This research examines the integration of local wisdom-based green construction practices and their influence on sustainable performance through implementation strategies in the Indonesian construction industry. It focuses on ten construction projects in Bali. The main problem faced is the lack of understanding of the effectiveness of local wisdom-based green construction practices in improving sustainable performance in developing countries. Using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method, data was collected from 200 engineers involved in green construction projects. Results show that local wisdom-based green construction practices significantly influence sustainable performance, both directly (path coefficient 0.290) and indirectly through the mediation of implementation strategies (indirect effect 0.575). The research model shows high explanatory power with R-squared values of 0.802 for Implementation Strategy and 0.831 for Sustainable Performance. These findings indicate that integrating local wisdom in green construction practices when mediated by an effective implementation strategy, can significantly improve the sustainable performance of construction projects. Sustainable waste management was identified as the dominant indicator (loading factor 0.936) of local wisdom-based green construction. In contrast, alignment with government policies and regulations (loading factor 0.925) became critical in the implementation strategy. The results of this study can be applied by project developers, construction managers, and policymakers in designing more effective implementation strategies for integrating local wisdom into green construction practices, considering customizations based on variations in cultural and geographical contexts

***Keywords:** green construction, local wisdom, implementation strategy, sustainable performance, PLS-SEM*

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ENHANCING SUSTAINABLE PERFORMANCE WITH GREEN CONSTRUCTION BASED ON LOCAL WISDOM THROUGH IMPLEMENTATION STRATEGY AS A MEDIATING VARIABLE

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1. Introduction

The construction industry globally significantly impacts the environment, especially in developing countries [1], with the construction sector accounting for more than 40 % of global energy consumption and about 18 % of global greenhouse gas (GHG) emissions [2]. This practice often ignores aspects of social sustainability, such as the neglect of local communities and traditions [3]. With rapid population growth and urbanization in Indonesia, the demand for new infrastructure and buildings continues to increase, potentially exacerbating environmental impacts [4]. Therefore, there is an urgent need to adopt green construction.

Developing countries face challenges in balancing economic development with environmental protection [5]. The implementation of green construction, especially in developing countries, still faces various barriers despite the increasing awareness of the importance of sustainable development due to multiple factors, such as lack of access to modern technology, higher costs, and lack of government support [6]. A study shows that only about 15 % of construction projects in Indonesia apply green construction principles thoroughly [7], indicating the urgent need for the integration of green construction practices.

Local wisdom offers a sustainable approach to construction challenges, which includes intergenerational knowledge and practices relating to the environment and natural resources [8, 9]. Industry often ignores these insights, resulting in suboptimal sustainability outcomes and resistance to green practices [10]. Local natural building materials are environmentally friendly and culturally valuable [11]. Applying local wisdom can reduce carbon footprint, improve energy efficiency, and minimize waste while strengthening a community's cultural and social identity [12].

A well-designed implementation strategy can significantly increase the adoption and effectiveness of green construction practices, reducing negative environmental impacts [13, 14]. Sustainable performance in green construction practices includes interrelated social, environmental, and economic aspects, all of which contribute to sustainable development goals [15].

Previous research described a synergy model between stakeholders through SEM, which is important for optimizing the successful adoption of green construction implementation strategies [16]. Another study developed a model that examined the influence of barriers, drivers, and strategies on GBT adoption in Ghana using PLS-SEM [17]. Another study developed a green construction model with seven key aspects positively correlated with improved sustainable performance. Other findings developed a comprehensive model integrating important variables to achieve the SDGs in the context of Vietnamese tourism [18]. Previous studies developed a model that examined the relationship between green construction practices, environmental performance, and economic performance in Nigeria, with the three main variables in green construction practices being waste, energy, and stormwater management [19]. The model provides a comprehensive framework for understanding green construction practices that can promote environmental sustainability in the construction industry in developing countries.

In modern conditions, it is crucial to conduct scientific research on applying green construction based on local wisdom and its implementation strategies to enhance sustainable performance in construction projects. The construction industry faces significant challenges in reducing environmental impacts and meeting sustainable development goals, particularly in developing countries like Indonesia, which are rich in cultural heritage. Despite the growing awareness of sustainable construction practices, integration with local wisdom must be explored. This research gap underscores the relevance and pressing need to investigate the synergy between green construction and local wisdom to uncover innovative and culturally appropriate approaches to sustainable development. Therefore, research that addresses green construction practices based on local wisdom and understands their impact on sustainable performance through effective implementation strategies is highly relevant and important to advance the theory and practice of sustainable construction.

The results of these studies can provide practical guidance for project managers, policymakers, and construction industry practitioners in designing and implementing more effective strategies for integrating local wisdom into green construction practices. The findings from these studies will assist in developing culturally sensitive and environmentally responsible approaches in construction projects, considering diverse local contexts. Specifically, identifying key success indicators such as local wisdom-based sustainable waste management and alignment with government policies will enable professionals to optimize the sustainable performance of their projects.

Green construction practices based on local wisdom are an important and timely area of research in sustainable development, especially for developing countries with rich cultural heritage. The relevance of this topic is not only of academic interest but also to fulfill pressing practical needs in a construction industry grappling with significant environmental impacts and cultural preservation challenges. Blending modern green construction techniques with traditional knowledge offers a promising avenue to achieve sustainability goals while preserving cultural identity and promoting social inclusiveness. Despite the growing awareness of sustainable practices, integration with local wisdom remains largely unknown, especially in developing countries. This research gap underscores the relevance and ongoing need to investigate the synergy between green construction and local wisdom to uncover innovative and culturally appropriate approaches to sustainable development. Therefore, research that addresses green construction practices based on local wisdom and understands their impact on sustainable performance through effective implementation strategies is highly relevant and important to advance the theory and practice of sustainable construction.

2. Literature review and problem statement

Green construction and adaptive local knowledge support sustainability achievement [20]. Green construction, with its focus on minimizing environmental impacts through optimizing energy efficiency, utilizing recycled materials, and effective waste management [21], has the potential to synergize with local knowledge and practices that have accumulated across generations. Local wisdom, which represents a community's adaptive response to its environment by optimally utilizing natural resources, has proven resilient and relevant through transmitting knowledge between generations [22]. The synthesis of contemporary green construction principles and time-tested local wisdom has the potential to produce construction solutions that are not only ecologically sustainable but also contextualized and responsive to local-specific conditions [23].

Several studies have been conducted to develop models relating to green construction practices and their impact on sustainable performance. Previous research provides empirical evidence that integrating green practices in construction can promote the long-term sustainability of the construction industry. The study [24] developed a green construction model consisting of seven main aspects, namely supplier awareness, client awareness, energy and water saving, training, management commitment, green practice facilitation, and renewable resources. The model shows that the adoption of these green construction factors by construction companies is positively correlated with improved sustainable performance, which includes environmental, economic, and social aspects. However, there are unresolved issues regarding applying this model in diverse cultural contexts. The reason may be the impossibility of capturing the nuances of local wisdom and traditional practices within a standardized framework. Integrating context-specific cultural factors into the model may overcome this difficulty. In the context of developing countries, the study [25] presents research results on a comprehensive framework for understanding green construction practices that can promote environmental sustainability. The model integrates green construction practices and environmental performance, consisting of three main dimensions of green construction practices (energy management, stormwater management, and waste management) and three environmental performance indicators (air quality, water, and sanitation). The results show that green construction practices contribute about 75 percent to the variation in environmental performance, with the energy management dimension, especially the use of natural lighting and cooling, being the most significant and conserving water resources being the most critical environmental performance indicator. However, there are some unresolved issues related to generalizing these findings across different contexts and scales of construction projects. The reason may be the objective difficulties associated with the study's limited scope, which focused on specific environmental indicators without considering potential trade-offs or synergies with economic and social factors. One way to overcome this difficulty is to conduct a study on integrating local wisdom into green construction practices toward sustainable performance by investigating the potential synergies between environmental, economic, and social dimensions of sustainability when local wisdom is integrated. This approach has been used in previous research on sustainable construction practices. Still, a comprehensive model has not been developed that considers contextual factors and cultural variations when implementing green construction practices.

The study [24] presents the research results on factor analysis of green construction to develop long-term strategies for improving sustainability performance. However, unresolved issues remain regarding integrating local context and traditional knowledge in these strategies. The reason may be due to the challenges in measuring and standardizing culturally diverse practices in different regions, which makes relevant research complex and potentially resource-intensive. One way to overcome this difficulty is to create an adaptable framework that integrates local knowledge indicators with existing green construction metrics. This approach has been used in [26], which presents research results on factors that drive sustainable performance in the construction industry, such as education, technology adoption, leadership, policy and commitment, and regulatory compliance. The results show that these factors are critical to improving sustainable construction practices in Indonesia. However, there are some unresolved issues related to the applicability of these findings across different cultural backgrounds in Indonesia and abroad. The reason may be the objective difficulties associated with capturing the nuances of local wisdom and cultural context within a standardized framework, which makes comprehensive research difficult. One way to overcome this difficulty is to develop a context-appropriate framework that integrates indicators of local wisdom and cultural practices and identifies factors driving sustainable performance.

[27] emphasized the importance of a holistic approach in integrating green construction practices, considering sustainability's technical, cultural, social, and economic aspects. However, these studies still face challenges in incorporating local wisdom into their frameworks. This may be due to the inherent difficulty in measuring and standardizing traditional knowledge and practices, which vary significantly across communities and regions.

The study [28] presents the research results on the green building sustainability model that establishes hypothesized relationships among nine constructs: issues, challenges, government, firms, developers, buyers, private bodies, strategic mix, and sustainable development. The results show that collaborative efforts between the government and other stakeholders play an important role in developing a strategic mix that will lead to sustainable development, with the government playing the most important role as the regulatory body. However, there are some unresolved issues related to the generalizability of the findings across different cultural backgrounds and the complexity of capturing the nuances of local wisdom within a standardized framework. The reason may be the objective difficulties associated with measuring and standardizing diverse cultural practices in different regions, which makes comprehensive research difficult. One way to overcome this difficulty is to develop a context-appropriate framework that integrates indicators of local wisdom and cultural practices and identifies factors driving sustainable performance.

The study [7] presents the research results on developing a building performance score (BPS) model for assessing the sustainability of buildings in India, considering the three main factors: environmental, economic, and social factors throughout the project life cycle. The results show that various indicators, such as topography and climate change, health and safety of construction workers, project management consultation, risk management, security measures, and solid waste management, are the main sources of sustainable buildings, and these indicators are not assessed in existing assessment tools. However, some unresolved issues relate to the model's generalization across different regions and building types in India. This may be because of the objective difficulties of capturing the nuances of local conditions and cultural practices and building typologies within a standardized framework, making comprehensive research challenging. One way to overcome this difficulty is to develop BPS models tailored to specific regions and building types, incorporating local legal systems, incentive structures, and stakeholder perspectives.

The study [17] presents research results regarding the influence of various barriers, drivers, and promotional strategies on adopting green building technologies in Ghana. It was shown that government-related barriers have a significant negative influence, while firm-related drivers have a considerable positive impact on green technology adoption. However, there are still unresolved issues regarding the need for strategies to be customized to each country's local context and characteristics, especially in developing countries. The main reason may be the fundamental differences in climatic conditions, culture, building type and age, and environmental, economic, and social priorities that shape each country's approach to green construction. A way to overcome this difficulty is to integrate locality into green construction adoption strategies.

The study [19] presents research results related to how the adoption of green construction practices at project sites affects economic performance through environmental performance. It was shown that environmental performance only partially mediates the relationship between green construction practices and project economic performance. However, there is still an unsolved issue regarding the reason why not all situations will result in projects that meet environmental performance standards, which will result in economically profitable projects. One of the reasons may be that the existing regulations in the study site (Nigeria) are not comprehensive enough to cover all aspects of green construction, as is generally the case in developing countries where the concept of 'green' is still relatively new. This implementation of green practices does not always lead to achieving environmental or economic performance. One way to overcome this difficulty is to strengthen government participation in promoting the adoption of green construction by creating more comprehensive regulations and standards that consider locality aspects such as local priorities and readiness. This approach was used by [19] who proposed an implementation strategy based on the findings in Nigeria, but its applicability in other countries still needs to be readjusted.

Despite the vast literature on green construction and sustainability, there is still a void in research that explicitly explores the integration of local wisdom into green construction frameworks, especially in developing countries with rich cultural heritage. In addition, the role of implementation strategy as a mediating variable in enhancing sustainable performance through integrating local wisdom is yet to be investigated.

Literature studies show that the variables of local wisdom-based green construction practices and implementation strategies impact the sustainability performance of construction projects. The problem that arises is whether these variables influence each other on sustainability performance. Therefore, this study is designed to build a model by utilizing local wisdom-based green construction practices as a variable to predict the sustainability model of construction project performance, as well as establishing implementation strategy as a mediating variable that will analyze the indirect relationship between local wisdom-based green construction practices and sustainability performance.

All this suggests that it would be worthwhile to research the interrelationships between green construction practice factors, local wisdom, implementation strategies, and sustainability performance measures, especially in developing countries with rich cultural heritage. Such research can provide valuable insights for practitioners and policymakers seeking to implement more effective and culturally appropriate green construction practices. This more integrated approach is expected to address outstanding issues and contribute to developing more appropriate sustainable construction strategies, particularly in culturally and geographically diverse contexts.

3. The aim and objectives of the study

The aim of the study is to identify the effect of green construction and local wisdom-based implementation strategies on sustainable performance in construction projects in Indonesia using PLS-SEM. This will allow construction industry professionals to develop more effective and culturally sensitive strategies for integrating local wisdom into green construction practices. The findings will enable project managers, policymakers, and other stakeholders to optimize the sustainable performance of construction projects by leveraging the synergies between modern green technologies and traditional knowledge systems. By demonstrating the significant impact of local wisdom-based green construction practices on economic, social, and environmental sustainability, this research will provide a compelling evidence base for industry professionals to adopt and scale up these approaches across diverse project types and geographical contexts. This will allow the construction sector to contribute substantially to achieving global sustainability goals while respecting and leveraging the unique cultural heritage of the communities in which they operate.

To achieve this aim, the following objectives are accomplished:

– to study green construction based on local wisdom, implementation strategies, and sustainable economic, social, and environmental performance in construction projects;

– to conduct PLS-SEM analysis to see the correlation between green construction based on local wisdom and sustainable performance, with implementation strategies as mediation.

4. Material and methods

The objects of this research are 10 construction projects that implement green construction practices based on local wisdom in Bali, Indonesia, namely Denpasar, Badung, and Gianyar, which can be representative to increase the objectivity of the analysis results. These projects were selected based on a commitment to integrating sustainable practices with traditional building techniques, covering a range of construction types, including hotels, apartments, offices, hospitals, and markets. This diverse selection allows for a comprehensive assessment of how local wisdom influences green construction practices and sustainable performance across different contexts. Sampling was categorized based on the following criteria:

1. Role in the project: those involved in green construction projects as project managers, site operational managers, site engineering managers, civil engineers, environmental engineers, architects, and supervisors.

2. Age of workers, with sub-criteria of age below 30 years (<30 years), between 30 to 45 years (30–45 years), and above 45 years (>45 years).

3. Experience is when a worker has worked and been involved in green construction projects, with sub-criteria of <2 years, 2–4 years, and >4 years.

4. Educational background, with sub-criteria of diploma/bachelor's degree, master's degree, and doctoral degree.

The following are the hypotheses in this study:

– H0: there is no significant influence between green construction based on local wisdom and sustainable performance. H1: there is a positive and significant influence between green construction based on local wisdom and sustainable performance;

– H0: there is no significant influence between green construction based on local wisdom and implementation strategy. H2: there is a positive and significant influence between green construction based on local wisdom and implementation strategy;

– H0: there is no significant influence of implementation strategy on sustainable performance. H3: there is a positive and significant influence of implementation strategy on sustainable performance;

– H0: there is no significant indirect influence between green construction based on local wisdom and sustainable performance through implementation strategy as a mediating variable. H4: there is a positive and significant indirect effect between green construction based on local wisdom and sustainable performance through implementation strategy as a mediating variable.

The main hypotheses of this study are H1 and H4. In conducting this survey, we assumed that all respondents had attended green building training and thus had a basic understanding of green construction principles and local building traditions. In addition, it was assumed that the respondents were aware of the current sustainability challenges in the construction industry.

Data was collected using a questionnaire completed by 200 engineers. The survey instrument used a 5-point Likert scale, and the judgments from the respondents of this study were consistently assessed using the scale. Therefore, the lowest respondent answer value was 1, and the highest was 5, with a class interval of (5–1): 5=0.8. The interpretation of the average value follows the explanation of the score offered by [29].

For the inferential analysis, this study used PLS-SEM (Partial Least Squares Structural Equation Modeling) analysis using SmartPLS software version 3.0. This approach was chosen for its ability to handle complex models with many latent variables and its robustness to non-normal data distributions, which is often encountered in sustainability-related research. PLS-SEM is an excellent research tool for advancing and developing theory. There are three simultaneous activities in SEM, namely confirming the validity and reliability, testing the correlation model between variables (path analysis), and obtaining an appropriate prediction model. Second-order confirmatory factor analysis is a two-level SEM measurement model that describes how first-level latent variables act as indicators of second-level latent variables [30].

The quantitative approach used in this study is based on the research objectives, namely, to determine the relationship between local wisdom-based green construction practices, implementation strategies, and sustainable performance. Using the PLS analysis technique, which is part of SEM (Structural Equation Modeling) analysis, it can effectively measure the direct and indirect relationships between these variables through their respective indicators, providing a comprehensive understanding of the factors affecting sustainable performance in the context of green construction based on local wisdom.

5. Results of analyzing the effect of green construction based on local wisdom on sustainable performance using PLS-SEM

5. 1. Green construction based on local wisdom, implementation strategies, and sustainable performance

This study distributed questionnaires to a sample of respondents to obtain primary data. The study analyzed four main variables: Green Construction based on Local Wisdom (*GCLW*), Implementation Strategy (S), and Sustainable Performance (*SP*). Table 1 shows the variables, factors, and indicators.

Table 1 shows this study's variables, factors, and indicators. The Green Construction based on Local Wisdom variable consists of 45 indicator items that measure 9 aspects of green construction practices with local wisdom, the Implementation Strategy variable consists of 41 indicator items that measure 13 aspects of green construction implementation strategies with local wisdom, and the Sustainable Performance variable consists of 21 indicator items that measure 3 aspects of sustainable performance.

Table 1

Variables, factors and indicators

Variable	Factors	Indicators
Green Construction based on Local Wisdom	Cultural heritage preservation	Local cultural elements, customary consultation, traditional techniques, social sensitivity, heritage honoring, ritual accommodation, local empowerment, identity space
	Energy efficiency & conservation	Passive design, efficient equipment, adaptive technology, energy audit
	Indoor & outdoor environment quality	Local materials, low emission, adequate ventilation, ecological landscaping, pollution mitigation
	Local & eco-friendly materials selection	Local sources, sustainable material, cycle evaluation, supply chain
	Local technology and resources utilization	Local sustainability, appropriate technology, contextual innovation, knowledge transfer
	Renewable energy utilization	Potential assessment, contextualized implementation, modular design, community energy empowerment
	Sustainable land use & development	Comprehensive site analysis, ecosystem conservation, ecological integration, participatory land management
	Sustainable waste management	Waste planning, 3R principle, community collaboration, localized materials and technologies, construction waste management training, community waste management education
	Water efficiency and conservation	Efficient technology, consumption monitoring, runoff management, water audit, local wisdom of water management, community-based water conservation
Implementation Strategy	Integration of sustainability assessment with local cultural values	Cultural sustainability assessment, local holistic indicators, stakeholder participatory assessment
	Development of locally-informed sustainability frameworks	Integration of local sustainable practices, cultural green construction framework, harmonization of local-global standards
	Development of context-responsive technological innovations	Contextualized innovation in green construction, appropriate collaborative research, implementation of culturally-adaptive technologies
	Facilitation of multi-stakeholder collaboration and partnerships	Multi-stakeholder strategic partnerships, collaborative coordination platform, local-based innovation synergies
	Active engagement of local communities in the construction process	Continuous community engagement, accommodation of local aspirations, local economic empowerment
	Enhancement of contextual sustainability and technological literacy	Contextualized green construction education, collaborative capacity building, dissemination of local green practices
	Implementation of adaptive green certification and environmental management systems	Contextualized green certification, adaptive environmental management, local sustainability monitoring
	Optimization of inclusive cross-disciplinary team collaboration	Green construction expert team, effective intra-team communication, inclusive decision-making
	Alignment with government policies and regulations	Local regulatory compliance, proactive government coordination, local green policy contribution
	Occupational health and safety	Standardized OHS management, participatory risk assessment, standardized provision of personal protection equipment, contextualized OHS training, effective incident investigation
	Application of holistic waste management strategies rooted in local practices	Local construction waste strategy, contextualized 3R principle, wisdom-based waste management
	Implementation of integrated risk management incorporating local wisdom	Contextualized risk assessment, local wisdom-based mitigation, participatory risk evaluation
	Utilization of BIM for sustainable design and construction with local considerations	Contextualized sustainable BIM, BIM local data integration, BIM local sustainability simulation
Sustainable Performance	Economic sustainability performance	Construction cost efficiency, creation of local employment opportunities, strengthening of local supply chains, improvement of market competitiveness, long-term operational cost savings, contribution to regional economic growth, savings in social and environmental costs
	Social sustainability performance	Improvement of community quality of life, preservation and reinforcement of local cultural heritage, community empowerment and inclusive participation, enhancing sociocultural resilience, protection and promotion of health and well-being, education and skills development, strengthening of community identity and pride
	Environmental sustainability performance	Climate change mitigation and reduction of carbon emissions, maintaining biodiversity and local ecosystems, efficient and sustainable water resource management, promotion of circular economy and sustainable waste management, improvement of air quality and environmental health, resilience and adaptation to climate change, preservation and revitalization of cultural landscapes

5. 2. Analysis using PLS-SEM

In PLS-SEM analysis, the initial step involves establishing inner and outer models of the observed variables. An outer model, or outer relation, is identified for each block of indicators connected to its latent variable. This model tests the reliability and validity of the research instrument, which is generally a questionnaire. This process involves evaluating loading factors, convergent validity, and discriminant validity. Meanwhile, the inner model describes the relationship between latent variables.

Fig. 1 illustrates the research conceptual framework in the form of a PLS-SEM path diagram based on the hypotheses previously made in section 4. This visualization clarifies the relationship between variables and facilitates structural analysis.

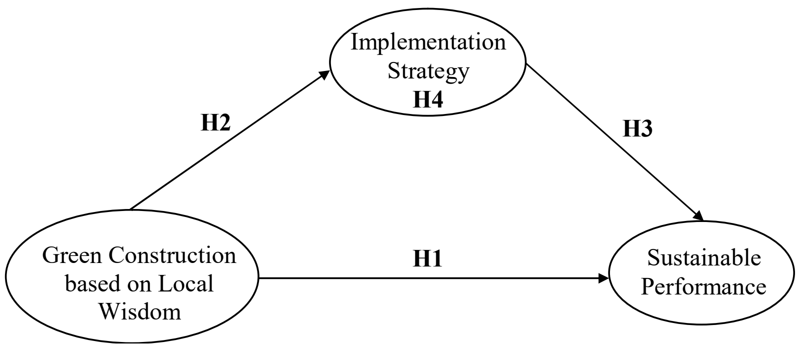

Fig. 1. Conceptual framework of the research path diagram

The evaluation of the measurement model in Structural Equation Modeling (SEM) using SmartPLS involves rigorous validity and reliability assessments. Convergent validity is established through the examination of Average Variance Extracted (AVE) (≥0.5). Reliability is assessed using Cronbach's Alpha (≥0.7) and Composite Reliability (≥0.7). The structural model's significance is determined through bootstrapping, with relationships considered significant at T-statistic >1.96 and P-value <0.05. This iterative process ensures robust measurement and structural models, providing a solid foundation for statistical inference and result interpretation. The comprehensive results of these validity and reliability tests are presented in Table 2, offering a detailed overview of the measurement quality in the proposed model and demonstrating adherence to the established criteria for quantitative research.

Referring to Table 2, the measurement model evaluation demonstrates robust validity and reliability. The Average Variance Extracted (*AVE*) values ≥0.50 support this validity. Reliability is established through Cronbach's Alpha ≥0.70 and Composite Reliability (*CR*) ≥0.70 for all constructs. These results indicate that the latent variables are adequately measured by their respective indicators, fulfilling the criteria for a robust measurement model. This rigorous approach, utilizing SmartPLS for Structural Equation Modeling (*SEM*), provides a solid foundation for subsequent analysis of relationships between variables, enhancing the credibility of the research findings in sustainability contexts.

The inner model evaluation employs R-Squared analysis for endogenous variables to assess explained variance proportion. It also utilizes correlation analysis and examines T-statistics' significance through resampling techniques like bootstrapping. This comprehensive approach ensures estimate stability and robust assessment of the structural relationships within the model. The measurement accuracy is categorized based on R-squared values: substantial if R-squared>0.75, moderate if R-squared>0.50, and weak if R-squared>0.25 [54]. This classification provides a standardized interpretation of the model's explanatory power, enabling researchers to gauge the strength of relationships between constructs and the overall predictive capability of the structural model in the context of PLS-SEM analysis.

In evaluating Structural Equation Models (SEM) using Partial Least Squares (PLS), the R-squared value for each endogenous latent variable is pivotal in assessing the structural model's predictive power, analogous to OLS regression interpretation. Variations in R-squared values elucidate the substantive impact of exogenous latent variables on endogenous constructs, determining their significance within the model. The PLS results quantify the model's explanatory power, with Table 3 presenting the R-squared values for the model's constructs. This analysis, part of the inner model assessment, is complemented by correlation analysis and T-statistics significance examination through bootstrapping, ensuring a comprehensive evaluation of structural relationships and construct importance within the theoretical framework.

Table 2

Evaluation of the Measurement Model Stage 2

Variable	Validity Overall (per construct)		Reliability		
	AVE (≥0.5)=Valid		Composite Reliability (≥0.7)=Reliable	Cronbach's Alpha (≥0.7)=Reliable	Description
	AVE	Conclusion	CR	Cronbach's Alpha	
Green Construction based on Local Wisdom (*GCLW_X*)	0.606	Valid	0.986	0.985	Reliable
Implementation Strategy (*S_Y*1)	0.651	Valid	0.987	0.986	Reliable
Sustainable Performance (*SP_Y*2)	0.654	Valid	0.992	0.992	Reliable

Table 3

PLS R-Squared evaluation results

Influence		R-Squared	
Green Construction based on Local Wisdom (*GCLW*_X)	→	Implementation Strategy (*S_Y*1)	0.802
Green Construction based on Local Wisdom (*GCLW_X*)	→	Sustainable Performance (*SP_Y*2)	0.831
Implementation Strategy (*S_Y*1)	→		

The PLS R-Squared Evaluation Results in Table 3 demonstrate robust predictive power within the structural model. Green Construction based on Local Wisdom (*GCLW_X*) substantially influences Implementation Strategy (*S_Y1*), with an R-squared value of 0.802. This indicates that *GCLW_X* explains 80.2 % of the variance in *S_Y1*, suggesting a strong predictive relationship. Moreover, the combined influence of *GCLW_X* and Implementation Strategy (*S_Y1*) on Sustainable Performance (*SP_Y2*) yields an even higher R-squared value of 0.831. This implies that these two constructs collectively account for 83.1 % of the variance in *SP_Y2*, demonstrating a robust predictive capability. According to established thresholds, both R-squared values exceed 0.75, categorizing them as substantial, which underscores the model's high explanatory power and the significance of the proposed relationships among the constructs.

The coefficient of total determination (Q^2) is a crucial metric for assessing model goodness of fit in structural equation modeling. It quantifies the model's efficacy in representing observed data, with values ranging from 0.0 to 100.0 %. Higher percentages indicate superior model performance in capturing empirical observations. This measure elucidates the path model's ability to explain variability in the dataset, providing insight into its predictive relevance and explanatory power. As Q^2 increases, it signifies a more robust and well-fitted model capable of effectively describing complex relationships among constructs. The calculated results for the coefficient of total determination are presented as follows:

$$Q^2 = 1-\left(1-R_1^2\right)\times\left(1-R_2^2\right) = \\ = 1-\left(1-0.802\right)\times\left(1-0.831\right) = \\ = 0.967 = 96.7\%. \quad (1)$$

The coefficient of total determination (Q^2) derived from the structural model is 0.967, indicating that the path model elucidates 96.7 % of the observed data variance, with the remaining 3.3 % attributed to exogenous factors beyond the scope of this research. This exceptionally high Q^2 value surpasses the threshold for strong models, firmly categorizing this construct as robust for theory confirmation. The magnitude of this coefficient underscores the model's superior predictive relevance and explanatory power. Consequently, the path construction is deemed highly appropriate and feasible for hypothesis testing.

The Goodness of Fit (GoF) calculation for the Partial Least Squares Structural Equation Modeling (PLS-SEM) in this study yields the following results:

$$G_0FY_{SP}^2 = \sqrt{\left(AVE\times R^2\right)}, \\ G_0FY_{SP}^2 = \sqrt{\left(0.654\times 0.831\right)}, \\ G_0FY_{SP}^2 = 0.737. \quad (2)$$

The Goodness of Fit (GoF) criterion for PLS-SEM models is categorized as small at 0.1, moderate at 0.25, and high at 0.38. In this study, the GoF calculation for Sustainable Performance yields a value of 0.737, substantially exceeding the threshold for high model fit. This result indicates exceptional model accuracy, demonstrating that the constructed model possesses strong explanatory power and predictive relevance. Consequently, the model is deemed highly adequate and appropriate for rigorous hypothesis testing within sustainable performance analysis.

This section analyzes the coefficients or parameters elucidating the statistical relationships between latent variables. The critical ratio (C.R.) serves as a key indicator of significance, with values falling outside the range of –1.96 to 1.96 at a 0.05 significance level, denoting statistically significant associations. The PLS software application facilitates the estimation of these critical ratio values for the structural model. Table 4 presents a comprehensive summary of the coefficient calculations, providing insight into the strength and direction of relationships among constructs. This analysis is crucial for determining the validity of hypothesized connections within the model.

Table 4

Results of PLS-SEM Path Analysis

Effect between Latent Variables			H	Path coeff.	*t*-value	*p*-value	Description
Explanatory variable	→	Response variable					
Green Construction based on Local Wisdom (*GCLW_X*)	→	Sustainable Performance (*SP_Y2*)	H1	0.290	3.454	0.001	Significant (H1 accepted)
Green Construction based on Local Wisdom (*GCLW_X*)	→	Implementation Strategy (*S_Y1*)	H2	0.895	39.221	0.000	Significant (H2 accepted)
Implementation Strategy (*S_Y1*)	→	Sustainable Performance (*SP_Y2*)	H3	0.642	7.913	0.000	Significant (H3 accepted)

Based on the results shown in Table 4, it can be concluded that H1-H3 can be accepted significantly, the explanation is as follows:

1. Green Construction based on Local Wisdom has a substantial consequence on the Sustainable Performance variable with Path Coefficient 0.290.

2. Green Construction based on Local Wisdom has a substantial consequence on the Implementation Strategy variable with Path Coefficient 0.895.

3. Implementation Strategy has a substantial consequence on the Sustainable Performance variable with Path Coefficient 0.642.

Mediating variable analysis employs two primary approaches: coefficient differentiation and coefficient multiplication. While the former involves comparative analyses with and without the mediating variable, this study utilizes the coefficient multiplication approach. This method thoroughly examines the indirect effects through the mediating pathway. The analysis process yields coefficient multiplication results systematically presented in Table 5. These findings elucidate the strength and significance of the mediating relationships within the structural model, providing crucial insights into the indirect effects between constructs.

The interpretation of Table 5 is as follows.

The indirect effect of Green Construction based on Local Wisdom (*GCLW_X*) on Sustainable Performance (*SP_Y2*) through Implementation Strategy (*S_Y1*) is 0.575 with a P-Value of 0.000. Because the P-Value=0.000<0.05, it is statistically declared Significant. So it can be concluded that Implementation Strategy (*S_Y1*) is able to act as a mediation between the influence of Green Construction based on Local Wisdom (*GCLW_X*) on Sustainable Performance (*SP_Y2*). This finding underscores the importance of implementing strategies in conducting green construction based on local wisdom for sustainable performance outcomes.

Table 5

Testing the Mediating Variable

Relationship between variables			H	Indirect effect	P-Value	Description
Explanatory variable	Mediating variable	Response variable				
Green Construction based on Local Wisdom (*GCLW_X*)	Implementation Strategy (*S_Y1*)	Sustainable Performance (*SP_Y2*)	H4	0.575	0.000	Significant (H4 accepted)

The structural relationships and measurement model specifications can be visually represented through path diagrams, which elucidate the path coefficients within the structural model and the loading factors of manifest variables in the measurement model. Fig. 2 presents a comprehensive visual depiction of these interrelationships, illustrating the path coefficients that quantify the direct effects between latent constructs in the structural model, as well as the loading factors that represent the strength of association between latent variables and their respective indicators in the measurement model.

Based on Fig. 2, it can be seen that the Sustainable Performance variable (*SP_Y2*) is more dominantly influenced by the Implementation Strategy variable (*S_Y1*), namely with the highest path coefficient of 0.642. The Green Construction based on Local Wisdom (*GCLW_X*) variable has a path coefficient of 0.895 on the Implementation Strategy (*S_Y1*) variable, where the dominant sub-variable that plays a role in representing the Green Construction based on Local Wisdom (*GCLW_X*) variable is the sustainable waste management dimension (*X*8), with the highest loading factor of 0.936. The sustainable waste management sub-variable (*X*8) is more dominantly measured by the indicator of utilizing sustainable local materials and technology in waste management (*X*8.4), with the highest loading factor of 0.918. The sub-variable that dominantly plays a role in representing the implementation strategy (*S_Y1*) variable is the alignment with government policies and regulations dimension (*Y*1.9), with the highest loading factor being 0.925.

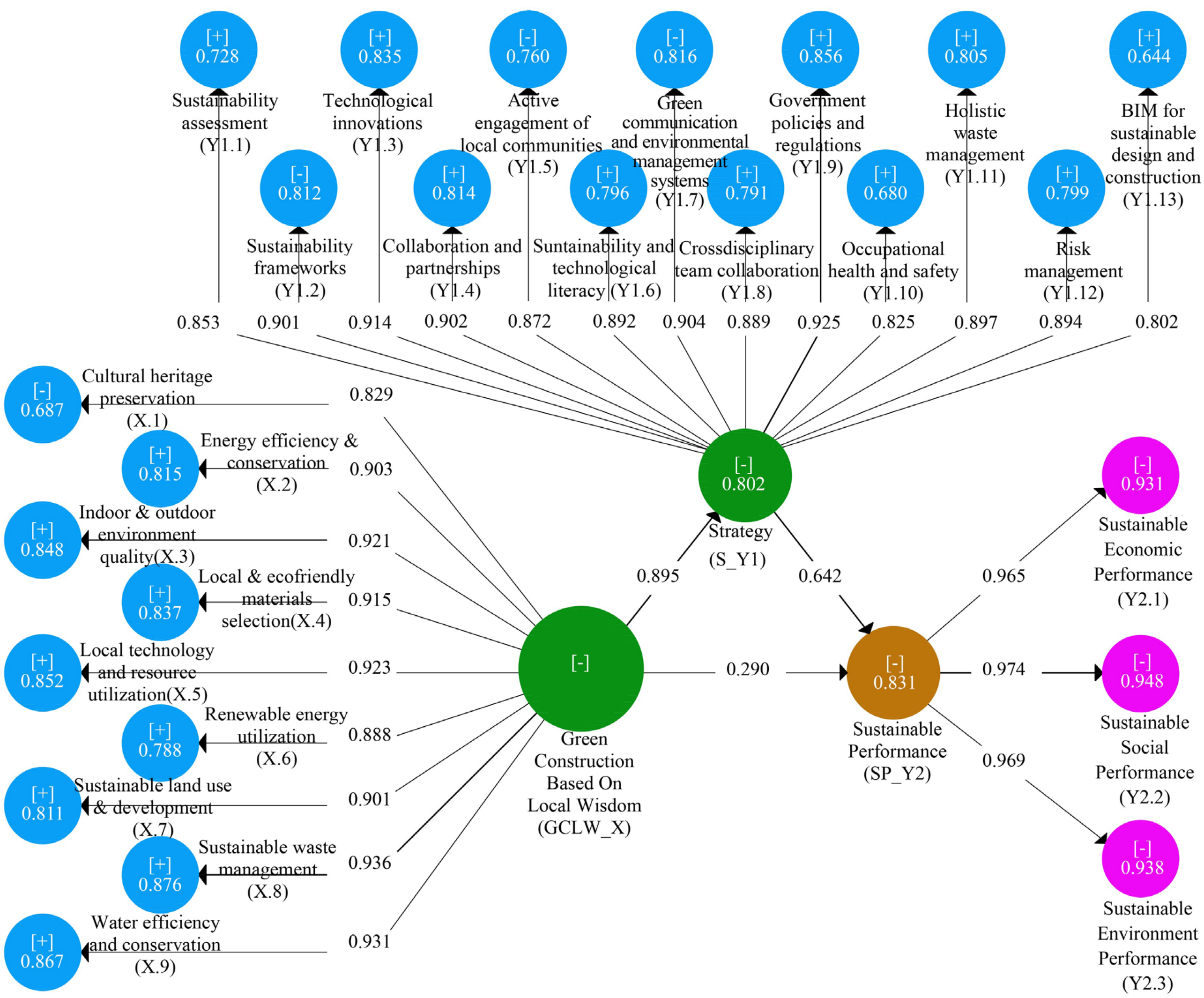

Fig. 2. Measurement model path diagram and structural model

6. Discussion of integrating local wisdom in green construction to enhances sustainable performance through implementation strategies

The results of this study reveal some critical insights into the relationship between green construction based on local wisdom, implementation strategies, and sustainable performance. The analysis of Table 2 shows that the indicators of the latent variables exhibit robust and feasible metrics, underlining their suitability for measurement. Furthermore, Table 3 describes the R-squared values for the two latent variables, which show high coefficients. The high R-squared values (0.802 for Implementation Strategy and 0.831 for Sustainable Performance, as shown in Table 3) indicate that the model has strong explanatory power. This suggests that green construction practices based on local wisdom significantly influence sustainable performance when mediated by effective implementation strategies.

Analysis of Table 4 shows that hypotheses H1–H3 are statistically supported, indicating a significant direct effect of Green Construction based on Local Wisdom on the other latent variables and the dependent variable, Sustainable Performance. Simultaneously, Table 5 provides evidence for the acceptance of H4, which indicates a significant indirect effect of Green Construction based on Local Wisdom on Sustainable Performance, mediated by Implementation Strategy.

The path coefficients shown in Table 4 further explain this relationship, namely the strong direct effect of green construction based on local wisdom on implementation strategies (path coefficient of 0.895). In addition, the substantial indirect effect (0.575, as shown in Table 5) of local wisdom-based green construction on sustainable performance, mediated through implementation strategies, highlights the important role of a well-designed implementation approach in translating local wisdom into tangible sustainability outcomes.

These findings are visually represented in Fig. 2, which illustrates the complex interactions between these variables. Notably, the dominating one is sustainable waste management (with a loading factor of 0.936) as an indicator of green construction based on local wisdom aligned with circular economy principles imbued in traditional practices. These results suggest that waste management using local materials and technologies with an implementation strategy of alignment with government policies and regulations (highest loading factor of 0.925) can be a key driver in improving the overall sustainability of construction projects. The high Goodness of Fit value (0.737, calculated using (2)) further validates the robustness of the model, indicating strong predictive relevance and explanatory power in the context of sustainable construction practices.

Previous studies that only investigated sustainable construction that did not involve local wisdom [5] and findings from previous studies that did not investigate the direct and indirect effects of each variable on sustainable performance were examined [10–12]. This study is unique in that green construction is based on local wisdom and examines the indirect effects of each variable. By demonstrating the significant impact of culturally-inspired practices on all three dimensions of sustainability – economic, social and environmental, this research provides a comprehensive framework, offering a more nuanced and culturally-sensitive approach to sustainable construction, which is particularly beneficial for developing countries with rich cultural heritage.

This research contributes to existing knowledge by proposing a new framework that integrates local wisdom-based green construction principles into sustainable performance, mediated by implementation strategies. The findings of this study have significant implications for construction managers, policymakers, and researchers in the field of sustainable development. By explaining the role of local wisdom and implementation strategies in enhancing sustainable performance, this study provides practical guidance for developing culturally sensitive and environmentally responsible construction practices.

Several limitations must be acknowledged in critically evaluating the scope and applicability of this study, including the geographical constraints of data collection in a specific region of Bali, Indonesia, while providing valuable insights into a culturally rich context, which may limit the generalizability of the findings to other cultural or geographical contexts. In addition, while this study identified sustainable waste management as a dominant indicator, specific local practices and their scalability across different project types and sizes were not extensively explored. These details are critical for practical application and may require further investigation to develop context-appropriate implementation guidelines. Alternatively, while valuable, the study's focus on the construction industry may not fully account for the wider ecosystem of stakeholders involved in sustainable development. The perspectives of policymakers, community leaders, and end-users of the constructed facilities were not directly included, potentially limiting a holistic understanding of the impact and acceptance of local wisdom-based green construction practices. These limitations underscore the need for careful interpretation and application of the findings.

This research provides a solid foundation for understanding the integration of local wisdom in green construction practices. However, there are several avenues for further development that could significantly increase its impact and applicability, including expanding the geographical coverage beyond Bali to include different regions in Indonesia and other developing countries, which would significantly increase the generalizability of the findings. This expansion is critical as it would allow for comparative analyses of how different cultural contexts influence the implementation and effectiveness of local wisdom-based green construction practices, thus providing a more comprehensive framework for sustainable development in different places. In addition, ethnographic studies, case analyses and participatory action research can complement PLS-SEM findings by providing detailed contextual information and stakeholder perspectives that are difficult to capture through quantitative methods alone. This holistic approach will be highly beneficial in understanding the complex socio-cultural dynamics that influence the adoption and effectiveness of green construction practices based on local wisdom. In addition, broadening the base of stakeholders involved in this research to include policymakers, community leaders, and end-users of built facilities will provide a more comprehensive view of the ecosystem involved in sustainable construction. In addition, developing more specific and context-sensitive indicators and measurement tools to assess the integration of local wisdom in green construction practices could significantly advance this field of study. This development is crucial as it will enable a more precise evaluation of the effectiveness of different local practices across various project types and scales, thus facilitating better decision-making in implementation strategies and policy formulation.

By undertaking this development, future research can build on current research to create a more comprehensive, nuanced and globally applicable understanding of how local wisdom can be effectively utilized to improve sustainable performance in the construction industry. Expanding the scope and depth of this research is critical to addressing the complex challenges of sustainable development in an increasingly interconnected yet culturally diverse global context.

7. Conclusions

1. This study successfully investigated the influence of green construction based on local wisdom and implementation strategies on sustainable performance in construction projects in Indonesia. Through rigorous PLS-SEM analysis, this study quantitatively demonstrates that green construction practices rooted in local wisdom significantly affect sustainable performance, with a direct effect path coefficient of 0.290. In addition, implementation strategy is an important mediating variable, amplifying this effect with an indirect effect coefficient of 0.575. These findings provide strong empirical evidence of integrating traditional knowledge into modern green construction techniques to improve the construction industry's economic, social and environmental performance.

2. PLS-SEM analysis revealed a strong correlation between green construction based on local wisdom and sustainable performance, with implementation strategy as a mediating variable. The model demonstrated high explanatory power, with an R-squared value of 0.802 for the relationship between green construction and implementation strategies and 0.831 for the combined effect on sustainable performance. Notably, sustainable waste management emerged as the dominant indicator in measuring green construction based on local wisdom, with the highest loading factor of 0.936. Alignment of implementation strategies with government policies and regulations also plays an important role, with a loading factor of 0.925. These quantitative indicators underscore the importance of utilizing local wisdom and aligning it with regulatory frameworks to achieve optimal sustainable outcomes in construction projects.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

All data are available in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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