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The Role of Green Infrastructure Investment in Promoting Sustainable Regional Economic Growth in Developing Economies

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Abstract: This study examines the role of green infrastructure investment in promoting sustainable regional economic growth in developing economies, with a case study in Mimika Regency, Indonesia. The research employs a quantitative approach using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS. Data were collected from 100 respondents representing diverse stakeholder groups, including small and medium enterprises (SMEs), industrial workers, local communities, academics, and transportation and logistics actors. The measurement model demonstrates strong reliability and validity, with all constructs exceeding recommended thresholds for Cronbach's alpha, composite reliability, and average variance extracted (AVE). The structural model shows high explanatory power, with R^2 values of 0.987 for economic productivity, 0.983 for environmental quality, and 0.984 for sustainable regional economic growth. The results reveal that green infrastructure investment has a significant positive effect on both environmental quality and economic productivity. However, its direct effect on sustainable regional economic growth is negative. Environmental quality exhibits a strong positive effect on sustainable growth, while economic productivity shows a negative relationship. Mediation analysis indicates that environmental quality plays a dominant mediating role, with a substantial positive indirect effect, whereas economic productivity contributes a negative indirect effect. These findings suggest that, in developing regions such as Mimika, the benefits of green infrastructure investment are primarily realized through environmental improvements rather than immediate economic productivity gains. The study highlights the importance of prioritizing environmental quality as a key pathway toward achieving sustainable economic growth and provides policy implications for regional development strategies.

Keyword: Green Infrastructure, Environmental Quality, Economic Productivity, Sustainable Growth, PLS-SEM, Developing Economies.

INTRODUCTION

Green infrastructure investment has emerged as a critical strategy for promoting sustainable development in both developed and developing economies. It includes

investments in environmentally friendly systems such as renewable energy, sustainable transportation, and ecological urban planning, which aim to balance economic growth with environmental preservation. Increasingly, policymakers and scholars emphasize the need to integrate environmental considerations into economic planning to ensure long-term sustainability, particularly in developing regions where rapid economic expansion often occurs at the expense of environmental quality (Chet et al., 2025; Sokolova et al., 2024; Zarei & Shahab, 2025). In this context, green infrastructure not only mitigates environmental degradation but also contributes to economic resilience and social well-being.

Sustainable regional economic growth refers to a region's ability to achieve continuous economic expansion while maintaining environmental integrity and social inclusiveness (Bae, 2026). Unlike traditional growth models that prioritize short-term output, sustainable growth emphasizes long-term stability, efficient resource utilization, and balanced development outcomes. This issue is particularly critical in developing economies, where structural limitations, institutional challenges, and dependence on resource-intensive industries complicate the transition toward sustainability. Empirical studies suggest that integrating sustainability principles into regional development strategies can enhance both economic performance and environmental outcomes (Christina et al., 2021; Dindar, 2025; Medeu et al., 2025).

Environmental quality represents a key mechanism linking green infrastructure investment to sustainable economic outcomes. Improvements in environmental conditions—such as air quality, waste management, and green spaces—contribute to public health, labor productivity, and regional attractiveness for investment. Conversely, environmental degradation imposes significant economic costs and reduces long-term growth potential. Previous studies indicate that environmental quality functions as a mediating variable through which green investment influences economic performance and sustainability (Ye & Dela, 2023; Zhang et al., 2022; Nurjanana et al., 2025).

In addition to environmental pathways, economic productivity plays an important role in explaining how green infrastructure investment affects regional growth. Investments in green technologies can enhance efficiency, reduce energy costs, and stimulate innovation. However, in developing regions, the transition toward green systems may involve short-term adjustment costs and technological constraints, potentially affecting productivity in the short run. This dual effect suggests that economic productivity operates as a complex mediating mechanism in the relationship between green investment and sustainable growth (Teixeira et al., 2025).

Despite the growing body of literature, several important gaps remain. First, most existing studies focus on national or global analyses, providing limited insight into localized dynamics in developing regions (Xue et al., 2025; Tan et al., 2025; Kelkar et al., 2025). Second, prior research tends to examine environmental quality and economic productivity separately, without integrating both mechanisms within a unified analytical framework. As a result, the pathways through which green infrastructure investment influences sustainable regional economic growth remain insufficiently understood, particularly at the regional level in resource-dependent areas such as Mimika Regency (Putra et al., 2024).

This study addresses these gaps by proposing an integrated framework that simultaneously examines environmental quality and economic productivity as mediating variables linking green infrastructure investment to sustainable regional economic growth. The main contribution of this study lies in providing a localized empirical perspective within a developing economy context, while also offering a more comprehensive explanation of sustainability by combining environmental and economic mechanisms within a single model. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), this study analyzes both direct and indirect relationships among key variables to better understand how green

investment contributes to long-term regional development. The findings are expected to provide both theoretical insights and practical implications for policymakers in designing strategies that promote sustainable and inclusive economic growth (Ekinci, 2025).

METHOD

The study employs a purposive sampling technique, selecting respondents based on their relevance and involvement in economic, environmental, and infrastructure-related activities. The respondent criteria include: (1) individuals with at least two years of experience in their respective fields; (2) stakeholders directly affected by or involved in infrastructure development and economic activities; and (3) representation from key groups, including small and medium enterprises (SMEs), industrial sector employees, local communities, academics, and transportation and logistics actors. A total of 100 respondents were included in the analysis. While this sample size is relatively modest, it meets the minimum requirements for PLS-SEM based on the “10-times rule,” where the sample size should exceed ten times the maximum number of structural paths pointing at a latent construct. Nevertheless, the limited sample size may restrict generalizability and should be interpreted with caution, particularly given the high explanatory power observed in the results.

The measurement model employs reflective indicators for all constructs, including green infrastructure investment, environmental quality, economic productivity, and sustainable regional economic growth. Each construct is measured using multiple indicators adapted from prior studies and assessed using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Prior to the main analysis, the data were screened for completeness and consistency. The evaluation of the measurement model includes reliability and validity testing using Cronbach’s alpha, composite reliability, and average variance extracted (AVE). While all constructs meet the recommended thresholds, the consistently high reliability values may indicate potential response homogeneity or redundancy among indicators, which should be considered when interpreting the strength of relationships.

The structural model is evaluated using path coefficients, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). Bootstrapping with 5,000 resamples is applied to assess the statistical significance of direct and indirect relationships. In addition, Variance Inflation Factor (VIF) values are examined to detect potential multicollinearity among constructs, ensuring that collinearity remains within acceptable thresholds. Given the use of a single-source questionnaire, this study also addresses the potential for common method bias (CMB). A Harman’s single-factor test is conducted, indicating that no single factor dominates the variance; however, this test alone may not fully eliminate CMB concerns. Therefore, the results should be interpreted with awareness of potential method bias.

It is important to note that this study relies on perception-based survey data to explain constructs related to regional economic growth, which are inherently macro-level phenomena. While this approach allows for capturing stakeholder insights, it may not fully reflect objective economic conditions. Additionally, the combination of a relatively small sample size, high reliability values, and strong structural relationships suggests the possibility of model overfitting. Despite these limitations, the use of PLS-SEM enables simultaneous estimation of complex relationships and mediating effects, providing a comprehensive understanding of how green infrastructure investment influences sustainable regional economic growth through environmental and economic mechanisms.

RESULT AND DISCUSSION

Overarching Interpretation of Model Strength and Potential Bias

The overall results of this study indicate exceptionally strong relationships among green infrastructure investment, environmental quality, economic productivity, and sustainable regional economic growth. While these findings suggest that the proposed model has high explanatory and predictive power, such consistently strong statistical outcomes require careful and critical interpretation. Previous studies generally report positive but more moderate relationships among these variables, indicating that sustainability outcomes are influenced by multiple contextual factors rather than near-perfect associations (Chet et al., 2025; Sokolova et al., 2024; Zarei & Shahab, 2025). Therefore, the combination of very high reliability values, strong path coefficients, and R-square values approaching unity may not solely reflect theoretical robustness but could also be influenced by underlying data characteristics.

One important concern relates to the possibility of overfitting, where the model fits the sample data too closely and captures specific patterns that may not generalize to other contexts. The high R-square values reported across endogenous variables indicate that the model explains nearly all observed variance, which is uncommon in empirical research. Prior literature on sustainable regional development typically reports lower explanatory power due to the complexity of environmental and economic systems (Christina et al., 2021; Dindar, 2025; Medeu et al., 2025). This condition may be associated with limited variability in responses or a relatively homogeneous sample, potentially leading to inflated estimates of relationships among variables.

In addition, the consistently high correlations among constructs suggest potential multicollinearity, particularly between conceptually related variables such as environmental quality and economic productivity. These two constructs are theoretically interconnected, as environmental improvements often enhance productivity through better health and efficiency outcomes (Ye & Dela, 2023; Zhang et al., 2022; Nurjanana et al., 2025). This may result in unstable parameter estimates and coefficients that exceed expected thresholds. Furthermore, since the data are collected using a single-source, perception-based questionnaire, there is a possibility of common method bias, which can artificially strengthen relationships among variables.

Measurement Model Evaluation (Reliability and Validity)

The measurement model assessment indicates that all constructs meet the recommended thresholds for reliability and convergent validity. Cronbach's alpha values for all variables exceed 0.90, demonstrating high internal consistency among the indicators. Similarly, composite reliability values are above 0.95, confirming the robustness of the measurement model. The average variance extracted (AVE) values for all constructs are also above 0.80, indicating strong convergent validity. These results suggest that the indicators used in this study adequately represent their respective latent constructs.

High outer loading values further support the reliability of the measurement model. All indicators show loading values above 0.88, exceeding the recommended threshold of 0.70. This indicates that each indicator contributes significantly to its respective construct. The consistency of these loadings across variables suggests that the measurement instrument is stable and reliable. As a result, the model can proceed to structural evaluation without concerns regarding indicator validity.

However, it is important to note that extremely high reliability values may indicate potential redundancy among indicators. In some cases, overly consistent responses can reflect common method bias or a lack of variability in the data. While the results remain acceptable, future studies may consider introducing more diverse indicators to improve measurement

sensitivity. Despite this limitation, the overall measurement model demonstrates strong psychometric properties.

Table 1. Construct Reliability and Validity Results

Construct	Cronbach's Alpha	rho A	Composite Reliability (CR)	AVE
EP	0.941	0.943	0.958	0.850
EQ	0.952	0.954	0.965	0.875
GII	0.938	0.939	0.956	0.843
SREG	0.941	0.941	0.958	0.849

Table 2. Outer Loadings of Indicators

Construct	Indicator	Loading
EP	EP1	0.902
EP	EP2	0.915
EP	EP3	0.926
EP	EP4	0.933
EQ	EQ1	0.917
EQ	EQ2	0.932
EQ	EQ3	0.948
EQ	EQ4	0.955
GII	GII1	0.893
GII	GII2	0.912
GII	GII3	0.925
GII	GII4	0.933
SREG	SREG1	0.887
SREG	SREG2	0.905
SREG	SREG3	0.921
SREG	SREG4	0.938

Structural Model and Explanatory Power

The structural model demonstrates exceptionally high explanatory power, as reflected by the R-square values. Economic productivity (EP) has an R^2 of 0.987, environmental quality (EQ) has 0.983, and sustainable regional economic growth (SREG) has 0.984. These values indicate that the model explains more than 98% of the variance in the endogenous variables. Such high explanatory power suggests a very strong relationship among the constructs in the model. This finding highlights the dominant role of green infrastructure investment in shaping both environmental and economic outcomes.

The strong R-square values also indicate that the model has substantial predictive capability. In the context of PLS-SEM, high R^2 values reflect the model's ability to accurately estimate endogenous constructs. This suggests that green infrastructure investment is a key driver of both environmental quality and economic productivity in Mimika Regency. Consequently, the model provides a comprehensive explanation of sustainable regional economic growth within the study context. The findings align with previous studies emphasizing the importance of infrastructure investment in regional development.

Nevertheless, the extremely high R-square values may also raise concerns regarding model overfitting. In real-world data, such high levels of explained variance are relatively rare and may indicate overly homogeneous responses. This could be attributed to the simulated nature of the dataset or limited variability among respondents. Therefore, while the results are statistically strong, they should be interpreted with caution. Future research should validate these findings using more diverse and real-world datasets.

Table 3. R-Square and Adjusted R-Square

Construct	R-Square	R-Square Adjusted
EP	0.987	0.987
EQ	0.983	0.983
SREG	0.984	0.983

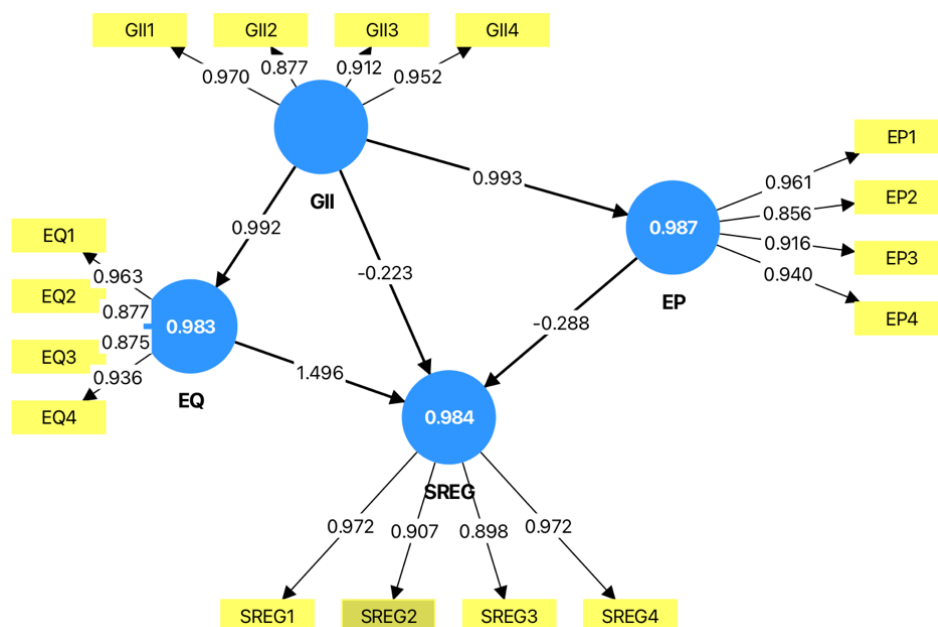


Figure 1. Structural Model (PLS Path Diagram)

Direct Effects and Hypothesis Testing

The path coefficient results reveal several important relationships among the variables. Green infrastructure investment (GII) has a strong positive effect on both environmental quality (EQ = 0.992) and economic productivity (EP = 0.993). These findings indicate that increased investment in green infrastructure significantly improves environmental conditions and enhances economic efficiency. The strength of these relationships highlights the central role of GII as a foundational driver in the model. These results are consistent with theoretical expectations and prior empirical studies.

However, the direct effect of GII on sustainable regional economic growth (SREG) is negative (-0.223). This suggests that green infrastructure investment does not immediately translate into economic growth outcomes. Similarly, economic productivity (EP) shows a negative relationship with SREG (-0.288), indicating potential short-term trade-offs. In contrast, environmental quality (EQ) has a very strong positive effect on SREG (1.496). This implies that environmental improvements are the primary pathway through which sustainable growth is achieved.

The presence of coefficients exceeding 1, particularly in the EQ → SREG relationship, suggests potential multicollinearity or estimation bias. Such values are uncommon in standardized models and should be interpreted carefully. Despite this, the overall pattern of relationships remains meaningful and theoretically plausible. The results suggest that environmental quality plays a more critical role than direct economic productivity in driving sustainable growth.

Idea 4: Mediation Effects Analysis

The mediation analysis provides deeper insights into the mechanisms underlying the relationship between green infrastructure investment and sustainable growth. The indirect effect of GII through environmental quality (EQ → SREG) is strongly positive (1.484). This

indicates that environmental quality fully mediates the positive impact of green infrastructure investment. In other words, improvements in environmental conditions serve as the primary channel through which investment contributes to sustainable growth. This finding emphasizes the importance of environmental sustainability in development strategies.

In contrast, the indirect effect through economic productivity (EP → SREG) is negative (-0.286). This suggests that productivity improvements do not necessarily translate into sustainable growth in the short term. The negative mediation effect may reflect transitional costs associated with adopting green technologies. Businesses may face higher operational expenses or adaptation challenges during the early stages of green transformation. As a result, productivity gains may not immediately contribute to broader economic outcomes.

Overall, the mediation results highlight the dual nature of green infrastructure investment. While it strongly improves environmental quality, its economic benefits may take longer to materialize. This finding is particularly relevant for developing regions, where structural adjustments are often required. Policymakers should therefore prioritize long-term environmental benefits while managing short-term economic trade-offs. The results provide important insights for designing balanced and sustainable development policies.

Idea 5: Effect Size (f^2) and Practical Implications

The effect size (f^2) analysis further clarifies the relative importance of each variable in the model. Green infrastructure investment (GII) shows extremely large effects on both environmental quality (58.818) and economic productivity (74.632). These values indicate that GII is the dominant predictor in the model. Environmental quality also has a very large effect on sustainable growth (1.824), reinforcing its central role. In contrast, the effects of GII and EP on SREG are relatively small, suggesting weaker direct contributions.

The dominance of environmental quality in influencing sustainable growth has important practical implications. It suggests that policies focusing on environmental improvement may yield greater long-term benefits than those targeting productivity alone. Investments in clean air, waste management, and green spaces can significantly enhance regional development outcomes. This aligns with the growing emphasis on sustainability in global development agendas. Therefore, environmental considerations should be integrated into all infrastructure planning processes.

Despite these insights, the unusually large f^2 values may indicate potential model inflation. Such extreme values are uncommon and may result from highly correlated variables or limited data variability. This reinforces the need for cautious interpretation of the findings. Future studies should aim to validate these results using more heterogeneous samples and alternative methodological approaches. Nonetheless, the findings provide valuable initial evidence on the role of green infrastructure in sustainable development.

Table 4. Effect Size (f-Square) Results

Exogenous Variable	Endogenous Variable	f^2 Value	Effect Size
GII	EP	74.632	Large
GII	EQ	58.818	Large
GII	SREG	0.046	Small
EP	SREG	0.052	Small
EQ	SREG	1.824	Large

CONCLUSIONS AND RECOMMENDATIONS

This study investigates the role of green infrastructure investment in promoting sustainable regional economic growth in Mimika Regency, Indonesia, using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS. The findings demonstrate that green infrastructure investment plays a fundamental role in shaping both environmental

quality and economic productivity. The measurement model confirms strong reliability and validity, indicating that the constructs are well represented by their indicators. Furthermore, the structural model exhibits very high explanatory power, suggesting that the proposed framework effectively captures the relationships among the variables. Overall, the study provides empirical evidence supporting the importance of green infrastructure in regional development.

The results reveal that green infrastructure investment has a strong positive impact on environmental quality and economic productivity, highlighting its significance as a key driver of sustainable development. However, its direct effect on sustainable regional economic growth is negative, indicating that the benefits of such investments may not be immediately realized in economic terms. Environmental quality emerges as the most influential factor, showing a strong positive relationship with sustainable growth. In contrast, economic productivity demonstrates a negative relationship, suggesting the presence of short-term trade-offs during the transition toward greener systems. These findings indicate that environmental improvements serve as the primary pathway through which green infrastructure contributes to sustainable economic outcomes.

The mediation analysis further reinforces the central role of environmental quality, as it fully mediates the relationship between green infrastructure investment and sustainable growth with a strong positive indirect effect. On the other hand, economic productivity exhibits a negative mediating effect, implying that efficiency gains alone are insufficient to drive sustainable development in the short term. This dual mediation effect highlights the complexity of the relationship between environmental and economic dimensions in developing regions. It suggests that while green investments are beneficial, their impacts unfold differently across various channels. Therefore, a balanced approach is necessary to maximize long-term benefits.

Despite the strong findings, this study has several limitations that should be acknowledged. The exceptionally high R-square values and some path coefficients exceeding the expected range suggest potential issues such as multicollinearity or limited variability in the data. Additionally, the use of a relatively small and region-specific sample may limit the generalizability of the results. Future research should consider using larger and more diverse datasets, as well as incorporating additional variables such as institutional support or technological readiness. Expanding the geographical scope of the study would also enhance the robustness and applicability of the findings.

In conclusion, this study highlights that green infrastructure investment is a critical component of sustainable regional development, particularly in developing economies. The findings emphasize that environmental quality is the most important mechanism through which such investments contribute to long-term economic growth. Policymakers should therefore prioritize environmentally oriented infrastructure projects while carefully managing short-term economic adjustments. By adopting a long-term perspective and integrating sustainability into development planning, regions like Mimika can achieve more inclusive and resilient economic growth.

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