementation level of each indicator was calculated and classified into performance categories to identify areas of strong and weak application at the planning stage. To determine dominant constraints influencing implementation, the Relative Importance Index method was used to rank constraint factors based on respondents' perceptions. To further support strategy formulation, cluster analysis was applied to group constraint factors into low, moderate, and dominant categories, enabling the identification of priority issues requiring intervention (Santosa, 2004). The final stage of the research involved qualitative data collection through focus group discussions with key stakeholders, including representatives from local government agencies and planning practitioners. These discussions were conducted to validate the quantitative findings and to develop practical and context-specific strategies for improving green building implementation in educational building planning (Sugiyono, 2016).

Result and Discussion

Level of Green Building Implementation

The assessment results show that the average level of green building implementation at the planning stage of educational buildings in Badung Regency is approximately 61 percent, which is classified as fairly good. This indicates that green building principles have been partially incorporated into planning practices; however, implementation remains uneven across different indicators. This finding supports the argument in sustainable construction theory that early-stage sustainability adoption is often selective and influenced by regulatory pressure rather than holistic environmental performance considerations (Kibert, 2016).

Table 1. Summary of key indicator implementation levels

Code	Indicator	Implementation level (%)	Category
TP1f	Site planning – basement site management	96.11	Very good
TP1e	Pedestrian pathway provision	58.33	Fair
TP1g	Parking area provision	51.11	Fair
TP1h	Outdoor lighting system	41.11	Poor
TP2a	Building envelope performance	56.67	Fair
TP2e	Energy efficiency calculation	36.67	Poor
TP2f	Electrical system efficiency	45	Poor
TP3a	Water use efficiency	40,56	Poor
TP4b	CO_2 and CO emission control	42.78	Poor
TP6a	Application of 3R principles (waste)	36.11	Poor
TP6b	Waste handling system	48.89	Fair
TP7a	Domestic wastewater management	21.11	Poor

As presented in Table 1, the highest implementation level is observed in basement site management planning (TP1f), which achieved a very good category. This high performance is closely related to strict compliance with mandatory regulatory requirements, particularly those verified during the building permit approval process. Indicators that are directly linked to formal administrative approval tend to demonstrate higher levels of implementation, as compliance becomes a non-negotiable condition for project continuation. This pattern aligns with institutional theory, which emphasizes that coercive regulations strongly shape organizational behavior in the public sector.

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In contrast, performance-based indicators such as energy efficiency calculation, electrical system efficiency, domestic wastewater management, and application of waste reduction principles show relatively low implementation levels. These indicators require advanced technical analysis, performance simulation, and integrated design approaches. The low scores indicate that planning practices remain focused on fulfilling minimum regulatory requirements rather than optimizing environmental performance. Similar findings have been reported in previous studies, which note that sustainability measures requiring specialized technical capacity and additional planning effort are often deprioritized when regulatory enforcement is weak or incentives are limited (Ervianto, 2005).

Dominant Constraints Affecting Green Building Implementation

The Relative Importance Index analysis reveals that regulatory and institutional factors constitute the most influential constraints affecting green building implementation at the planning stage.

Table 2. Dominant Constraints Based on Relative Importance Index (RII)

Rank	Code	Constraint factor	RII Value
1	KP1c	Lack of strict legal sanctions or enforcement mechanisms for green building implementation	0.961
2	KP2c	Insufficient government-led training on green building implementation	0.883
3	KP3b	Limited budget allocation constraining green building implementation	0.844
4	KP5d	Unsupportive work culture toward the adoption of green building principles	0.794
5	KP2a	Insufficient government dissemination of green building concepts	0.789

As shown in Table 2, the lack of strict legal sanctions or enforcement mechanisms ranks as the most dominant constraint. This finding indicates that the absence of enforceable consequences reduces stakeholder commitment to fully integrating green building principles into planning documents. From a governance perspective, this reflects the limitation of voluntary policy instruments in driving sustainable practices.

Insufficient government-led training and limited dissemination of green building concepts are also identified as major constraints. These results highlight deficiencies in institutional capacity and knowledge transfer, which are critical components of effective policy implementation. Capacity-building theory emphasizes that regulatory frameworks must be supported by adequate human resource development to translate policy intent into practical action. Without continuous training and technical guidance, planning consultants tend to rely on conventional design approaches that are familiar and perceived as lower risk.

Budget limitations further constrain implementation, particularly for indicators that involve performance-based design and long-term efficiency considerations. Financial constraints often lead decision-makers to prioritize short-term cost savings over life-cycle benefits, despite evidence that green building strategies can reduce operational costs in the long run (Ranaweera & Crawford, 2010; Kazemi & Kazemi, 2022; Isaksson & Linderoth, 2018). Additionally, an unsupportive work culture reflects organizational resistance to change, reinforcing path dependency in planning practices.

Constraint Typology Based on Cluster Analysis

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Cluster analysis was conducted to group constraint factors based on similarities in their Relative Importance Index (RII) values, enabling their classification into three levels of influence: low, moderate, and dominant constraints. The K-means clustering method was applied using IBM SPSS Statistics (version 29), with the number of clusters (K = 3) determined conceptually in accordance with the research objective of distinguishing constraint influence levels on green building implementation. The average RII values for each cluster are presented in Table 3, illustrating the relative influence of each constraint group.

Table 3. Average RII Values by Constraint Cluster

Cluster	Average RII	Constraint Category
1	0.495	Low constraints
2	0.672	Moderate constraints
3	0.854	Dominant constraints

As summarized in Tables 3, Cluster 1 exhibits the lowest average RII value, indicating constraints with relatively minor influence, primarily related to limited availability of alternative materials and design flexibility. Cluster 2 represents constraints with moderate influence, including technical regulations, material availability, and human resource capacity. In contrast, Cluster 3 shows the highest average RII value, representing dominant constraints that exert the strongest influence on the low level of green building implementation. Based on the K-means clustering results, five constraint factors were classified into the dominant cluster, as summarized in Table 4.

Table 4. Dominant Constraints Based on K-means Cluster Analysis

No.	Code	Constraint factor	Cluster
1	KP1c	Lack of strict legal sanctions or enforcement mechanisms for green building implementation	3
2	KP2a	Insufficient government dissemination of green building concepts	3
3	KP2c	Insufficient government-led training on green building implementation	3
4	KP3b	Limited budget allocation constraining green building implementation	3
5	KP5d	Unsupportive work culture toward the adoption of green building principles	3

The dominance of these constraints confirms that barriers to green building implementation are primarily institutional, regulatory, financial, and cultural, rather than technical. The prominence of regulatory enforcement (KP1c) indicates that implementation remains largely compliance-driven, while the inclusion of budgetary and cultural factors highlights the role of organizational commitment and leadership in shaping planning-stage decisions. These findings reinforce the need for integrated policy enforcement, capacity-building programs, and institutional support to improve green building adoption.

Strategic Implications for Improving Implementation

Based on the integrated analysis of implementation levels, dominant constraints, and stakeholder input from focus group discussions, several strategic directions can be identified. Strengthening leadership commitment emerges as the primary driver for improving green building implementation at the planning stage. Strong leadership enables the integration of sustainability priorities into regional development agendas, supports the formulation of clearer local regulations, and ensures consistent enforcement mechanisms (Breuer et al., 2023; Marín-González et al., 2022).

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Capacity-building initiatives are also essential to address technical and knowledge-related constraints (Nurdin & Purna, 2023; Ali & Kamraju, 2024). These include coordinated dissemination programs, regular technical training for planning consultants and government staff, and collaboration with academic and professional institutions to develop practical training modules. Enhancing technical competence is particularly important for improving performance-based indicators such as energy efficiency and wastewater management.

To address budget constraints, the development of pilot green school projects is recommended. Pilot projects can function as demonstration models that provide empirical evidence of environmental and economic benefits, supporting more informed budget allocation decisions. Finally, transforming organizational culture requires sustained regulatory consistency, continuous learning, and visible success stories that reinforce the value of sustainable planning practices.

Overall, the findings indicate that effective green building implementation at the planning stage depends on an integrated approach that combines regulatory enforcement, institutional capacity building, financial support mechanisms, and cultural transformation within planning organizations.

Conclusion

This study concludes that the level of green building implementation at the planning stage of educational buildings in Badung Regency is classified as fairly good, with an average implementation level of approximately 61 percent. The results indicate that planning practices tend to prioritize indicators that are directly regulated and verified during the permitting process, while performance-based indicators such as energy efficiency calculation, wastewater management, and resource efficiency remain weak. The analysis further reveals that the main barriers to effective implementation are not technical limitations but institutional and organizational constraints, particularly weak regulatory enforcement, limited dissemination and training, budget constraints, and an unsupportive work culture. Cluster analysis confirms that these constraints form a dominant group that significantly influences the low performance of several green building indicators. Based on these findings, improving green building implementation at the planning stage requires strengthening leadership commitment and regulatory enforcement, enhancing technical capacity through continuous training and dissemination programs, allocating budgets more strategically based on life-cycle benefits, and developing pilot green school projects as demonstration models. These efforts are expected to support more effective, measurable, and sustainable planning practices for educational infrastructure and contribute to the advancement of green building implementation in the public sector.

Suggestions

Based on the findings of this study, it is suggested that local governments strengthen the integration of green building principles into the planning stage of educational infrastructure through clearer local regulations, consistent enforcement mechanisms, and measurable performance requirements. Continuous capacity-building programs are recommended to improve the technical competence of planning consultants and government staff, particularly in performance-based aspects such as energy efficiency analysis and wastewater management planning. The development of pilot green school projects is also recommended as a practical strategy to demonstrate environmental and economic benefits, support evidence-based budgeting, and encourage wider adoption. For future research, it is suggested that studies expand the scope to include post-construction performance evaluation and comparative

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analysis across regions to deepen understanding of the long-term effectiveness of green building implementation in public educational facilities.

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