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Strategies for Overcoming Barriers to Green Construction Implementation Using Interpretive Structural Modeling in Building Construction Projects in Bali

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Abstract

The construction sector has significantly contributed to economic development while simultaneously increasing environmental impacts through high energy consumption, carbon emissions, and construction waste. Green Construction has emerged as an important approach to support sustainable development; however, its implementation in building projects in Bali continues to face various barriers despite existing government policies. This study aims to identify the main barriers, analyze their structural relationships, and formulate strategies to overcome the barriers to Green Construction implementation in building projects in Bali. Data were collected through questionnaire surveys involving contractors, design consultants, and supervision consultants with experience in building projects in Bali. The analysis employed the Relative Importance Index to determine the significance of barriers and identify dominant indicators, followed by Interpretive Structural Modeling (ISM) and MICMAC analysis to examine structural relationships and identify key driving factors. Strategies were subsequently formulated using Strength, Weakness, Opportunity and Threats (SWOT) analysis based on expert interviews. The results identified 21 barrier indicators, of which 12 were classified as very high importance and selected as dominant barriers. The findings indicate that the limited availability of guidelines and ideal standards for Green Construction implementation and the low priority given by project owners are the principal driving barriers influencing other obstacles. The proposed strategies include developing Green Construction guidelines and operational standards, enhancing human resource competencies through training and certification, strengthening project owner commitment, and improving monitoring, evaluation, and technological innovation to support more effective and sustainable Green Construction implementation in building projects in Bali.

Keywords: Green Construction, Relative Importance Index (RII), Interpretive Structural Modeling (ISM), MICMAC, SWOT, Barriers, Strategies, Sustainable Construction

Introduction

Typed The construction industry has experienced rapid growth over recent decades and has become one of the primary drivers of economic development and urbanization worldwide. Despite its significant contribution to infrastructure development and employment, the construction sector is also recognized as one of the largest contributors to environmental degradation due to its intensive consumption of energy, natural resources, and water, as well as its substantial generation of greenhouse gas emissions and construction waste.

According to the United Nations Environment Programme, the building construction sector accounts for approximately 36% of global energy consumption and 39% of carbon dioxide emissions, while emissions generated during the construction phase alone contribute approximately 20–50% of the total life-cycle carbon emissions of buildings (Chen et al., 2023). In addition, construction and demolition activities generate approximately 30–40% of global solid waste, much of which is still disposed of through conventional landfill practices without proper material recovery (Tafesse et al., 2022). These conditions indicate that improving construction practices is essential to achieving sustainable development and long-term environmental conservation (Ravinder, 2025).

Green Construction has emerged as an effective approach to reducing the environmental impacts of construction activities while maintaining project efficiency and productivity. The concept emphasizes efficient resource utilization, environmentally friendly construction methods, waste minimization, and sustainable management throughout the construction process (Ervianto, 2012). In Indonesia, sustainable construction has increasingly become a national priority through policies encouraging energy efficiency, environmentally friendly materials, and responsible resource management within construction projects.

At the regional level, the Provincial Government of Bali has reinforced this commitment through Governor Regulation Number 45 of 2019 concerning Bali Clean Energy, which promotes environmentally sustainable construction practices based on zero energy building principles (Santosa et al., 2020). Nevertheless, despite these regulatory initiatives, the implementation of Green Construction in building projects remains limited due to various financial, technical, managerial, institutional, and stakeholder-related barriers. As Bali continues to experience rapid tourism-related infrastructure development, ineffective implementation of Green Construction may further increase environmental degradation, including pollution and excessive resource consumption, thereby threatening the sustainability of the tourism sector and the surrounding environment.

These conditions demonstrate the necessity of identifying and addressing the barriers that hinder effective Green Construction implementation. Previous studies have investigated Green Construction implementation using various analytical approaches. Wijayaningtyas et al. (2023) identified the availability of advanced equipment, appropriate construction methods, and contractor awareness as important success factors based on practitioners' perceptions. Yustiarini (2018) employed the Analytical Hierarchy Process and reported that project management and worker awareness were among the dominant factors influencing Green Construction implementation.

Sun et al. (2023) developed a hybrid Decision-Making Trial and Evaluation Laboratory–Analytic Network Process framework, demonstrating that government policy support and technological readiness significantly influence Green Construction practices. Meanwhile, Susilo & Jin (2022)combined Analysis of Variance, Relative Importance Index, and Strengths, Weaknesses, Opportunities, and Threats analyses to formulate implementation strategies for Green Construction in Indonesia. Although these studies have contributed valuable insights, they primarily focus on identifying influencing factors or determining their priorities and have not comprehensively examined the structural relationships among barriers or formulated strategies based on their hierarchical interactions.

The existing literature therefore reveals an important methodological gap. Most previous studies have emphasized statistical prioritization or descriptive evaluation of Green Construction barriers without analysing the contextual relationships among the identified barriers. Consequently, the key driving barriers that influence other obstacles remain insufficiently understood. Furthermore, studies integrating systematic barrier analysis with strategic formulation within the context of building construction projects in Indonesia, particularly in Bali, remain limited. Addressing this gap requires a comprehensive analytical framework capable of identifying dominant barriers, explaining their structural relationships, determining their driving influence, and translating these findings into practical implementation strategies.

To overcome these limitations, this study integrates four complementary analytical methods. The Relative Importance Index is employed to determine the dominant barriers based on practitioners' perceptions. Interpretive Structural Modeling is subsequently used to analyse the contextual relationships among the identified barriers and establish their hierarchical structure. Matrix of Cross Impact Multiplications Applied to Classification analysis is then applied to classify the barriers according to their driving power and dependence, enabling the identification of key driving barriers within the system. Finally, Strengths, Weaknesses, Opportunities, and Threats analysis is utilized to formulate practical strategies for improving Green Construction implementation based on the structural relationships identified through the previous analyses.

The integration of these methods provides a more comprehensive analytical framework than previous studies that generally relied on isolated analytical techniques. Accordingly, this study aims to identify the dominant barriers affecting Green Construction implementation in building projects in Bali, analyse the structural relationships among these barriers, identify the key driving barriers, and formulate appropriate implementation strategies. As an exploratory study, this research focuses on developing a systematic understanding of the interactions among implementation barriers and generating practical strategies that support more effective and sustainable Green Construction practices in building projects in Bali.

Methods

This study employed a mixed-methods approach with an exploratory research design to identify barriers to Green Construction implementation and formulate strategies for overcoming these barriers in building construction projects in Bali. The study focused on medium- to large-scale public and private building projects across Bali Province, selected due to their higher complexity and greater potential for Green Construction implementation. Primary respondents consisted of construction practitioners, including contractors, design consultants, and supervision consultants who had at least five years of professional experience and were involved in building projects in Bali. Purposive sampling was adopted to ensure that all respondents possessed sufficient knowledge and practical experience related to Green Construction implementation. A total of 30 respondents participated in the preliminary questionnaire for validity, reliability, and Relative Importance Index (RII) analyses (Sugiyono, 2013), 15 experts completed the pairwise comparison questionnaire for Interpretive Structural Modeling (ISM) and Matrix of Cross Impact Multiplications Applied to Classification (MICMAC) analyses (Saiful, 2017), and five experts participated in the open-ended questionnaire for the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis (Corbin & Strauss, 2014).

Data collection was conducted through literature review, structured questionnaires, and expert judgement. The literature review was undertaken to identify the initial barrier indicators of Green Construction implementation based on previous studies and relevant regulations. The questionnaire survey consisted of three stages. The first-stage questionnaire employed a five-point Likert scale to assess the importance of the identified barrier indicators and to evaluate the validity and reliability of the research instrument. The second-stage questionnaire adopted a pairwise comparison format using the symbols V, A, X, and O to determine the contextual relationships among the dominant barriers for ISM analysis (Pfohl et al., 2011). The third-stage questionnaire consisted of open-ended questions addressed to experts to obtain recommendations for strategy formulation. Data processing and statistical analyses were performed using IBM SPSS Statistics Version 31 for validity and reliability testing, Microsoft Excel for Relative Importance Index calculations, and ExsimPro software for Interpretive Structural Modeling and MICMAC analyses.

The collected data were analysed sequentially using four analytical methods. First, the Relative Importance Index (RII) was employed to determine the level of importance and rank the identified barrier indicators based on practitioners' perceptions. Only indicators classified as Very High (RII ≥ 0.80) were selected for further analysis. Subsequently, Interpretive Structural Modeling (ISM) was applied to analyse the contextual relationships among the dominant barriers and develop their hierarchical structure. Matrix of Cross Impact Multiplications Applied to Classification (MICMAC) analysis was then conducted to classify the barriers according to their driving power and dependence, enabling the identification of key driving barriers within the Green Construction implementation system.

Finally, the principal barriers identified through the ISM and MICMAC analyses were used as the basis for formulating implementation strategies using the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. Internal and external factors were identified from expert responses and subsequently arranged into a SWOT matrix to generate four strategic alternatives: Strength–Opportunity (SO), Weakness–Opportunity (WO), Strength–Threat (ST), and Weakness–Threat (WT) strategies (Kurniasih et al., 2021). The integration of the Relative Importance Index, Interpretive Structural Modeling, Matrix of Cross Impact Multiplications Applied to Classification, and Strengths, Weaknesses, Opportunities, and Threats analyses provided a systematic framework for identifying the dominant barriers, understanding their structural relationships, and developing practical strategies to enhance the implementation of Green Construction in building projects in Bali.

Result and Discussion

Respondent Characteristics

The study involved 30 construction practitioners with direct experience in building projects implementing Green Construction in Bali. The respondents represented various professional roles, including project managers, site managers, engineers, quantity surveyors, architects, site supervisors, and quality control. Their diverse professional backgrounds ensured that the collected data reflected multiple perspectives on the barriers to Green Construction implementation. The demographic profile of the respondents is presented in Table 1.

Tabel 1. Characteristics of Respondents

Characteristic	Category	Frequency	Percentage
Gender	Male	25	83%
	Female	5	17%
Age	19–30 years	14	47%
	31–40 years	9	30%
	41–50 years	4	13%
	>50 years	3	10%
Education	Bachelor's Degree	24	80%
	Master's Degree	6	20%
Working Experience	<10 years	15	50%
	10–20 years	11	37%
	>20 years	4	13%

Position	Project Manager	6	20%
	Site Manager	6	20%
	Engineer	5	17%
	Quantity Surveyor	3	10%
	Quality Control	3	10%
	Site Supervisor	4	13%
	Architect	3	10%
Understanding of Green Construction	Understand and know	19	63%
	Know	10	33%
	Know but do not understand	1	3%
Implementation Experience	Always implement	5	17%
	Frequently implement	17	57%
	Rarely implement	8	26%

As shown in Table 1, the respondents were predominantly male (83.3%), reflecting the workforce composition of the Indonesian construction industry. Most respondents were between 19 and 30 years old (46.7%), held a Bachelor's degree (80.0%), and had less than ten years of professional experience (50.0%). Project Managers and Site Managers constituted the largest professional groups (20.0% each), indicating that the survey captured perceptions from individuals directly involved in project planning and decision-making processes.

Regarding Green Construction competence, 63.3% of the respondents reported that they both knew and understood the principles of Green Construction, while 33.3% indicated that they were familiar with the concept. Furthermore, 56.7% stated that they had frequently implemented Green Construction practices, and 16.7% had implemented them consistently across projects. These findings indicate that the respondents possessed sufficient knowledge and practical experience to provide reliable assessments of the barriers affecting Green Construction implementation in building projects in Bali.

Dominant Barriers Based on Relative Importance Index (RII)

Prior to the Relative Importance Index (RII) analysis, the questionnaire instrument was evaluated to ensure its validity and reliability. The validity test indicated that all 21 barrier indicators achieved Pearson correlation coefficients higher than the critical value ($r = 0.361$), confirming that all questionnaire items were valid. Furthermore, the reliability test yielded a Cronbach's Alpha value of 0.816, exceeding the minimum acceptable threshold of 0.70, which indicates good internal consistency of the instrument. Therefore, all indicators were considered appropriate for further analysis using the Relative Importance Index (RII).

The Relative Importance Index (RII) analysis was conducted to determine the significance of each identified barrier to Green Construction implementation based on respondents' perceptions. Twenty-one barrier indicators were initially evaluated using a five-point Likert scale. Based on the classification criteria adopted in this study, only indicators categorized as Very High/Important ($RII \geq 0.80$) were selected for further structural analysis. The ranking of these dominant barriers is presented in Table 2.

Table 2. Relative Importance Index (RII) Results for Dominant Barriers

Rank	Code	Dominant Barrier	RII
1	X10	Lack of clarity in green construction design details or technical specifications	0.853

2	X1	High initial investment cost for Green Construction implementation	0.847
3	X17	Shortage of skilled personnel in Green Construction	0.847
4	X14	Differences in stakeholder perceptions regarding Green Construction	0.840
5	X12	Limited availability and quality of environmentally friendly materials	0.833
6	X16	Time-consuming implementation procedures and duration	0.827
7	X18	Limited knowledge and experience among construction service providers	0.820
8	X4	Limited guidelines and ideal standards for Green Construction implementation	0.813
9	X11	Limited innovation capacity of suppliers and subcontractors	0.813
10	X21	Low priority given to Green Construction by project owners	0.807
11	X3	Absence of incentives for organizations implementing Green Construction	0.800
12	X9	Limited availability of environmentally friendly equipment and machinery	0.800

The RII analysis identified twelve barrier indicators classified as Very High, indicating that these factors were perceived by respondents as the most significant barriers to Green Construction implementation (Table 2). The highest-ranked barrier was the lack of clarity in Green Construction design details or technical specifications (X10), followed by high initial investment costs (X1) and the shortage of skilled Green Construction personnel (X17). These findings suggest that technical readiness, financial constraints, and human resource capacity remain the primary challenges in implementing Green Construction in building projects in Bali.

The results are consistent with previous studies reporting that financial constraints, inadequate technical guidance, and limited professional competencies are among the major barriers to Green Construction implementation (Sun et al., 2023; Wijayaningtyas et al., 2023). In addition, the remaining dominant barriers, including stakeholder perceptions, material availability, implementation guidelines, and project owner commitment, also achieved Very High importance, indicating that Green Construction implementation is influenced by multiple interrelated technical, managerial, and organizational factors. Based on the established selection criteria, only the twelve dominant barriers were retained for subsequent Interpretive Structural Modeling (ISM) analysis. This approach ensured that the structural analysis focused on the most influential barriers and provided a foundation for identifying the key driving factors and developing strategic implementation strategies.

Structural Self-Interaction Matrix

The SSIM was developed based on expert judgments collected from 15 experts through pairwise comparison questionnaires. Four symbols (V, A, X, and O) proposed by Pfohl et al. (2011) were used to represent the direction and nature of the relationships between each pair of barriers. The resulting SSIM is presented in Table 3.

V - Variable I will help in achieving variable J;
A - Variable J will help in achieving variable I;
X - Both will lead to each other and
O - Variables are unrelated.

Table 3. Structural Self Interaction Matrix (SSIM)

Elemen (i,j)		X10	X1	X17	X14	X12	X16	X18	X4	X11	X21	X3	X9
		1	2	3	4	5	6	7	8	9	10	11	12
X10	**1**	X	O	O	O	O	X	A	X	O	A	O	O
X1	**2**		X	O	A	X	O	A	A	O	A	X	O
X17	**3**			X	V	O	V	O	A	X	O	A	V
X14	**4**				X	O	O	V	O	X	O	A	X
X12	**5**					X	A	O	A	O	X	O	O
X16	**6**						X	A	A	O	A	O	O
X18	**7**							X	A	A	O	A	V
X4	**8**								X	V	O	O	O
X11	**9**									X	A	O	V
X21	**10**										X	V	O
X3	**11**											X	A
X9	**12**												X

As shown in Table 3, the SSIM represents the contextual relationships among the twelve dominant barriers using the VAXO notation. For example, the relationship between X10 and X4 is represented by the symbol X, indicating a mutual influence between the two barriers. Likewise, the relationship between X17 and X14 is denoted by V, indicating that X17 influences X14, whereas the reverse relationship does not occur. These contextual relationships formed the basis for constructing the reachability matrix in the next stage of the ISM analysis

Reachability Matrix

The contextual relationships identified in the Structural Self-Interaction Matrix were subsequently converted into a binary matrix, referred to as the Final Reachability Matrix (FRM), following the conversion rules proposed by Pfohl et al. (2011). The symbols V, A, X, and O were transformed into binary values (1 and 0), and the transitivity rule was applied to ensure the consistency of indirect relationships among the identified barriers. The resulting reachability matrix is presented in Table 4.

(1) V → (i, j) = 1 and (j, i) = 0

(2) A → (i, j) = 0 and (j, i) = 1

(3) X → (i, j) = 1 and (j, i) = 1

(4) O → (i, j) = 0 and (j, i) = 0

Table 4. Final Reachability Matrix

Elemen (i,j)		X10	X1	X17	X14	X12	X16	X18	X4	X11	X21	X3	X9
		1	2	3	4	5	6	7	8	9	10	11	12
X10	**1**	1	1*	1*	0	1*	1	0	1	1*	0	0	0
X1	**2**	0	1	1*	1*	1	0	1*	0	0	1*	1	0
X17	**3**	1*	1*	1	1	1*	1	1*	0	1	0	0	1
X14	**4**	1*	1	1*	1	1*	1*	1	0	1	0	1*	1
X12	**5**	1*	1	0	0	1	1*	0	0	0	1	1*	0
X16	**6**	1	1*	0	0	1	1	0	1*	0	1*	0	0
X18	**7**	1	1	0	1*	1*	1	1	1*	0	0	1*	1
X4	**8**	1	1	1	1*	1	1	1*	1	1	1*	1*	1*
X11	**9**	1*	1*	1	1	0	1*	1	0	1	0	0	1
X21	**10**	1	1	1*	1*	1	1	1*	1*	0	1	1	0
X3	**11**	1*	1	1	1	1*	1*	1	0	1*	0	1	1*
X9	**12**	0	1*	0	1	0	0	1*	0	1*	0	0	1

The application of the transitivity rule generated a consistent Final Reachability Matrix that served as the basis for calculating the driving power and dependence power of each barrier. The matrix also provided the input for the subsequent level partitioning process, enabling the hierarchical classification of barriers according to their contextual relationships.

Level Partitions

Based on the Final Reachability Matrix, the reachability set, antecedent set, and intersection set were determined for each barrier following the ISM procedure proposed by Pfohl et al. (2011). The hierarchical levels were established iteratively by comparing the reachability and intersection sets until all barriers were assigned to their respective levels. The results of the level partitioning process are presented in Table 5.

Table 5. Level Partition Result

Kode	Reachability Set	Antecendent Set	Intersection Set	Level
ITERASI I				
X1	2,3,4,5,7,10,11	1,2,3,4,5,6,7,8,9,10,11,12	2,3,4,5,7,10,11	I
X12	1,2,5,6,10,11	1,2,3,4,5,6,7,8,10,11	1,2,5,6,10,11	I
ITERASI II				
X10	1,3,6,8,9	1,3,4,6,7,8,9,10,11	1,3,6,8,9	II
X16	1,6,8,10	1,3,4,6,7,8,9,10,11	1,6,8,10	II
X9	4,7,9,12	3,4,7,8,9,11,12	4,7,9,12	II
ITERASI III				
X14	3,4,7,9,11	3,4,7,8,9,10,11	3,4,7,9,11	III
X18	4,7,8,11	3,4,7,8,9,10,11	4,7,8,11	III
ITERASI IV				
X17	3,9	3,8,9,10,11	3,9	IV
X11	3,9	3,8,9,11	3,9	IV
ITERASI V				
X3	11	8,10,11	11	V
ITERASI VI				
X4	8,10	8,10	8,10	VI
X21	8,10	8,10	8,10	VI

The level partition analysis classified the twelve dominant barriers into six hierarchical levels. Level I consists of X1 and X12, while Level II includes X10, X16, and X9. Level III comprises X14 and X18, followed by X11 and X17 at Level IV. Level V contains X3, whereas Level VI, representing the lowest hierarchical level, consists of X4 and X21. These results indicate that the barriers located at the lower levels have greater influence on the higher-level barriers and therefore should be prioritized in improving Green Construction implementation.

ISM Hierarchial Structure

The hierarchical relationships identified through the level partitioning process were subsequently visualized using the Interpretive Structural Modeling (ISM) framework. The ISM hierarchical model illustrates the causal relationships among the dominant barriers and identifies the underlying driving barriers within the Green Construction implementation system. The resulting hierarchical structure is presented in Figure 1.

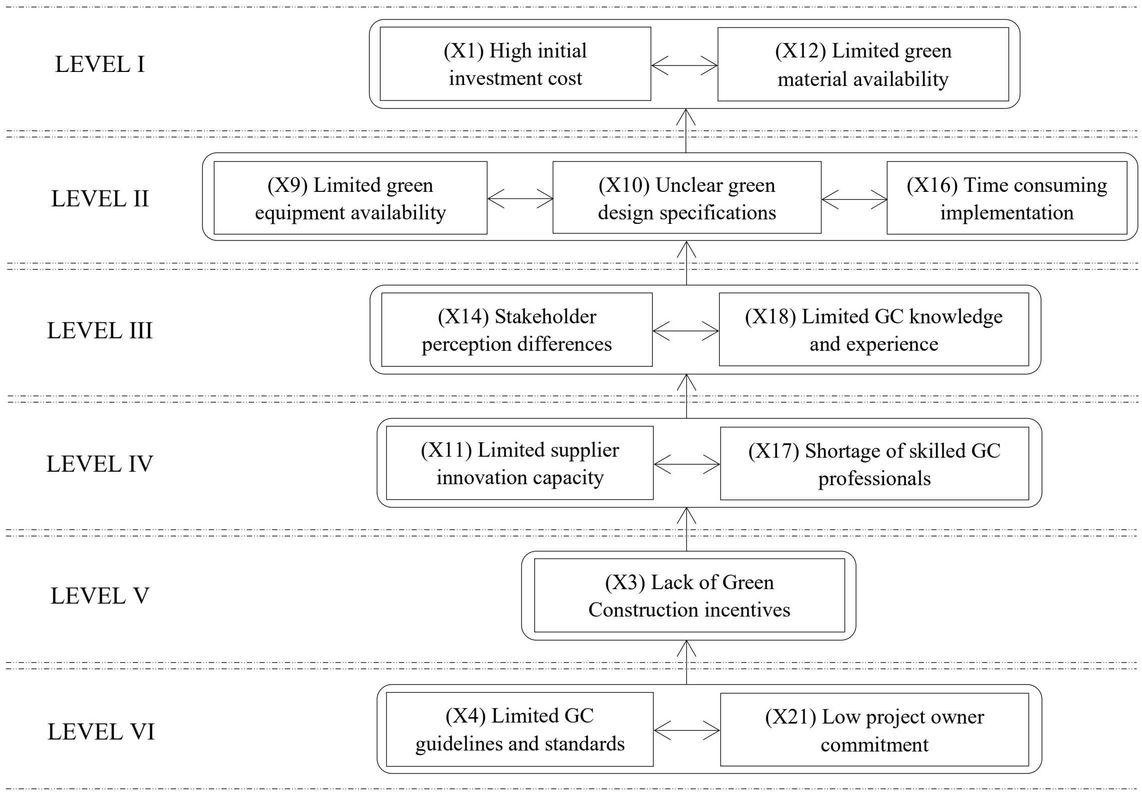

Figure 1. ISM Hierarchical Structure of Green Construction Implementation Barriers

As illustrated in Figure 1, the ISM model identifies limited guidelines and ideal standards for Green Construction implementation (X4) and the low priority given to Green Construction by project owners (X21) as the fundamental driving barriers located at Level VI. These barriers influence the higher-level barriers, including the absence of implementation incentives (X3), limited supplier innovation capacity (X11), shortage of skilled personnel (X17), stakeholder perception (X14), limited knowledge and experience (X18), technical and operational barriers (X9, X10, and X16), and ultimately the high initial investment cost (X1) and limited availability of environmentally friendly materials (X12). According to Pfohl et al. (2011), barriers positioned at the lowest hierarchical level represent the root causes within the system and should therefore receive the highest implementation priority. This finding is also consistent with Zaidi et al. (2021), who reported that lower-level elements in the ISM hierarchy generally function as key driving factors influencing the remaining variables within the system.

MICMAC Analysis

The Matrix of Cross Impact Multiplications Applied to Classification (MICMAC) analysis was conducted to classify the twelve dominant barriers according to their driving power and dependence power, based on the Final Reachability Matrix (FRM) obtained from the ISM analysis. The driving power of each barrier was calculated by summing the values across each row of the FRM, while the dependence power was obtained by summing the values in each column. The resulting driving and dependence values were subsequently plotted into the MICMAC Cartesian diagram to classify the barriers into four clusters: Autonomous, Dependent, Linkage, and Independent (Pfohl et al., 2011). The classification results are presented in Figure 2.

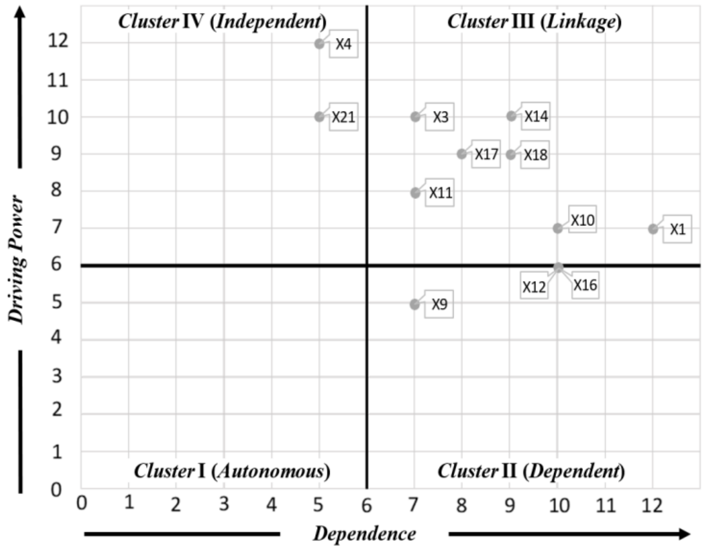

Figure 2. MICMAC Analysis of Green Construction Implementation Barriers

As shown in Figure 2, no barriers were classified in the Autonomous Cluster, indicating that all identified barriers are interconnected within the Green Construction implementation system. The Dependent Cluster consists of X1, X9, X10, X12, and X16, suggesting that these barriers are highly influenced by other factors and are therefore more likely to improve once the underlying driving barriers are addressed. The Linkage Cluster includes X3, X11, X14, X17, and X18, which exhibit both high driving power and high dependence. Barriers in this cluster are unstable because changes in one barrier may directly affect the others. In contrast, the Independent Cluster consists of X4 and X21, which possess the highest driving power and relatively low dependence. According to Pfohl et al. (2011), barriers within the Independent Cluster represent the key driving factors that should receive the highest priority for intervention. This finding is consistent with the ISM hierarchical model, where limited Green Construction guidelines and standards (X4) and low project owner commitment (X21) were identified as the root barriers influencing the implementation of Green Construction in building projects in Bali.

Strategy Formulation Using SWOT Analysis

To formulate practical strategies for overcoming the identified barriers, open-ended questionnaires were administered to five experts with extensive experience in Green Construction implementation. The resulting SWOT matrix is presented in Table 6.

Table 6. SWOT Matrix for Green Construction Implementation Strategies

Internal / **Eksternal**	***Strength* (S)**	***Weakness* (W)**
	a. Experience in Green Construction implementation. b. Management support and organizational commitment. c. Competent human resources and technological adaptability. d. Collaboration with government and related institutions. e. Innovation culture in environmentally friendly materials and technologies.	a. Lack of GC guidelines astandard operating procedures (SOPs). b. Low project owner commitment and attention. c. Limited training and human resource competencies. d. Weak coordination, monitoring, and evaluation. e. Absence of a dedicated GC implementation team

Opportunity (O)	S-O Strategi	W-O Strategi
a. Supportive sustainable construction regulations. b. Increasing market demand and stakeholder awareness. c. Advances in green construction technologies. d. Training, certification, and technical assistance programs. e. Availability of funding, investment, and incentive programs.	a. Develop Green Construction guidelines through multi-stakeholder collaboration. b. Enhance human resource competencies through training and certification. c. Promote innovation in environmentally friendly materials and technologies. d. Utilize regulatory support to accelerate Green Construction implementation	a. Develop GC guidelines, operational standards, and standard operating procedures (SOPs). b. Strengthen human resource capacity through continuous training and certification. c. Utilize technological advancements to develop technical guidelines. d. Strengthen coordination, supervision, and implementation mechanisms
***Threat* (T)**	**S-T Strategi**	**W-T Strategi**
a. High initial investment costs for Green Construction. b. Changes in regulations and economic conditions. c. Limited availability of environmentally friendly materials and technologies. d. Tender competition focused on cost and project duration. e. Low initial commitment from project owners.	a. Increase awareness of Green Construction benefits among project owners. b. Strengthen collaboration with government agencies and suppliers. c. Enhance human resource competencies to respond to changes in the construction market. d. Promote innovation to improve the cost efficiency of Green Construction implementation	a. Strengthen project owner commitment to GC implementation b. Establish a dedicated Green Construction implementation team c. Integrate Green Construction requirements into project procurement documents. d. Strengthen the monitoring and evaluation system for GC implementation.

The SWOT analysis indicates that the proposed strategies primarily focus on strengthening institutional support, enhancing human resource competencies, increasing project owner commitment, and promoting technological innovation to overcome the key barriers identified through the RII, ISM, and MICMAC analyses. The development of comprehensive Green Construction guidelines, standard operating procedures, and supporting regulations is considered a priority strategy, as clear regulatory frameworks provide consistent implementation standards and encourage greater project owner commitment. This finding is consistent with Clean Water America Alliance (2012), which emphasized the importance of adequate regulations and clear implementation guidelines for successful Green Construction practices, and Aziz & Utomo (2011), who highlighted that regulatory improvement and government support are essential for promoting sustainable construction. Furthermore, strengthening human resource competencies through continuous training and certification is in line with the findings of Susilo & Jin (2022), who identified professional capacity development as a critical factor for improving Green Construction implementation. In addition, promoting technological innovation, environmentally friendly materials, and stakeholder awareness supports the finsdings of Hwang & Tan (2012), Chan etal. (2017), Ahn et al. (2013), Zhang et al. (2019), who emphasized that project owner education, government support, and technological advancement are key drivers of successful Green Construction implementation. These findings demonstrate that addressing the principal driving barriers requires an integrated strategy combining regulatory, organizational, technical, and human resource improvements.

Conclusion

This study identified 21 barriers to Green Construction implementation in building projects in Bali through a literature review. Using the Relative Importance Index (RII), twelve barriers were classified as having very high importance and were subsequently analysed using Interpretive Structural Modeling (ISM). The ISM analysis revealed a six-level hierarchical structure, identifying limited Green Construction guidelines and standards (X4) and low project owner commitment (X21) as the principal driving barriers. The MICMAC analysis further confirmed that these two barriers belong to the Independent Cluster, indicating the highest driving power and the lowest dependence, thereby representing the root causes influencing the remaining barriers. Based on these findings, the SWOT analysis formulated four priority strategies: developing comprehensive Green Construction guidelines and standard operating procedures, strengthening human resource competencies through training and certification, enhancing project owner commitment, and improving monitoring, evaluation, and technological innovation. The integration of the RII–ISM–MICMAC–SWOT approach provides a comprehensive framework for identifying dominant barriers, understanding their structural relationships, and developing practical strategies to improve Green Construction implementation in building projects in Bali.

Suggestions

The findings suggest that government agencies should strengthen technical guidelines, regulations, incentive schemes, and capacity-building programs to support Green Construction implementation. Construction companies and project owners are encouraged to integrate Green Construction principles into project planning, procurement, and execution while continuously improving workforce competencies and stakeholder collaboration. Future studies are recommended to investigate Green Construction implementation in other regions and to examine critical success factors that complement barrier analysis, thereby providing broader recommendations for promoting sustainable construction practices.

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