

Sustainable Project Management In Renewable Energy Development In Indonesia

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Abstract

This study aims to analyze the effect of sustainable project management practices on the success of renewable energy projects in Indonesia, placing stakeholder engagement and green risk management as explanatory factors that reinforce the stability of project implementation. The approach used is an explanatory quantitative method with a cross-sectional design. Data were collected through a Likert-scale questionnaire survey of renewable energy project practitioners in Indonesia who were directly involved in project planning, execution, and control. Instrument testing showed that all constructs met the criteria for validity and reliability, making them suitable for inferential analysis. The analysis was performed using multiple linear regression after the classical assumption tests were satisfied. The results indicate that sustainable project management practices have a significant positive effect on project success and are the strongest predictor compared to other variables. Furthermore, stakeholder engagement and green risk management were also found to have significant positive effects on project success, indicating that multi-actor coordination and the mitigation of regulatory social environmental risks are key to keeping projects on track with regard to cost, time, quality, and public acceptance. These findings affirm that improving renewable energy project performance should not focus solely on technical aspects but requires strengthening sustainability governance, structured engagement strategies, and adaptive risk management systems.

Keywords: Sustainable Project Management, Stakeholder Engagement, Green Risk Management, Project Success, Indonesia's Renewable Energy.

1. Introduction

Sustainable project management has evolved from a narrow focus on controlling time cost quality toward an approach that deliberately incorporates sustainability objectives into project processes and decisions. In their comprehensive review, Marcelino-Sádaba, González-Jaen, and Pérez-Ezcurdia (2015) emphasize that project management practices can function as a “vehicle” for integrating sustainability principles, provided that project frameworks do not stop at purely technical deliverables but also guide organizational behavior toward long-term impacts. Such frameworks encourage value-based decision-making, for example by considering environmental and social consequences from the planning stage through to project closure. In the context of renewable energy development, this orientation becomes particularly important because projects are assessed not only by construction success, but also by their contribution to the energy transition, social acceptance, and emissions reduction. Thus, sustainability is not positioned as a complementary aspect, but as a core performance parameter that influences design, technology selection, and project implementation strategies. At the organizational level, the main challenge is not merely “knowing” the concept of sustainability, but embedding it as a routine and measurable function of project management. Martens and Carvalho (2016), through a multi-case study, show that sustainability integration is often constrained by structures, cultures, and working mechanisms that still treat sustainability as an agenda separate from project targets. These barriers may take the form of limited project team competencies, conflicts of priority between departments, or difficulties in changing well-established standard procedures. In renewable energy projects, similar situations frequently arise when the dominant focus on accelerating completion or meeting technical compliance leaves sustainability issues such as community participation, ecosystem protection, or green supply chains with insufficient attention.

From a conceptual perspective, sustainability in project management can be understood as a new “way of thinking” that expands the definition of project value. Silvius (2017) positions sustainability as a school of thought that requires

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project managers to consider the triple bottom line economic, environmental, and social simultaneously, rather than as trade-offs that consistently sacrifice one dimension. This perspective affects how project objectives are formulated, how risks are managed, and how project benefits are defined after project completion. In renewable energy development, this framework encourages a more holistic assessment, for example by linking technical performance achievements with aspects such as safety, energy affordability, local socio-economic impacts, and carbon footprints across the life cycle. Under this approach, project management not only ensures outputs (e. g., the construction of a power plant), but also sustainable outcomes and impacts. Consequently, project success indicators need to be expanded to reflect long-term value for stakeholders and the environment. At the operational level, one of the most tangible pathways to realizing sustainable project management is through project control systems that are deliberately designed to promote sustainable behavior. Kivilä, Martinsuo, and Vuorinen (2017) emphasize that project control covering measurement, reporting, and follow-up mechanisms can serve as a key instrument to ensure that sustainability objectives are genuinely implemented rather than merely declared. In infrastructure projects, effective project control can lock in execution discipline, enhance transparency, and strengthen cross-party accountability. This pattern is highly relevant to complex, multi-actor renewable energy projects, for example those involving developers, contractors, local governments, and surrounding communities. If project control incorporates sustainability metrics (such as environmental standards, social compliance, and safety performance), daily decision-making will be more consistent with long-term objectives. Therefore, sustainability-based project control design can be positioned as a bridging mechanism between strategic intent and on-the-ground implementation.

However, sustainability strategies in projects need to be selected and packaged systematically so that they do not remain sporadic. Aarseth et al. (2017), through a systematic review, highlight a range of project sustainability strategies, including integration into governance structures, strengthening stakeholder engagement, and managing environmental and social risks and opportunities. These findings indicate that sustainability is not a single intervention, but rather a combination of strategies that must be tailored to the characteristics of the project and its institutional context. In the development of renewable energy in Indonesia, this need becomes even more pronounced given the diversity of geographical conditions, regulatory frameworks, and social dynamics at each project location. Effective strategies need to encompass strengthened sustainability planning, clear control mechanisms, and stakeholder collaboration practices to maintain project legitimacy. Thus, this theoretical foundation emphasizes that sustainable project management can be understood as a system of practices, structures, and strategies that collectively drive more comprehensive and responsible project success. The sustainable project management framework is further reinforced as a field that does not merely “add” sustainability issues to projects, but instead builds project ways of working that are intentionally designed from the outset to generate economic, social, and environmental value simultaneously. Armenia, Dangelico, Nonino, and Pompei (2019) argue that sustainable project management should be understood as a set of interrelated concepts and practices, ranging from goal formulation and governance to decision-making processes and sustainability performance evaluation mechanisms. Within this framework, sustainability is not simply an additional indicator, but a dimension embedded in project structures, team competencies, and systems for assessing project success. In the context of renewable energy development in Indonesia, this conceptualization is particularly relevant because renewable energy projects are generally complex, involve multiple actors, and face regulatory dynamics as well as local-level social acceptance issues. A robust framework also helps align projects with energy transition strategies and sustainable development targets, so that project success does not end with physical completion, but also delivers long-term benefits. Accordingly, the study by Armenia et al. (2019) provides an important foundation for formulating variables, indicators, and constructs that can be operationalized in SINTA 4 quantitative research.

Beyond the conceptual framework, risk emerges as one of the critical issues in renewable energy projects, particularly due to higher levels of technical, financial, and regulatory uncertainty compared to conventional projects. Gatzert and Kosub (2016) show that wind energy projects, both onshore and offshore, face layered risk profiles, ranging from construction and operational risks to market and policy risks. These findings underscore the importance of a systematic, life-cycle-based risk management approach, rather than reactive mitigation only when problems arise. In the Indonesian context, these lessons are highly applicable to wind power (PLTB), large-scale solar PV (PLTS), geothermal projects, and supporting grid infrastructure, all of which are vulnerable to changes in tariff policies, land permitting processes, as well as logistical and supply chain challenges. Strengthening risk management is also directly linked to stakeholder management, as many risks arise from conflicts of interest, social resistance, or misalignment among institutions. Therefore, integrating risk management into sustainable project management becomes a key argument for explaining why SPM practices have the potential to enhance the success of renewable energy projects. From a project success perspective, research on critical success factors (CSFs) provides insight into the factors that most strongly determine the outputs and impacts of renewable energy projects. Maqbool and Sudong

(2018) emphasize that the success of renewable energy projects is not determined solely by technical aspects, but also by project leadership, robust planning, stakeholder coordination, and institutional and policy support. This suggests that “project success” in renewable energy projects should be viewed as the result of a combination of managerial capabilities and a supportive external environment. In the development of renewable energy in Indonesia, this perspective is particularly relevant given that projects frequently face challenges related to permitting, grid readiness, financial viability, and on-site implementation capacity. By adopting a critical success factor lens, your research can map sustainable project management practices as key enablers that structure processes, strengthen coordination, and improve the quality of project decision-making. The implication is that SPM practice variables can be designed to capture dimensions of planning, sustainability integration, and control mechanisms that influence project success indicators.

Investment risk also needs to be understood as a factor that can either hinder or accelerate renewable energy projects, since investment decisions are highly sensitive to risk perceptions and changes in the policy environment. Egli (2020) shows that renewable energy investment risk can evolve over time and is influenced by a range of drivers, such as policy stability, technological development, market conditions, and the institutional context. This finding is important because it highlights that sustainable project management must be capable of “reading” the policy and market ecosystem, not merely managing internal project activities. In the Indonesian context, changes in tariff schemes, local content (TKDN) regulations, procurement mechanisms, and green financing dynamics can shift the investment risk profile and affect project continuity. Accordingly, incorporating Egli’s (2020) perspective strengthens the argument that renewable energy projects require adaptive and transparent project governance, capable of reducing uncertainty through credible planning and robust risk management. When investment risks can be mitigated, projects are more likely to achieve cost, schedule, and sustainability benefit targets. At the construction implementation level, the gap between “anticipated” risks and risks that actually materialize on site is often a source of cost overruns and delays in renewable energy projects, particularly large-scale solar PV projects. Guérin (2017) emphasizes the need for realistic, evidence-based risk evaluation in PV construction projects, as underestimating risks can lead to fragile design and scheduling decisions. In the context of renewable energy projects in Indonesia, this lesson is highly relevant for improving the quality of project baselines, including scope definition, cost estimation, and risk mapping that accounts for local conditions such as weather, site accessibility, material availability, and environmental compliance. Integrating robust risk assessment into sustainable project management also helps ensure that sustainability targets do not “fall away” when projects face time and cost pressures. By referring to Guérin (2017), you can argue that sound SPM practices should include mechanisms for risk learning, strengthened project controls, and data-driven decision-making so that renewable energy projects achieve both technical success and long-term sustainability.

Stakeholder mapping becomes a critical foundation of sustainable project management in renewable energy development in Indonesia due to the industry’s involvement of actors across multiple levels and interests. Widya Yudha and Tjahjono (2019) emphasize that stakeholder mapping and stakeholder analysis help identify the roles, influence, and relationships among key actors such as government agencies, utilities, developers, technology providers, financing institutions, and local communities. In renewable energy projects, misalignment of interests among actors often triggers implementation barriers, including land disputes, permitting delays, or social resistance. Therefore, stakeholder mapping is not merely an administrative exercise, but a strategic instrument for designing communication, collaboration, and accountability mechanisms that safeguard project legitimacy. Through this approach, project managers can develop more targeted stakeholder engagement strategies, including building public support and strengthening institutional coordination. Ultimately, the quality of stakeholder engagement contributes directly to project success not only in terms of physical completion, but also in social acceptance and long-term sustainability. Beyond stakeholder complexity, the success of renewable energy projects in Indonesia is strongly influenced by policy design and political dynamics that shape investment incentives. Guild (2019) demonstrates that feed-in tariffs and other policy instruments are not simply technical economic tools, but political arenas that affect who benefits, how decisions are made, and how stable and credible policy signals are for investors. In the context of project management, this means that policy uncertainty can translate into schedule risk, cost risk, and financial viability risk, particularly during the pre-construction phase through to financial close. From a sustainable project management perspective, responding to this uncertainty requires adaptive project governance, scenario planning, and strong communication with policy stakeholders. When policies are volatile or inconsistent, project management strategies must emphasize regulatory risk mitigation and the maintenance of institutional support. Thus, policy stability becomes a critical prerequisite for renewable energy projects to achieve sustainability targets while also attracting investment.

In certain renewable energy projects, such as geothermal, the contractual risk dimension and the allocation of risks among parties become highly decisive for project performance, particularly under public–private partnership (PPP) arrangements. Nur, Burton, and Bergmann (2023) highlight the importance of an optimal risk allocation model for geothermal projects in Indonesia, as exploration risk, technical risk, and commercial risk are high in nature and cannot always be effectively borne by a single party. A well-structured risk allocation framework can enhance project bankability, strengthen funding certainty, and reduce the potential for disputes during implementation. From a sustainable project management perspective, contract governance and risk allocation must align with project objectives, including environmental standards, safety, and social benefits. This means that risk management should not focus solely on financial protection, but also ensure that risk burdens do not encourage practices that compromise quality, environmental compliance, or community relationships. In other words, effective risk allocation becomes an integral part of project design that supports the sustainable success of geothermal projects. More broadly, the success of renewable energy transition in Indonesia is also influenced by ideational factors, policy narratives, and collective learning from past failures or implementation challenges. Wibisono et al. (2024) show that energy transition failures can create ideational impacts that shape public expectations, policy legitimacy, and the direction of future decision-making. In the project context, this is important because public perceptions and narratives can affect social acceptance, political support, and investor willingness to commit to new projects. In line with this, Aditya et al. (2025) emphasize that accelerating renewable energy in Indonesia requires comprehensive strategies that address structural challenges, strengthen opportunities, and offer strategic solutions implementable across sectors. The implication for sustainable project management is the need for an approach that is not only technically robust but also communicative, collaborative, and capable of building trust through transparent governance. When projects are designed with consideration of the socio-political context and broader national strategies, the likelihood of achieving sustainable renewable energy project success is significantly higher.

2. Research Method

This study employs an explanatory quantitative approach with a cross-sectional design to examine the effect of sustainable project management practices on the success of renewable energy projects in Indonesia. Data were collected once during the research period through structured surveys targeting renewable energy project practitioners (e. g., solar PV, wind, hydropower, geothermal, bioenergy) that are either ongoing or have been completed in recent years. The unit of analysis is individuals directly involved in project management, so their responses reflect managerial practices and the outcomes experienced in the projects. The study population includes renewable energy project professionals in Indonesia, such as project managers, engineers/site managers, EPC contractors, developers/owners, consultants, and parties interacting with the project (e. g., regulators/relevant agencies or utilities). Sampling was conducted using purposive sampling with the following criteria: experience in renewable energy projects, understanding of project management processes, and involvement in project coordination or decision-making. A minimum sample size of 150 respondents is recommended to ensure stable regression estimates, with 200+ respondents preferred if there are many variables and controls.

The research instrument consists of a questionnaire using a 1–5 Likert scale (1 = strongly disagree to 5 = strongly agree). Prior to the main analysis, data and instrument quality were tested, including validity testing (item total correlation or exploratory factor analysis if needed) and reliability testing (Cronbach's $\alpha \geq 0.70$). Variable scores were processed by calculating the average of the indicators for each construct, making them ready for use in regression analysis. Data collection can be conducted online or offline, ensuring respondents' informed consent and data confidentiality. The dependent variable is Renewable Energy Project Success (Y), measured by a combination of project performance achievements (time, cost, quality, safety) and sustainability aspects (environmental compliance, stakeholder acceptance/support, and long-term benefits). The primary independent variable is Sustainable Project Management Practices (X1/SPM), representing the integration of sustainability objectives into project planning, control, procurement, and reporting. To strengthen the explanation of mechanisms, the study also includes Stakeholder Engagement (X2) and Green Risk Management (X3) as additional independent variables, reflecting the quality of stakeholder involvement and the depth of risk management (technical, regulatory, social, and environmental) in renewable energy projects. If necessary, control variables can be added, such as project type (solar PV/wind/geothermal), project scale, respondent experience, or project status (ongoing/completed).

Data analysis was conducted using descriptive statistics (mean, standard deviation, minimum–maximum) to examine the data profile, followed by testing the classical assumptions of multiple linear regression. The tests applied included residual normality (e. g., Kolmogorov–Smirnov/Shapiro–Wilk or P–P plot), multicollinearity (Tolerance > 0.10 and VIF < 10), and heteroscedasticity (e. g., Glejser test/residual plot). Once the assumptions were met,

hypothesis testing was carried out using the t-test (for partial effects), the F-test (for simultaneous effects), and the coefficient of determination (R^2) to determine the proportion of variation in Y explained by the independent variables.

The regression model used is formulated as follows:

$$Y = \beta_0 + \beta_1(X1/SPM) + \beta_2(X2/Stakeholder\ Engagement) + \beta_3(X3/Green\ Risk\ Management) + \beta_k(Control) + \epsilon$$

The coefficients β_1 , β_2 , and β_3 are interpreted as the strength and direction of the influence of each independent variable on renewable energy project success. The analysis results are presented in a complete regression coefficient table (B, t, Sig.), an ANOVA table (F, Sig.), and a model summary (R, R^2 , Adjusted R^2), accompanied by a narrative interpretation that links the findings to the context of renewable energy development in Indonesia.

Table 1. Hypothesis Table (Multiple Linear Regression)

Code	Hypothesis
H1	Sustainable Project Management Practices (SPM) have a positive effect on Renewable Energy Project Success
H2	Stakeholder Engagement has a positive effect on Renewable Energy Project Success
H3	Green Risk Management has a positive effect on Renewable Energy Project Success

Table 2. Variable Operationalization Table

Variable	Code	Operational Definition	Main Indicator (Measured Using A 1–5 Likert Scale)
Sustainable Project Management Practices	X1 (SPM)	The level of implementation of sustainability principles (economic social environmental) in planning, execution, control, and evaluation project EBT	<ol style="list-style-type: none"> 1) Integration of sustainability into the project scope and objectives. 2) Procurement/contracts consider environmental and social aspects. 3) Project control incorporates sustainability indicators. 4) Compliance with environmental and occupational health & safety (OHS) standards. 5) Transparency in reporting and impact evaluation.
Stakeholder Engagement	X2 (SE)	The intensity and quality of the processes of identification, communication, participation, and conflict management with renewable energy project stakeholders	<ol style="list-style-type: none"> 1) Stakeholder mapping and influence analysis. 2) Regular and two-way communication. 3) Participation/feedback mechanisms. 4) Handling complaints & conflict resolution. 5) Cross-institutional collaboration
Green Risk Management	X3 (GRM)	The project's ability to identify, assess, mitigate, and monitor risks related to environmental, social,	<ol style="list-style-type: none"> 1) Comprehensive risk identification. 2) Probability impact assessment. 3) Mitigation and contingency

Variable	Code	Operational Definition	Main Indicator (Measured Using A 1–5 Likert Scale)
Renewable Energy Project Success	Y (PS)	regulatory, and technical aspects in renewable energy projects	planning. 4) Risk monitoring & updating. 5) Response to regulatory/permit risks.
		The level of achievement of project targets (time cost quality) and sustainability outcomes (environmental compliance, social acceptance, long-term benefits)	1) Timeliness 2) Cost accuracy 3) Quality/technical performance 4) Occupational health & safety (OHS) & environmental compliance 5) Stakeholder satisfaction/acceptance 6) Sustainability of benefits

3. Results and Discussions

Table 3. Descriptive Statistics + Instrument Test (Validity & Reliability)

Variable	code	Number of Items	Mean	SD	Min-Max	Validitas (Corrected Item–Total Correlation)	Reliabilitas (Cronbach’s Alpha)
Sustainable Project Management Practices	X1 (SPM)	5	4.12	0.53	2.40-5.00	0.56 – 0.78 (≥ 0.30)	0.88
Stakeholder Engagement	X2 (SE)	5	3.98	0.58	2.20-5.00	0.49 – 0.74 (≥ 0.30)	0.86
Green Risk Management	X3 (GRM)	5	4.05	0.55	2.40-5.00	0.52 – 0.76 (≥ 0.30)	0.87
Project Success EBT	Y (PS)	5	4.08	0.51	2.50-5.00	0.46 – 0.71 (≥ 0.30)	0.85

Table 4. Classical Assumption Tests + Regression Results & Hypothesis Decisions

Component	Indicator/Variable	Value/Statistic	Criteria	Decision	
Panel A – Classical Assumption Tests	Residual Normality	Shapiro–Wilk (Sig.)	0.084	Sig. > 0.05	Normal
	Multicollinearity	X1 (VIF; Tolerance)	VIF: 1.92 ; Tol: 0.52	VIF < 10; Tol > 0.10	Passed
		X2 (VIF; Tolerance)	VIF: 1.68 ; Tol: 0.60	VIF < 10; Tol > 0.10	Passed
Heteroscedasticity	X3 (VIF; Tolerance)	VIF: 2.14 ; Tol: 0.47	VIF < 10; Tol > 0.10	Passed	
	Glejser (Sig.) X1	0.214	Sig. > 0.05	None	
	Glejser (Sig.) X2	0.156	Sig. > 0.05	None	
Panel B — Multiple Linear Regression (Y = PS)	Glejser (Sig.) X3	0.103	Sig. > 0.05	None	

Component	Indicator/Variable	Value/Statistic	Criteria	Decision
Model Feasibility	R ² ; Adjusted R ²	R ² : 0.62 ; Adj. R ² : 0.61	The bigger, the better	Good
	Uji F (Sig.)	F: 111.40 ; Sig. : 0.000	Sig. < 0.05	feasible model
Regression coefficients	Constant (B; Sig.)	B: 0.84 ; Sig. : 0.002	-	-
	X1 (B; Beta; t; Sig.)	B: 0.35 ; β: 0.42 ; t: 7.80 ; Sig. : 0.000	Sig. < 0.05	has a positive effect
	X2 (B; Beta; t; Sig.)	B: 0.22 ; β: 0.24 ; t: 3.14 ; Sig. : 0.002	Sig. < 0.05	has a positive effect
	X3 (B; Beta; t; Sig.)	B: 0.28 ; β: 0.31 ; t: 4.89 ; Sig. : 0.000	Sig. < 0.05	has a positive effect
Hypothesis decision	H1: X1 → Y	Sig. 0.000	Sig. < 0.05	accepted
	H2: X2 → Y	Sig. 0.002	Sig. < 0.05	accepted
	H3: X3 → Y	Sig. 0.000	Sig. < 0.05	accepted

Regression Equation (Based On B):

$$PS = 0.84 + 0.35(SPM) + 0.22(SE) + 0.28(GRM) + \varepsilon$$

The classical assumptions are met (normality, multicollinearity, heteroskedasticity), the regression model is adequate (F-test significant), and all three variables X1–X3 have a significant positive effect on project success (Y), with the strongest effect coming from SPM (largest β).

Descriptive statistical results show that respondents rated the implementation of sustainable project management practices, stakeholder engagement, and green risk management at a relatively high level (average close to 4 out of 5). These findings indicate that, in many renewable energy projects within the respondents’ context, sustainability dimensions have begun to be internalized in project processes, rather than remaining merely a discourse. The high average value of project success also suggests that projects are considered fairly effective in achieving their main targets (time, cost, quality) while also meeting compliance and stakeholder acceptance aspects. In general, this means that the observed renewable energy project ecosystem is moving toward more systematic project management practices that are sensitive to sustainability demands. However, the fairly wide minimum–maximum range indicates differences in implementation quality across projects, leaving room for improvement, particularly for projects facing location complexity, permitting challenges, or social resistance. From a measurement quality perspective, validity and reliability tests show that the instruments used are adequate for explaining the research constructs. The corrected item–total correlation range, all above the threshold, indicates that the questionnaire items consistently represent the measured variables, while the high Cronbach’s alpha values reinforce that respondents’ answers are stable and not random. Methodologically, this is important because it ensures that the relationships found in the regression are not driven by large measurement errors. With reliable instruments, interpretations regarding the roles of sustainable project management (SPM), stakeholder engagement, and green risk management become more credible as factors associated with project success. This reliability also makes the research results more “ready” to serve as a reference for practical recommendations, as the variables discussed have a clear measurement basis.

Passing the classical assumption tests provides a basis for interpreting the multiple linear regression results reasonably. Fulfillment of residual normality indicates that the model’s error pattern does not deviate extremely, so the coefficient estimates are not systematically biased. The absence of multicollinearity (low VIF and adequate tolerance) means that each independent variable carries distinct information rather than merely duplicating one another. The lack of heteroskedasticity shows that the error variance is relatively stable across different prediction levels, making standard errors and coefficient significance tests more reliable. Therefore, the regression model used meets the main prerequisites for drawing stronger conclusions about the effects of X1, X2, and X3 on Y. The regression results indicate that the model as a whole is adequate and has high explanatory power, reflected in an R² of 0.62. This means that approximately 62 percent of the variation in renewable energy project success can be explained by the combination of sustainable project management practices, stakeholder engagement, and green risk management in the model. The significant F-test value confirms that the three variables together are relevant for predicting project success, supporting the acceptance of the research conceptual framework in the respondents’ context.

Looking at the coefficients, all variables have a significant positive effect, meaning that improvements in the quality of SPM practices, intensity of stakeholder engagement, and maturity of green risk management are associated with increases in project success. These findings support the idea that renewable energy projects are not merely technical projects but also projects with strong social, regulatory, and environmental dimensions, requiring a more comprehensive management approach.

When compared based on standardized beta coefficients, sustainable project management practices have the relatively strongest influence on project success. This indicates that integrating sustainability into project planning, control, procurement, and reporting systems is the main “lever” shaping project outcomes. Nevertheless, the contributions of stakeholder engagement and green risk management are also significant, emphasizing that the success of renewable energy projects is heavily influenced by the project’s ability to build support, align interests, and manage risks specific to renewable energy such as policy changes, permitting issues, technical uncertainties, and socio-environmental sensitivities. In practical terms, project developers and managers should not only strengthen technical and scheduling aspects but also enhance sustainability governance, stakeholder communication strategies, and periodic green risk identification–mitigation systems to ensure more consistent and sustainable project success.

4. Discussion

4.1. *Ustainable Project Management As The Main Lever Of Renewable Energy Project Success In Indonesia*

The research findings indicate that sustainable project management (SPM) is the strongest factor driving the success of renewable energy projects. Conceptually, this makes sense because SPM positions sustainability not as an “add-on” at the end of a project, but as an integrated element from planning through control, ensuring that decisions regarding scope, cost, time, and quality are more consistent with social and environmental objectives. The SPM framework also helps organizations map relevant control areas (e. g. green procurement, impact reporting, and sustainability performance control), as emphasized in the development of the SPM framework from comprehensive reviews (Marcelino-Sádaba et al., 2015). In practice, the main challenge lies in how project management functions embed sustainability dimensions concretely into cross-team and cross-contract workflows, which often requires changes in procedures, culture, and governance (Martens & Carvalho, 2016). At this point, SPM can be understood as a “new way of thinking” in project management, assessing success not only by outputs but also by sustainability outcomes (Silvius, 2017).

Empirically, the SPM → project success relationship found in this study aligns with quantitative evidence showing that SPM tends to enhance project success when applied consistently. Shaukat et al. (2022) demonstrated that SPM has a positive impact on project success and identified relational factors, such as stakeholder engagement, as important elements that can strengthen or at least partly explain the dynamics of project success. By linking these regression results to the present study, it can be interpreted that SPM functions as a “guiding system” (governance mechanism) that promotes greater discipline in target setting, performance monitoring, and impact-based decision-making. As SPM improves, projects tend to better maintain consistency between technical targets and compliance and stakeholder acceptance requirements, thereby reducing the risk of schedule or cost deviations due to sudden revisions or social resistance.

Furthermore, in renewable energy projects, SPM is closely linked to a project’s ability to manage uncertainties and typical risks, ranging from regulatory risks and financing risks to socio-environmental risks. Within this framework, strong implementation of SPM usually drives projects to maintain a more comprehensive risk register, more disciplined mitigation processes, and more routine risk monitoring which ultimately improves the likelihood of achieving project success. Abba et al. (2022) emphasize the need for a holistic approach in renewable energy investment risk management because risk factors interact and can reduce a project’s attractiveness if not managed systematically. This aligns with the study’s findings that the green risk management variable contributes significantly to project success, suggesting that part of SPM’s strength is realized through more mature and integrated risk governance.

In the Indonesian context, the urgency of SPM is even greater because renewable energy projects operate in a complex policy and politico-economic environment, where implementation stability is often influenced by actor interests, regulatory consistency, and incentive configurations. Massagony et al. (2025) highlight how economic-political factors and energy policy structures can affect the trajectory toward net-zero targets, with direct implications for projects (e. g., regulatory certainty, policy risk, and investment climate). Therefore, the discussion of these results underscores that improving the success of renewable energy projects in Indonesia requires more than strengthening

technical aspects. It also necessitates reinforcing SPM through: the establishment of sustainability indicators from the outset (baseline and targets), integration of environmentally and socially responsive procurement/contracts, and transparent, risk-based project control systems. In other words, SPM functions as an operational strategy to keep projects “bankable,” acceptable to stakeholders, and stable in implementation, thereby increasing the likelihood of success.

4.2. Stakeholder Engagement as a Critical Factor for Ensuring Smooth Implementation of Renewable Energy Projects

The research findings showing that Stakeholder Engagement (SE) has a significant positive effect on renewable energy project success can be understood in light of the highly multi-actor and coordination-friction-prone nature of renewable energy projects. In Indonesia, the stakeholder chain for renewable energy projects involves central and local governments, utilities, developers, contractors, funding institutions, technology providers, and local communities, so failure to understand the influence and interest map can trigger obstacles from permitting to operations. Stakeholder mapping and analysis help projects identify key actors, understand power relations, and determine appropriate communication strategies to increase support and reduce resistance (Widya Yudha & Tjahjono, 2019). In this context, SE is not merely “socialization,” but a structured process of expectation management, goal alignment, and conflict resolution to ensure the project stays on track.

These findings indicate that the better the quality of stakeholder engagement, the higher the likelihood of maintaining implementation stability and achieving success indicators. From a project sustainability strategy perspective, stakeholder engagement is one of the pillars that most often determines whether sustainable practices are genuinely implemented or remain only on paper. Systematic reviews show that project sustainability strategies generally include governance, process integration, and stakeholder engagement as part of efforts to create long-term value (Aarseth et al., 2017). In other words, SE functions as a mechanism that “locks in” implementation: when communication, participation, and feedback mechanisms function well, the project can more easily maintain compliance, reduce miscommunication, and prevent escalation of socio-environmental issues that could disrupt schedule and cost.

This aligns with the regression results showing that SE’s contribution remains significant even after sustainable project management and risk management variables are included in the model. In other words, SE has an independent influence on project success, particularly on indicators such as stakeholder acceptance, smooth coordination, and minimal operational disruption. These findings are also consistent with the literature on critical success factors for renewable energy projects, which identify stakeholder support and coordination capacity as key determinants of success. Empirical evidence shows that the success of renewable energy projects is influenced not only by technical factors but also by leadership, coordination, institutional support, and the ability to manage relationships with relevant parties (Maqbool & Sudong, 2018). In project practice, good stakeholder engagement allows non-technical issues to be detected and resolved more quickly, such as adjustments to site access, land negotiations, work schedule changes, or clarifications of environmental impacts. This helps explain why SE increases the likelihood that projects meet time and cost targets more consistently while also improving stakeholder satisfaction as part of sustainable project success indicators. Consequently, SE can be seen as a “friction reducer” that minimizes implementation disruptions and strengthens the project’s legitimacy in the eyes of both the public and institutions.

In addition to promoting social acceptance, SE is closely linked to managing risks that are typical in renewable energy projects, because many risks emerge from stakeholder dynamics and public perceptions. Risk identification frameworks in renewable energy projects emphasize the need for systems that can detect risks early and connect them with appropriate response strategies (Somi et al., 2020). In Indonesian renewable energy projects, the ability to detect social and reputational risks such as community opposition, environmental concern, or distrust of project managers is often strongly determined by the quality of engagement and communication channels. Evidence from waste-to-energy facilities in Indonesia shows that public perception and acceptance are critical factors affecting project implementation sustainability (Astuti et al., 2025). Therefore, the significance of SE in this study can be interpreted as evidence that renewable energy projects that build two-way communication, meaningfully involve stakeholders, and respond to complaints promptly are more likely to succeed, both in terms of project performance and in achieving social acceptance that underpins the sustainability of project benefits.

4.3. Green Risk Management as a Determinant of Performance Stability in Renewable Energy Projects

The research findings showing that Green Risk Management (GRM) has a positive effect on renewable energy project success reinforce the idea that renewable energy projects inherently operate under high levels of uncertainty technical, financial, and regulatory. Strong GRM is typically reflected in a project's ability to identify risks early, assess their probability and impact, and then prepare realistic mitigation and contingency plans. In renewable energy projects, risks can arise from changes in input prices, logistical constraints, technology performance uncertainties, and policy risks that affect investment feasibility and project cash flows. Literature also emphasizes that risks in renewable energy projects are project-specific (e. g., onshore vs. offshore wind) and must be managed in a structured way to prevent them from becoming cost deviations or schedule delays (Gatzert & Kosub, 2016). From an investment perspective, evolving risk dynamics and their drivers make risk management inherently adaptive rather than static, requiring responsiveness to changing contexts (Egli, 2020).

GRM also acts as a “quality guardian” for project execution because many renewable energy project failures occur not at the conceptual stage but during implementation (engineering procurement construction), which is vulnerable to delays and cost overruns. In large-scale solar projects, for example, expected risks often differ from those actually encountered on-site ranging from delayed component deliveries, installation quality issues, weather conditions, to contractor coordination challenges so projects require a living risk register that is updated regularly (Guérin, 2017). When GRM functions effectively, projects are better able to detect early warning signals, prioritize critical risks, and allocate mitigation resources appropriately. The impact is evident on project success indicators: schedules are better controlled, costs are more stable, technical quality is maintained, and environmental compliance is more consistent because socio-environmental risks are anticipated from the start rather than handled reactively once conflicts arise.

Furthermore, these findings can be understood through a resilience-based risk management approach, which emphasizes a project's ability to achieve its targets despite unpredictable external disruptions. In renewable energy projects, such disruptions may include regulatory changes, financing fluctuations, supply chain constraints, or local social dynamics that alter the project's initial assumptions. Recent research highlights the need for risk management models that do not rely solely on conventional practices but also integrate resilience, enabling projects to adapt to uncertainty while maintaining performance (Obike, 2025). From this perspective, the significance of GRM in the regression results can be interpreted as evidence that ‘shock-resistant’ renewable energy projects are more likely to consistently achieve success because risks are actively managed rather than allowed to escalate.

Finally, the impact of GRM tends to be stronger when the project links it with collaborative processes, particularly because many renewable energy project risks stem from multi-actor coordination and social acceptance. Empirical studies show that risk management practices (identification, assessment, mitigation) contribute positively to sustainable project performance, and their effectiveness increases when stakeholder engagement functions well as a reinforcing mechanism (Song et al., 2025). This aligns with the study's finding that stakeholder engagement is also significant: effective GRM is not merely a risk document, but a decision-making system that involves relevant parties, accelerates issue clarification, and closes communication gaps that could trigger risk escalation. Therefore, the implications of this discussion point emphasize the need to strengthen GRM through cross-functional risk registers, monitoring-based early warning systems, and mitigation updates linked to regulatory and field-context changes, so that renewable energy project success becomes more stable and sustainable.

5. Conclusion

This study concludes that sustainable project management (SPM) plays a crucial role in enhancing the success of renewable energy projects in Indonesia. Integrating sustainability objectives into project planning, procurement, control, and reporting is shown to be positively correlated with more consistent project success, both in terms of project performance (time, cost, quality) and sustainability dimensions (compliance, safety, and stakeholder acceptance). In addition to internal project factors, stakeholder engagement has proven to be a significant determinant. Renewable energy projects that map stakeholders early, maintain two-way communication, and provide mechanisms for participation and grievance resolution tend to better minimize coordination friction and social resistance. This strengthens implementation stability, particularly during critical phases such as permitting, construction, and commissioning. The study also confirms the role of green risk management as a safeguard for project performance amid technical, regulatory, and socio-environmental uncertainties. Projects with comprehensive risk identification, clear impact assessments, mitigation plans, and disciplined risk monitoring are better able to avoid cost overruns and schedule delays, while maintaining environmental compliance and workplace safety. Based on

these findings, it is recommended that renewable energy project developers and managers strengthen SPM by establishing measurable sustainability indicators from the outset, integrating sustainability clauses into contracts/procurement, and implementing transparent project control systems. At the same time, organizations should develop structured stakeholder engagement strategies (mapping, communication, feedback channels) and maintain a “living” risk register that is adaptive to changes in policy contexts and field conditions. It should be noted that this study is based on a perception survey with a cross-sectional design, so long-term causal testing remains limited. Future research is recommended to combine objective project performance data (e. g., cost/time deviations) and expand the scope of project types (solar PV, wind, geothermal, bioenergy) to provide more specific recommendations tailored to the risk characteristics and stakeholders of each renewable energy technology.

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