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The Role of Environmental Governance, Public Policy Innovation, and Green Investment on the Performance of Industrial Estate Development in Indonesia

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ABSTRACT

The development of industrial estates plays a strategic role in supporting economic growth and industrial competitiveness in emerging economies, including Indonesia. However, increasing environmental pressures and sustainability demands require industrial estate development to be supported by effective governance, innovative public policies, and environmentally oriented investment. This study aims to examine the effect of environmental governance, public policy innovation, and green investment on the performance of industrial estate development in Indonesia. A quantitative research approach was employed using primary data collected from 85 respondents involved in industrial estate management, regulation, and development. Data were gathered through a structured questionnaire measured on a Likert scale and analyzed using multiple linear regression with SPSS version 25. The results indicate that environmental governance has a positive and significant effect on industrial estate development performance, followed by public policy innovation and green investment. The regression model explains 54.9% of the variance in development performance, indicating a substantial explanatory power. These findings demonstrate that strong environmental governance, adaptive policy frameworks, and strategic green investment are critical drivers of sustainable and high-performing industrial estate development. This study provides empirical evidence to support sustainability-oriented industrial policies and offers practical implications for policymakers, industrial estate developers, and investors in promoting green and competitive industrial growth in Indonesia.

Keywords: *Environmental Governance, Public Policy Innovation, Green Investment, Industrial Estate Development Performance, Sustainable Industrial Development*

1. INTRODUCTION

Industrial estate development has become a strategic instrument for accelerating economic growth, industrialization, and regional development in many emerging economies, including Indonesia [1]. As a country with abundant natural resources, a large labor force, and a growing domestic market, Indonesia has positioned industrial estates as key nodes for attracting investment, enhancing manufacturing competitiveness, and promoting export-oriented growth [2]. Industrial estates are expected not only to provide physical infrastructure for industrial activities but also to create integrated ecosystems that support efficiency, innovation, and sustainability [3]. However, rapid industrial expansion has also generated significant environmental pressures, governance challenges, and social concerns, making sustainable industrial estate development an increasingly critical policy agenda.

In recent decades, the global development paradigm has shifted toward sustainability, emphasizing the balance between economic growth, environmental protection, and social welfare. This shift is strongly reflected in the industrial sector, where environmental degradation, carbon emissions, resource depletion, and ecological risks have become major concerns. Industrial estates, as concentrated centers of industrial activity, often intensify these challenges if not managed properly [4]. In the Indonesian context, issues such as inadequate waste management, water and air pollution, land-use conflicts, and weak regulatory enforcement continue to affect the performance and legitimacy of industrial estate development [5]. These challenges highlight the importance of robust environmental governance frameworks that can guide industrial estates toward more responsible and sustainable practices.

Environmental governance plays a central role in shaping how industrial estates manage environmental risks and comply with sustainability standards [6]. It encompasses regulatory frameworks, institutional coordination, monitoring mechanisms, and stakeholder participation aimed at controlling environmental impacts and promoting sustainable industrial operations [7]. Strong environmental governance is expected to improve industrial estate performance by ensuring regulatory compliance, enhancing environmental efficiency, reducing operational risks, and increasing investor and public trust [8]. Conversely, weak governance structures may lead to environmental violations, inefficiencies, reputational damage, and long-term economic losses. Therefore, understanding the contribution of environmental governance to industrial estate performance is essential for achieving sustainable industrial development.

Alongside governance mechanisms, public policy innovation has emerged as a critical driver of industrial transformation in the era of sustainable development. Traditional, rigid policy approaches are increasingly viewed as insufficient to address the complex and dynamic challenges faced by modern industrial estates [9]. Public policy innovation refers to the development and implementation of adaptive, integrative, and forward-looking policy instruments that support sustainability objectives while maintaining economic competitiveness [10]. In Indonesia, policy innovations such as incentives for green industries, streamlined licensing systems, public–private partnerships, and integrated spatial and environmental planning are increasingly promoted to enhance the effectiveness of industrial estate development [11]. These innovative policies are expected to improve coordination among stakeholders, reduce bureaucratic inefficiencies, and foster a more conducive environment for sustainable industrial growth.

Green investment represents another crucial pillar in the sustainable development of industrial estates. Green investment refers to financial commitments directed toward environmentally friendly technologies, infrastructure, and practices, including renewable energy systems, energy-efficient facilities, waste treatment plants, and eco-industrial infrastructure [12]. In the context of industrial estates, green investment is not only a tool for environmental protection but also a strategic asset that enhances long-term performance, operational efficiency, and resilience [13]. By reducing resource consumption, minimizing environmental risks, and aligning with global sustainability standards, green investment can improve the attractiveness and competitiveness of industrial estates, particularly in an era where investors and tenants increasingly prioritize environmental, social, and governance (ESG) considerations [13].

Despite the growing recognition of environmental governance, public policy innovation, and green investment as critical determinants of sustainable industrial development, empirical studies that examine their combined effects on industrial estate performance remain limited, particularly in developing countries. Existing literature largely focuses on macro-level sustainability policies, firm-level environmental performance, or individual investment outcomes, while relatively little attention is given to industrial estates as a meso-level unit of analysis. In the Indonesian context, studies on industrial estate performance have predominantly emphasized economic indicators such as investment realization, employment generation, and output growth, with insufficient consideration of governance quality, policy innovation, and green investment as integrated and mutually reinforcing drivers of development performance.

This research gap highlights the need for empirical investigation into how environmental governance, public policy innovation, and green investment interact in shaping the performance of industrial estate development in Indonesia. Such analysis is particularly relevant given Indonesia's commitment to sustainable development goals, green growth strategies, and climate change mitigation efforts, where industrial estates are expected to play a pivotal role in translating national sustainability agendas into operational outcomes. Accordingly, this study aims to analyze the influence of environmental governance, public policy innovation, and green investment on industrial estate development performance using a quantitative approach based on data from key stakeholders. The findings are expected to contribute to the literature on sustainable industrial

development, provide evidence-based insights for policymakers and practitioners, and support the advancement of more sustainable and high-performing industrial estates in Indonesia.

2. LITERATURE REVIEW

2.1 Industrial Estate Development Performance

Industrial estate development performance refers to the extent to which industrial estates achieve economic, environmental, and managerial objectives in supporting industrial growth and regional development [14]. Traditionally, performance assessment has focused on economic indicators such as investment realization, occupancy rates, employment creation, and contributions to regional gross domestic product [15]; however, contemporary perspectives emphasize a more holistic evaluation that incorporates environmental sustainability, governance effectiveness, and long-term resilience. Industrial estates are increasingly viewed not merely as physical clusters of firms, but as integrated systems in which infrastructure provision, environmental management, institutional coordination, and stakeholder collaboration jointly shape performance outcomes [16]. From a sustainability perspective, high-performing industrial estates are expected to balance economic efficiency with environmental responsibility and social legitimacy, as poor environmental management can undermine performance through regulatory sanctions, community resistance, reputational damage, and higher operational costs [17]. Conversely, industrial estates that successfully integrate sustainability principles tend to enhance investor confidence, operational efficiency, and long-term competitiveness, indicating that development performance is closely linked to governance quality, policy support, and investment orientation, particularly in emerging economies where institutional and environmental challenges are more pronounced.

2.2 Environmental Governance

Environmental governance refers to the systems, rules, and institutions that regulate environmental management through regulations, enforcement, monitoring, and stakeholder participation to control environmental impacts and promote sustainability [6]. In industrial development, strong environmental governance—characterized by clear regulations, effective enforcement, transparency, and institutional coordination—plays a critical role in shaping firm behavior, reducing environmental risks, and enhancing industrial estate performance. Empirical studies show that effective environmental governance improves organizational performance by reducing uncertainty, encouraging innovation, and increasing operational efficiency [18]. However, in developing countries such as Indonesia, challenges such as regulatory fragmentation, limited enforcement capacity, and weak institutional coordination often hinder effectiveness, particularly within industrial estates governed by multiple regulatory frameworks [19]. Therefore, the impact of environmental governance on development performance depends not only on regulatory existence but also on effective implementation and integration at the industrial estate level.

2.3 Public Policy Innovation

Public policy innovation refers to the development and implementation of new or significantly improved policy instruments, processes, and governance approaches

designed to address complex and evolving challenges through adaptability, experimentation, cross-sector collaboration, and evidence-based decision-making [20]. In the context of industrial estate development, public policy innovation is reflected in initiatives such as integrated licensing systems, fiscal incentives for green industries, public–private partnerships, regulatory flexibility, and coordinated spatial and environmental planning, all of which aim to reduce bureaucratic inefficiencies, encourage sustainable investment, and improve coordination among stakeholders [21]. In Indonesia, policy innovation has been advanced through regulatory simplification, investment facilitation, and sustainability-oriented industrial policies [11]; however, its effectiveness in enhancing industrial estate performance depends on coherent design, effective implementation, and alignment with environmental governance and green investment strategies, positioning public policy innovation as a critical enabling mechanism that links governance frameworks and investment decisions to development performance.

2.4 Green Investment

Green investment refers to financial investments directed toward projects, technologies, and infrastructure that generate environmental benefits while supporting economic growth, including renewable energy, energy efficiency, pollution control, waste management, and eco-industrial infrastructure [22]. In industrial estates, green investment is particularly important due to the concentration of industrial activities and the potential for shared environmental facilities such as centralized waste treatment and renewable energy systems [23]. The sustainable finance and green growth literature identifies green investment as a key driver of environmental performance and long-term competitiveness, as it reduces resource consumption and environmental risks, lowers operational costs, and enhances compliance with environmental standards and ESG requirements [24]. For industrial estates, green investment functions not only as an environmental initiative but also as a development strategy that improves efficiency, resilience, and overall performance; however, its implementation often depends on supportive governance frameworks and effective policy incentives, especially in developing countries where financial and technological constraints may limit private sector participation [25].

2.5 Relationship between Environmental Governance, Public Policy Innovation, and Green Investment

Environmental governance, public policy innovation, and green investment constitute interrelated pillars of sustainable industrial development, where environmental governance provides the regulatory and institutional foundation, public policy innovation introduces flexible and incentive-based mechanisms to enhance compliance and adaptability, and green investment translates sustainability objectives into tangible infrastructure and technological improvements [26]. Drawing on institutional and sustainable development theories, development systems are expected to perform more effectively when regulatory frameworks, policy support, and investment incentives are aligned, as strong governance reduces uncertainty and risk, innovative policies lower barriers and transaction costs, and coordinated incentives stimulate green investment [25]. Despite this conceptual coherence, empirical evidence

on the combined effects of these factors at the industrial estate level remains limited, particularly in emerging economies, as most studies focus on firm-level or national-level outcomes [27]. Therefore, this study addresses the existing gap by empirically examining how environmental governance, public policy innovation, and green investment interact to influence the performance of industrial estate development in Indonesia.

2.6 Hypothesis Development

Based on the theoretical and empirical literature reviewed, this study proposes that environmental governance, public policy innovation, and green investment each have a positive influence on the performance of industrial estate development. Strong environmental governance is expected to enhance performance by improving compliance, efficiency, and stakeholder trust. Public policy innovation is anticipated to support performance by creating adaptive and supportive institutional environments. Green investment is expected to directly enhance performance through improved infrastructure, efficiency, and sustainability outcomes. Accordingly, the hypotheses of this study are formulated as follows:

H1: Environmental governance has a positive effect on the performance of industrial estate development.

H2: Public policy innovation has a positive effect on the performance of industrial estate development.

H3: Green investment has a positive effect on the performance of industrial estate development.

3. METHODS

3.1 Research Design and Approach

This study employs a quantitative research design to examine the effect of environmental governance, public policy innovation, and green investment on the performance of industrial estate development in Indonesia. A quantitative approach is considered appropriate because the objective of the study is to test hypothesized relationships among variables using measurable indicators and statistical analysis. The research adopts an explanatory approach, aiming to explain causal relationships between independent variables and the dependent variable based on empirical data. Cross-sectional data were collected at a single point in time to capture the perceptions and assessments of respondents regarding the current conditions of industrial estate development.

3.2 Population and Sample

The population of this study consists of stakeholders involved in the development, management, and regulation of industrial estates in Indonesia, including industrial estate managers, policymakers, government officials, and professionals engaged in industrial operations and environmental management. Due to the specialized characteristics of this population, purposive sampling was applied to select respondents with relevant knowledge and experience in industrial estate development and sustainability practices. A total of 85 respondents were included in the study, a sample size considered adequate for multiple regression analysis in exploratory and explanatory research using SPSS, thereby enabling reliable interpretation of the relationships among environmental governance, public policy innovation, green investment, and industrial estate development performance.

3.3 Data Collection Method

Primary data were collected through a structured questionnaire distributed to selected respondents, designed to capture perceptions of environmental governance, public policy innovation, green investment, and industrial estate development performance. The questionnaire was administered both directly and electronically, depending on respondent accessibility, and its items were developed based on established literature and adapted to the Indonesian industrial estate context to ensure relevance. Prior to full distribution, the instrument was reviewed to ensure content validity and clarity, and respondents were informed of the study's purpose as well as assured of confidentiality and anonymity to encourage honest responses. Data collection was conducted within a defined period to maintain consistency across responses.

3.4 Measurement of Variables

All variables in this study were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), as it is suitable for capturing respondents' perceptions and assessments of complex constructs. Environmental Governance (EG) measures the effectiveness of environmental regulations, enforcement mechanisms, institutional coordination, monitoring systems, and stakeholder involvement within industrial estates, with indicators such as regulatory clarity, enforcement consistency, transparency, and environmental management practices. Public Policy Innovation (PPI) reflects the extent to which adaptive and supportive policy measures are implemented, including regulatory flexibility, incentive schemes, policy coordination, public–private partnerships, and responsiveness to sustainability challenges. Green Investment (GI) assesses the level of financial commitment to environmentally friendly infrastructure and technologies, including renewable energy, energy efficiency initiatives, waste and water treatment facilities, and sustainable industrial infrastructure. Industrial Estate Development Performance (IEDP), as the dependent variable, captures overall development outcomes encompassing economic performance, operational efficiency, environmental performance, and long-term sustainability, measured through indicators such as investment attractiveness, infrastructure quality, environmental outcomes, and development sustainability.

3.5 Data Analysis Techniques

The collected data were analyzed using SPSS version 25 through several stages of analysis. Descriptive statistics were first employed to summarize respondent characteristics and describe the distribution of responses using measures such as means, standard deviations, and frequency distributions [28]. Instrument testing was then conducted to ensure measurement reliability and validity, with reliability assessed using Cronbach's alpha (acceptable at ≥ 0.70) and validity evaluated through item–total correlation analysis. Subsequently, multiple linear regression analysis was applied to test the research hypotheses and examine both the partial and simultaneous effects of environmental governance, public policy innovation, and green investment on industrial estate development performance, with significance evaluated using t-tests and an F-test at a 0.05 level. To ensure the robustness of the regression model, classical assumption tests—including normality, multicollinearity, and heteroscedasticity tests—were performed, confirming that the data met the required statistical assumptions and that the results were reliable.

4. RESULTS AND DISCUSSION

4.1 Respondent Profile

This study involved 85 respondents who are directly engaged in the development, management, and regulation of industrial estates in Indonesia, ensuring adequate experience, institutional representation, and decision-making relevance related to environmental governance, public policy, and green investment.

Table 1. Demographic Sample

Characteristic	Category	Frequency (n)	Percentage (%)
Institutional Background	Industrial Estate Management	32	37.6%
	Government Agencies	24	28.2%
	Industrial Estate Developers	15	17.6%
	Environmental & Policy Consultants	14	16.6%
	Total	85	100%
Position Level	Top Management	21	24.7%
	Middle Management	39	45.9%
	Operational/Technical Staff	25	29.4%
	Total	85	100%
Work Experience	< 5 Years	18	21.2%
	5–10 Years	34	40.0%
	> 10 Years	33	38.8%
	Total	85	100%
Educational Level	Bachelor's Degree	36	42.4%
	Master's Degree	41	48.2%
	Doctoral Degree	8	9.4%
	Total	85	100%

Based on Table 1 respondents came from diverse institutional backgrounds, dominated by industrial estate management (32 respondents; 37.6%), followed by government agencies (24; 28.2%), industrial estate developers (15; 17.6%), and environmental and policy consultants (14; 16.6%), reflecting strong operational and regulatory perspectives. In terms of position level, most respondents occupied middle management roles (39; 45.9%), followed by operational/technical staff (25; 29.4%) and top management (21; 24.7%), indicating substantial involvement in policy implementation and operational decision-making. Regarding work experience, a majority had more than five years of experience (67; 78.8%), comprising 5–10 years (34; 40.0%) and more than 10 years (33; 38.8%), suggesting a high level of professional expertise. Educationally, most respondents held postgraduate degrees (49; 57.6%), including master's (41; 48.2%) and doctoral degrees (8; 9.4%), supporting the credibility and analytical quality of the data collected.

4.2 Descriptive Statistics

Descriptive statistics were used to summarize respondents' perceptions of environmental governance, public policy innovation, green investment, and industrial estate development performance.

Table 2. Descriptive Statistics of Research Variables (N = 85)

Variable	Minimum	Maximum	Mean	Std. Deviation
Environmental Governance (EG)	2.40	4.80	3.92	0.53
Public Policy Innovation (PPI)	2.20	4.90	3.85	0.57
Green Investment (GI)	2.10	4.70	3.76	0.61
Industrial Estate Development Performance (IEDP)	2.50	4.90	3.98	0.55

Table 2 presents the descriptive statistics of the research variables based on responses from 85 participants, indicating generally positive perceptions across all constructs. Industrial Estate Development Performance (IEDP) shows the highest mean value (3.98) with a relatively low standard deviation (0.55), suggesting that respondents largely perceive the performance of industrial estate development in Indonesia as favorable and consistently assessed. Environmental Governance (EG) also records a high mean score (3.92) with moderate variability (SD = 0.53), reflecting respondents' agreement that environmental regulatory frameworks, enforcement, and institutional coordination are relatively well implemented within industrial estates. Public Policy Innovation

(PPI) has a mean value of 3.85 and a standard deviation of 0.57, indicating a positive yet slightly more varied perception regarding the adaptability and effectiveness of policy innovations. Meanwhile, Green Investment (GI) shows the lowest mean score (3.76) and the highest standard deviation (0.61), suggesting that although investments in environmentally friendly infrastructure are generally present, their level and consistency vary more widely across industrial estates.

4.3 Reliability and Validity Testing

Reliability testing using Cronbach's alpha indicates strong internal consistency across all research variables.

Table 3. Validity and Reliability

Variable	Item	Corrected Item–Total Correlation	Cronbach's Alpha	Cut-off (Validity ≥0.30; Alpha ≥0.70)
Environmental Governance (EG)	EG1	0.612	0.846	Valid & Reliable
	EG2	0.684		
	EG3	0.701		
	EG4	0.655		
	EG5	0.638		
Public Policy Innovation (PPI)	PPI1	0.574	0.829	Valid & Reliable
	PPI2	0.623		
	PPI3	0.689		
	PPI4	0.641		
	PPI5	0.608		
Green Investment (GI)	GI1	0.542	0.812	Valid & Reliable
	GI2	0.611		
	GI3	0.658		
	GI4	0.629		
	GI5	0.587		
Industrial Estate Development Performance (IEDP)	IEDP1	0.646	0.861	Valid & Reliable
	IEDP2	0.712		
	IEDP3	0.688		
	IEDP4	0.734		
	IEDP5	0.671		

Table 3 demonstrates that all measurement items meet the required validity and reliability standards. The corrected item–total correlation values for all indicators range from 0.542 to 0.734, exceeding the minimum threshold of 0.30, which confirms that each item adequately represents its respective construct. Furthermore, the Cronbach's Alpha values for Environmental Governance (0.846), Public Policy Innovation (0.829), Green Investment (0.812), and Industrial Estate Development Performance (0.861) are all above the acceptable level of 0.70, indicating strong internal consistency and reliability of the measurement instruments. These results confirm that the constructs used in this study are both valid and reliable, and therefore suitable for further statistical analysis, including multiple regression testing.

4.4 Classical Assumption Test Results

To ensure the robustness of the regression model, classical assumption tests were performed.

Table 4. Classical Assumption Test Summary

Test	Indicator	Result
Normality	Kolmogorov–Smirnov Sig.	0.200 (> 0.05)
Multicollinearity	VIF (EG)	1.826
	VIF (PPI)	1.673

	VIF (GI)	1.946
Heteroscedasticity	Glejser Test Sig.	> 0.05

Table 4 presents the results of the classical assumption tests conducted to ensure the robustness of the regression model. The normality test using the Kolmogorov–Smirnov statistic shows a significance value of 0.200, which is greater than the threshold of 0.05, indicating that the residuals are normally distributed. This result confirms that the normality assumption is satisfied, allowing the regression analysis to proceed without bias related to non-normal error distribution.

In terms of multicollinearity, the Variance Inflation Factor (VIF) values for Environmental Governance (1.826), Public Policy Innovation (1.673), and Green Investment (1.946) are all well below the commonly accepted critical value of 10, indicating that there is no serious multicollinearity among the independent variables. Additionally, the heteroscedasticity test using the Glejser method shows significance values greater than 0.05, suggesting that the variance of the residuals is homoscedastic. Overall, these results confirm that the regression model meets the classical assumptions and is statistically appropriate for hypothesis testing.

4.5 Multiple Regression Analysis

Multiple linear regression analysis was conducted to test the hypotheses regarding the influence of environmental governance, public policy innovation, and green investment on industrial estate development performance.

Table 5. Regression Results

Variable	Beta Coefficient (β)	t-value	Sig.
Environmental Governance (EG)	0.341	3.965	0.000
Public Policy Innovation (PPI)	0.289	3.213	0.002
Green Investment (GI)	0.267	2.986	0.004
Constant	0.812	2.414	0.018

Table 5 presents the results of the multiple regression analysis examining the effects of environmental governance, public policy innovation, and green investment on industrial estate development performance. The results indicate that Environmental Governance has the strongest and most significant positive influence on development performance ($\beta = 0.341$; $t = 3.965$; $p = 0.000$), highlighting the critical role of effective regulatory frameworks, enforcement mechanisms, and institutional coordination in enhancing industrial estate outcomes. Public Policy Innovation also shows a positive and statistically significant effect ($\beta = 0.289$; $t = 3.213$; $p = 0.002$), suggesting that adaptive and incentive-based policy approaches contribute substantially to improved development performance. Similarly, Green Investment exerts a positive and significant influence ($\beta = 0.267$; $t = 2.986$; $p = 0.004$), emphasizing the importance of environmentally oriented investments in infrastructure and technology for strengthening sustainability and competitiveness. The constant term is statistically significant ($\beta = 0.812$; $t = 2.414$; $p = 0.018$), indicating the presence of a baseline level of industrial estate development performance even without the influence of the independent variables. Overall, these findings confirm that each independent variable individually contributes to industrial estate development performance, with environmental governance emerging as the most influential factor.

Table 6. F Test

Model	Independent Variables	Dependent Variable	N	df (Regression; Residual)	F-value	Sig. (p-value)
1	EG, PPI, GI	IEDP	85	3; 81	32.91	0.000

The overall regression model is statistically significant, as indicated by an F-statistic of 32.91 with a significance level of 0.000, demonstrating that environmental governance, public policy

innovation, and green investment jointly explain a substantial proportion of the variance in industrial estate development performance.

Table 7. Coefficient Determination

R	R^2	Adjusted R^2	Interpretation
0.741	0.549	0.531	The model explains 54.9% of the variance in IEDP

The model shows a strong correlation coefficient (R = 0.741) and an R^2 value of 0.549, indicating that approximately 54.9% of the variation in development performance is explained by the three independent variables, while the adjusted R^2 of 0.531 suggests a robust explanatory power after accounting for model complexity. Based on these results, all research hypotheses are supported at the 5% significance level, confirming that environmental governance (H1), public policy innovation (H2), and green investment (H3) each have a positive and significant effect on industrial estate development performance in Indonesia.

Discussion

The empirical findings of this study reveal that environmental governance exerts the strongest influence on industrial estate development performance. The positive and significant relationship indicates that clear regulatory frameworks, effective enforcement mechanisms, transparency, and institutional coordination are critical determinants of sustainable industrial outcomes. This result aligns with prior studies emphasizing the importance of governance quality in shaping environmental and organizational performance [6], [26]. Strong environmental governance reduces regulatory uncertainty, enhances compliance, and improves operational efficiency, which ultimately strengthens development performance. In line with earlier research highlighting the role of governance institutions in emerging economies [19], the findings suggest that regulatory effectiveness in Indonesia plays a central role in mitigating environmental risks and enhancing investor confidence within industrial estates.

The significant effect of environmental governance also supports sustainability-oriented performance frameworks, which argue that environmental management is not merely a compliance obligation but a strategic asset [17]. Studies on sustainable real estate and industrial development indicate that improved governance mechanisms increase long-term competitiveness and stakeholder trust [8]. In the context of industrial estates, where environmental externalities are often concentrated, governance structures function as institutional safeguards that balance economic objectives with ecological responsibility. Therefore, the present findings reinforce the argument that environmental governance constitutes a foundational pillar in achieving high-performing and sustainable industrial estates.

Public policy innovation is also found to significantly enhance industrial estate development performance. This finding is consistent with the innovation policy literature, which highlights the importance of adaptive and forward-looking policy instruments in addressing complex sustainability challenges [10]. Policy innovation—such as integrated licensing systems, green incentives, and public–private partnerships—reduces bureaucratic inefficiencies and fosters coordination among stakeholders. Similar conclusions have been drawn in studies examining innovation policy under sustainability transitions, which emphasize the role of flexible regulatory instruments in industrial transformation [9]. In Indonesia, regulatory reform and green economy initiatives further demonstrate how policy innovation can facilitate sustainable industrial growth [11].

The results further show that green investment has a positive and significant effect on development performance, underscoring the strategic role of environmentally oriented financial commitments. This finding is in line with research linking green finance and sustainable investment to improved organizational and industrial performance [12], [24]. Investments in renewable energy, energy efficiency, and pollution control not only reduce environmental risks but also enhance cost

efficiency and operational resilience. In eco-industrial park literature, shared environmental infrastructure and green supply chain practices are identified as drivers of sustainable competitiveness [23]. Thus, green investment strengthens both environmental and economic dimensions of industrial estate performance.

Overall, the findings indicate that environmental governance, public policy innovation, and green investment operate as complementary and mutually reinforcing mechanisms in driving industrial estate development performance. This integrated perspective corresponds with prior research suggesting that sustainable development systems perform more effectively when governance structures, policy instruments, and investment incentives are aligned [25], [26]. Rather than functioning independently, these three factors collectively create an enabling ecosystem for sustainable industrial transformation. For Indonesia, this implies that industrial estate development strategies should not rely solely on economic expansion but must integrate strong governance frameworks, innovative policy design, and targeted green investment to achieve long-term competitiveness and sustainability.

CONCLUSION

This study provides empirical evidence on the role of environmental governance, public policy innovation, and green investment in shaping the performance of industrial estate development in Indonesia, based on quantitative analysis of data from 85 stakeholders. The findings demonstrate that all three factors have positive and statistically significant effects on development performance, with environmental governance emerging as the most influential determinant, highlighting the importance of clear regulations, effective enforcement, and strong institutional coordination. Public policy innovation plays a critical enabling role by improving policy adaptability, enhancing stakeholder coordination, reducing regulatory barriers, and encouraging sustainable industrial practices, while green investment contributes substantially by strengthening environmental infrastructure, improving operational efficiency, and supporting long-term resilience. Overall, the results indicate that industrial estate development performance is best achieved through the integration of robust environmental governance, innovative policy frameworks, and targeted green investment, enabling industrial estates to balance economic objectives with environmental sustainability and social legitimacy. This study enriches the literature on sustainable industrial development by emphasizing industrial estates as a meso-level unit of analysis and provides practical insights for policymakers, industrial estate managers, and investors, while future research may extend this work through larger samples, longitudinal approaches, or the inclusion of mediating and moderating variables.

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