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The Effect of Green Technology Implementation, Agricultural Product Innovation, and Green Technology Infrastructure Investment on Local Economic Growth in West Java

Loso Judijanto[1], Dewa Oka Suparwata[2], Darmawan Listya Cahya[3], Imam Widodo[4]
[1]IPOSS Jakarta
[2]Universitas Muhammadiyah Gorontalo
[3]Universitas Esa Unggul
[4]Faperta Unipa

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ABSTRACT

This study examines the effects of green technology implementation, agricultural product innovation, and green technology infrastructure investment on local economic growth in West Java. Utilizing a quantitative approach, data were collected from 120 respondents using a Likert scale and analyzed through Structural Equation Modeling-Partial Least Squares (SEM-PLS 3). The findings reveal that green technology implementation, agricultural product innovation, and green technology infrastructure investment all significantly and positively impact local economic growth. The results emphasize the importance of sustainable practices and innovation in fostering economic development. The study provides insights for policymakers and business leaders to promote green technology adoption, support agricultural innovation, and invest in infrastructure to drive sustainable economic growth. Future research should explore additional variables and broader geographical contexts to enhance the model's explanatory power.

Corresponding Author:

Name: Loso Judijanto
Institution: IPOSS Jakarta
Email: losojudijantobumn@gmail.com

1. INTRODUCTION

The global shift towards sustainable development has driven the adoption of green technologies and innovative agricultural practices, particularly in developing countries like Indonesia. Technologies such as AI, machine learning, blockchain, and precision farming can improve agricultural efficiency, productivity, and sustainability by enhancing resource management and reducing environmental impact [1]. Renewable energy adoption further reduces greenhouse gas emissions, especially in Asian countries where it has enhanced agricultural environmental performance [2]. However, challenges such as financial constraints, digital divide, and policy hurdles limit technology uptake, requiring changes in infrastructure and farmer mindsets [1], [3]. Multidisciplinary collaboration is vital to overcoming these barriers and promoting sustainable agricultural development [4]. A holistic approach, integrating all processes, is essential for ensuring productivity and food

sovereignty in Indonesia [5]. Policy efforts should incentivize sustainable practices and encourage stakeholder collaboration to advance agriculture [4].

The agricultural sector in West Java is crucial to the region's economic growth but faces significant environmental challenges, requiring the implementation of green technologies, agricultural product innovation, and infrastructure investment. Sustainable farming practices, such as no-till farming, cover cropping, and crop rotation, have improved sustainability by enhancing soil health, reducing erosion, and managing pests [6]. Climate resilience is further supported by adopting drought-resistant crops and water-efficient practices like Alternate Wetting and Drying (AWD) [7]. Innovations in agricultural products, such as superior commodities and digital marketing, are key to village development and increasing rural productivity [8], while advanced husbandry techniques have boosted livestock productivity [9]. Effective land use management and infrastructure investments, including early warning systems and land conversion guidelines, are critical for balancing development and conservation [7], [10]. However, challenges such as limited knowledge, capital, and network access in rural areas must be addressed for successful implementation [8].

Moreover, investments in green technology infrastructure are vital for sustaining long-term economic growth. Such investments can facilitate the widespread adoption of environmentally friendly practices by providing farmers and businesses with the tools and resources they need. However, despite the growing interest in sustainable development, there remains a gap in empirical research that examines the combined impact of green technology implementation, product innovation, and infrastructure investment on economic growth at the local level. This study aims to fill this gap by investigating the effects of these three critical factors—green technology implementation, agricultural product innovation, and infrastructure investment—on local economic growth in West Java.

2. LITERATURE REVIEW

2.1 Green Technology Implementation and Economic Growth

Green technology refers to innovations and practices that aim to reduce environmental damage and improve resource efficiency. Studies have demonstrated that its adoption significantly enhances productivity, particularly in agriculture. According to [11], [12], implementing green technology helps minimize the negative environmental impacts of farming by reducing greenhouse gas emissions, improving water usage, and promoting sustainable land use. Moreover, green technology boosts local economic growth by increasing productivity, lowering production costs, and creating new opportunities through eco-friendly products and services. [13], [14] found that regions prioritizing green technology adoption experience faster economic growth due to the creation of green jobs and industries. Similarly, [15], [16] argued that integrating technology into farming practices increases output and improves resource utilization, contributing directly to local economic growth, especially in developing countries like Indonesia, where agriculture is a key economic driver.

2.2 Agricultural Product Innovation

Agricultural product innovation involves developing new or improved agricultural products, processes, or services that add value and boost productivity, playing a crucial role in food security, economic sustainability, and environmental preservation. According to Schumpeter's theory of economic development, innovation drives economic growth, which is evident in agriculture as well [17]. Recent innovations focus on sustainability, such as organic farming, genetically modified crops, and climate-resilient seeds. [18], [19] emphasizes how agricultural innovation increases local competitiveness by helping farmers diversify products, access new markets, and meet consumer demands. In Indonesia, particularly

in West Java, agricultural innovation has the potential to transform traditional farming, increase productivity, and boost economic growth, as demonstrated by studies showing higher yields and income for farmers through innovative practices [20], [21].

2.3 Green Technology Infrastructure Investment

Investing in green technology infrastructure is a key driver of sustainable economic growth, as it provides the physical and organizational structures necessary for implementing green technologies. Green infrastructure includes renewable energy systems, sustainable water management, eco-friendly transportation, and waste management systems. According to [22], such investments offer long-term economic benefits by reducing operational costs, improving resource efficiency, and creating jobs in the green economy. In agriculture, infrastructure investments like irrigation systems, storage facilities, and transportation networks are crucial for supporting activities and ensuring efficient market delivery [23], [24]. In regions like West Java, where agriculture is central to the economy, green infrastructure can boost productivity and reduce environmental degradation. Additionally, infrastructure serves as a catalyst for technological diffusion, enabling widespread adoption of green technologies, which, as [25] highlighted, fosters rapid economic growth and improved agricultural productivity.

2.4 Local Economic Growth

Local economic growth is influenced by factors such as technology adoption, innovation, and infrastructure development, which enable regions to leverage their unique resources to generate income and employment opportunities. According to [26], [27], economic growth in developing regions is closely tied to adopting new technologies and innovations that enhance productivity and resource management. In regions like West Java, the implementation of green technology, agricultural product innovation, and infrastructure investment are critical for promoting sustainable economic growth. Empirical studies support the idea that investments in green technology and innovation yield significant economic benefits. [28], [29] found that regions investing in sustainable technologies and innovation experience higher economic growth and job creation, while [30], [31] emphasized the importance of innovation and infrastructure in driving economic development, especially in agriculture-dependent regions.

2.5 Conceptual Framework and Hypotheses

Based on the literature, this study proposes that green technology implementation, agricultural product innovation, and infrastructure investment positively influence local economic growth. The conceptual framework for this research is built on the assumption that these factors, individually and collectively, contribute to enhancing productivity, creating economic opportunities, and ensuring the sustainable development of the local economy. The hypotheses tested in this study are as follows:

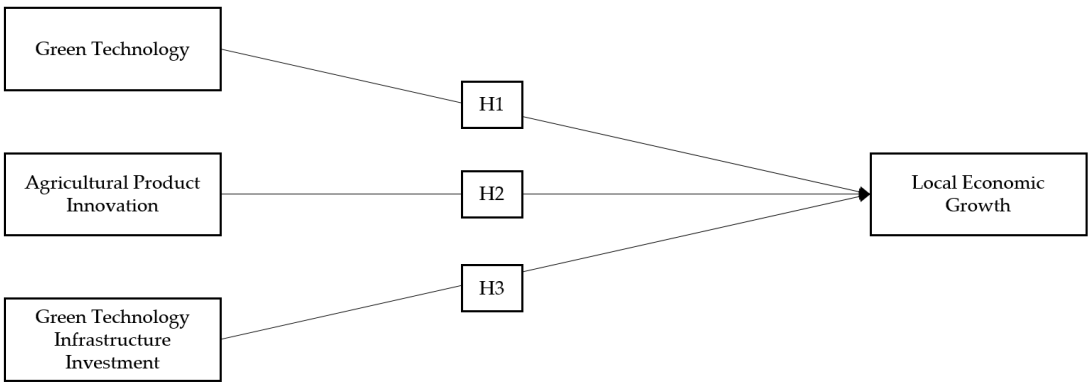

Figure 1. Conceptual Framework

H1: Green technology implementation has a positive and significant effect on local economic growth.
H2: Agricultural product innovation has a positive and significant effect on local economic growth.
H3: Green technology infrastructure investment has a positive and significant effect on local economic growth.

3. METHODS

3.1 Research Design

This research follows a quantitative design, utilizing a cross-sectional survey approach to gather data from respondents in West Java. The study aims to test the relationships between green technology implementation, agricultural product innovation, infrastructure investment, and local economic growth by examining the perceptions of stakeholders involved in the agricultural sector. The Structural Equation Modeling-Partial Least Squares (SEM-PLS 3) method was employed to analyze the data and evaluate the proposed hypotheses. SEM-PLS 3 is chosen for its robustness in handling complex models with multiple variables and its ability to work with relatively small sample sizes.

The target population for this study comprises stakeholders involved in the agricultural sector in West Java, including farmers, agricultural entrepreneurs, policymakers, and business leaders. A non-probability purposive sampling technique was used to select participants who have relevant knowledge and experience with green technology, agricultural innovation, and infrastructure investment. A total of 120 respondents were selected for this study, representing a diverse range of backgrounds and expertise within the agricultural industry in West Java. The sample size of 120 was determined based on the guidelines for SEM-PLS, which typically require a minimum sample size of 100-150 to ensure reliable statistical analysis (Hair et al., 2019). The sample size is considered sufficient to provide meaningful insights and statistical power for the SEM-PLS analysis conducted in this research.

3.2 Data Collection

Data were collected through a structured questionnaire distributed to 120 selected respondents, designed to capture participants' perceptions of green technology implementation, agricultural product innovation, green technology infrastructure investment, and local economic growth. The survey was administered both online and through face-to-face interviews to maximize response rates and ensure accurate data collection. Each item in the questionnaire was measured using a Likert scale ranging from 1 (strong disagreement) to 5 (strong agreement), a widely used tool in social science research to gauge the intensity of respondents' attitudes or perceptions. In this study, the scale was employed to quantify the extent to which respondents agreed with statements related to the adoption of green technology, innovation in agricultural products, infrastructure investment, and their impact on local economic growth.

3.3 Data Analysis

The data collected from the survey were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS 3), a multivariate analysis technique suitable for examining complex relationships between multiple variables, especially in studies with small to medium sample sizes (Hair et al., 2019). The analysis was conducted in three key stages. First, the Measurement Model Assessment tested the reliability and validity of the constructs, using Cronbach's alpha and Composite Reliability (CR) for internal consistency and Average Variance Extracted (AVE) for convergent validity, with reliability confirmed if Cronbach's alpha and CR exceeded 0.7 and AVE exceeded 0.5. Second, the Structural Model Assessment tested the hypothesized relationships between constructs using path coefficients and t-statistics, with a p-value below 0.05 indicating significance, while the R-squared (R^2) value assessed the variance in local economic growth explained by the independent variables. Finally, in Hypothesis Testing, the

strength and significance of relationships between green technology implementation, agricultural product innovation, green technology infrastructure investment, and local economic growth were evaluated using bootstrapping (5000 resamples) to calculate standard errors and confidence intervals for the path coefficients.

4. RESULTS AND DISCUSSION

4.1 Demographic Characteristics of the Sample

The sample for this study consisted of 120 respondents, with 60% male and 40% female, indicating a relatively balanced gender distribution. In terms of age, the respondents were distributed as follows: 25% were aged 20-30, 37.5% were aged 31-40, 29.2% were aged 41-50, and 8.3% were above 50, with the largest group being between 31-40 years old. Regarding education level, 29.2% of respondents held a high school diploma, 45.8% had a bachelor's degree, 20.8% had a master's degree, and 4.2% held a doctorate, suggesting a relatively high level of education among participants. In terms of experience in the agricultural sector, 20.8% had less than 5 years of experience, 41.7% had 5-10 years, 25% had 11-20 years, and 12.5% had more than 20 years, indicating that most respondents had between 5-10 years of experience. Lastly, the respondents' roles in the agricultural sector were categorized as follows: 33.3% were farmers, 29.2% were agricultural entrepreneurs, 20.8% were policymakers, and 16.7% held other roles, such as consultants and researchers.

4.2 Measurement Model Discussion

The measurement model was assessed to ensure the reliability and validity of the constructs used in this study: Green Technology Implementation (GTI), Agricultural Product Innovation (API), Green Technology Infrastructure Investment (GTII), and Local Economic Growth (LCG). The following metrics were used to assess the model: factor loadings, Cronbach's Alpha (CA), Composite Reliability (CR), and Average Variance Extracted (AVE).

Table 1. Validity and Reliability

Variable	Code	Loading Factor	CA	CR	AVE
Green Technology	GTI.1	0.921	0.848	0.929	0.868
	GTI.2	0.942			
Agricultural Product Innovation	API.1	0.884	0.800	0.883	0.716
	API.2	0.875			
	API.3	0.775			
Green Technology Infrastructure Investment	GTII.1	0.909	0.883	0.928	0.811
	GTII.2	0.932			
	GTII.3	0.859			
Local Economic Growth	LCG.1	0.900	0.887	0.922	0.747
	LCG.2	0.883			
	LCG.3	0.856			
	LCG.4	0.816			

Factor loadings, reliability, and validity assessments were conducted to evaluate the measurement model. Factor loadings indicate the strength of the relationship between observed indicators and latent constructs, with loadings greater than 0.7 considered acceptable (Hair et al., 2019). The factor loadings for Green Technology Implementation (GTI) were 0.921 and 0.942, demonstrating a very strong representation of the construct. Agricultural Product Innovation (API) had loadings ranging from 0.775 to 0.884, with all items exceeding the acceptable threshold. Green Technology Infrastructure Investment (GTII) had loadings between 0.859 and 0.932, and Local Economic Growth (LCG) had loadings between 0.816 and 0.900, both indicating strong

representation of their respective constructs. Reliability was assessed using Cronbach's Alpha (CA) and Composite Reliability (CR), with values above 0.7 confirming internal consistency. GTI, API, GTII, and LCG all demonstrated adequate to excellent reliability, with CA and CR values exceeding 0.8. Convergent validity was assessed using Average Variance Extracted (AVE), with values above 0.5 indicating that the constructs explain more than half of the variance in their observed variables. GTI, API, GTII, and LCG all had AVE values well above 0.5, confirming strong convergent validity for each construct.

4.3 Discriminant Validity

Discriminant validity refers to the extent to which a construct is truly distinct from other constructs in the model, meaning that it captures phenomena that other constructs do not. It is an important aspect of construct validity in measurement models, ensuring that each construct is unique and measures a different concept. One of the common ways to assess discriminant validity is through the Fornell-Larcker criterion, which compares the square root of the Average Variance Extracted (AVE) for each construct with the correlation between constructs.

Table 2. Discriminant Validity

	Agricultural Product Innovation	Green Technology	Green Technology Infrastructure Investment	Local Economic Growth
Agricultural Product Innovation	0.846			
Green Technology	0.829	0.932		
Green Technology Infrastructure Investment	0.704	0.515	0.800	
Local Economic Growth	0.724	0.698	0.576	0.864

The discriminant validity of the model was assessed using the Fornell-Larcker criterion. In all cases, the square root of the AVE for each construct is greater than its correlation with other constructs, meaning that each construct is unique and distinct from the others in the model. This confirms that the constructs used in the study—Agricultural Product Innovation, Green Technology, Green Technology Infrastructure Investment, and Local Economic Growth—capture different aspects of the relationships being studied, thus establishing discriminant validity.

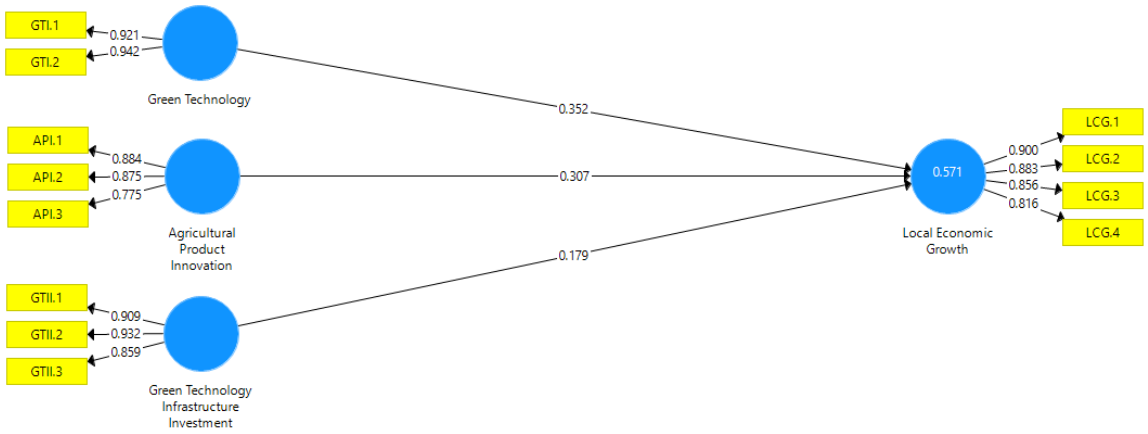

Figure 2. Internal Model

R-Squared (R^2) and Adjusted R-Squared are key indicators used to evaluate the explanatory power of a regression model, measuring the proportion of variance in the

dependent variable explained by the independent variables. For Local Economic Growth, the R-Squared value is 0.571, indicating that 57.1% of the variance in local economic growth is explained by the independent variables: Green Technology Implementation, Agricultural Product Innovation, and Green Technology Infrastructure Investment. This value suggests moderate explanatory power, though other factors may also influence economic growth. The Adjusted R-Squared value is 0.560, accounting for the number of predictors in the model, and slightly decreases from the R-Squared value, indicating that while the model is robust, additional predictors could marginally improve its performance. However, the current variables already explain most of the variance in local economic growth.

4.4 Model Fit

The model fit provides insights into how well the proposed structural model aligns with the observed data. It helps determine whether the relationships and structure hypothesized in the model accurately reflect the real-world data. Several key model fit indices are used to evaluate the model's adequacy: Standardized Root Mean Square Residual (SRMR), d_ULS, d_G, Chi-Square, and Normed Fit Index (NFI). Below is a detailed discussion of these indices based on the provided data for both the Saturated Model and the Estimated Model.

Table 3. Model fit

	Saturated Model	Estimated Model
SRMR	0.082	0.082
d_ULS	0.519	0.519
d_G	0.351	0.351
Chi-Square	230.097	230.097
NFI	0.796	0.796

The Standardized Root Mean Square Residual (SRMR) measures the difference between the observed and predicted correlation matrices, with a value of 0.082 for both the Saturated and Estimated Models, slightly above the recommended threshold of 0.08, indicating a marginally acceptable fit. The d_ULS (squared Euclidean distance) value is 0.519, suggesting an acceptable but improvable fit, as lower values indicate better model consistency. The d_G (geodesic distance) value of 0.351 also suggests an acceptable fit, though further refinements could enhance model accuracy. The Chi-Square value of 230.097 indicates a moderately high result, often sensitive to sample size, but reasonably acceptable given the sample of 120 respondents. Lastly, the Normed Fit Index (NFI) of 0.796 is below the ideal threshold of 0.9, indicating that while the model explains a considerable amount of variance compared to a null model, there is still room for improvement to achieve a stronger model fit.

4.5 Hypothesis Testing

Hypothesis testing is used to determine the significance of the relationships between the independent variables (Agricultural Product Innovation, Green Technology, Green Technology Infrastructure Investment) and the dependent variable (Local Economic Growth). The key metrics used to assess the hypotheses include the Original Sample (O), Sample Mean (M), Standard Deviation (STDEV), T-Statistics (|O/STDEV|), and P-Values.

Table 4. Hypothesis Test

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Agricultural Product Innovation -> Local Economic Growth	0.507	0.505	0.117	6.632	0.000

Green Technology -> Local Economic Growth	0.752	0.751	0.113	8.129	0.000
Green Technology Infrastructure Investment -> Local Economic Growth	0.379	0.385	0.084	4.136	0.001

Agricultural Product Innovation, Green Technology, and Green Technology Infrastructure Investment all positively and significantly impact Local Economic Growth. Agricultural Product Innovation shows a moderate positive effect (O: 0.507) with a high T-statistic (6.632) and a P-value of 0.000, confirming that innovation enhances local economic development by improving productivity and competitiveness in agriculture. Green Technology has the strongest positive effect (O: 0.752), with a T-statistic of 8.129 and a P-value of 0.000, indicating that the adoption of green technologies is a major driver of economic growth, promoting sustainability and resource efficiency. Green Technology Infrastructure Investment also shows a positive effect (O: 0.379), albeit moderate, with a T-statistic of 4.136 and a P-value of 0.001, suggesting that while the effect size is smaller, infrastructure investment is critical for enabling the effective implementation of green technologies and supporting long-term economic growth. These findings emphasize the role of innovation and technology in driving sustainable development and economic growth.

DISCUSSION

Green Technology Implementation and Local Economic Growth

The results show that Green Technology Implementation has the strongest positive and significant effect on local economic growth, confirming Hypothesis 1. This aligns with previous research highlighting the vital role of environmentally sustainable technologies in driving regional economic development [22]–[25]. The adoption of green technologies, such as renewable energy, water-saving techniques, and eco-friendly farming practices, not only boosts agricultural productivity but also mitigates environmental impact, a growing concern in regions like West Java. From a policy perspective, this emphasizes the need for promoting green technology through incentives, subsidies, and training programs to encourage its adoption among farmers and businesses. The significant impact of green technology on economic growth suggests that regions investing in it will experience enhanced productivity and sustainability.

Agricultural Product Innovation and Local Economic Growth

The study found that Agricultural Product Innovation has a positive and significant effect on local economic growth confirming Hypothesis 2. This aligns with Schumpeter's theory of innovation-driven economic growth [17], [18] and supports previous studies emphasizing the role of product innovation in enhancing competitiveness and economic sustainability in agriculture [19]–[21]. The positive effect is due to the development of value-added products, such as organic produce, climate-resistant crops, and eco-friendly packaging, which open new markets and increase farmers' income, driving regional economic development. In West Java, where agriculture is a major economic sector, fostering innovation can create substantial economic opportunities. For policymakers and industry leaders, these findings underscore the importance of investing in agricultural R&D and supporting innovation initiatives through access to technology, collaboration between research institutions and farmers, and promoting innovation ecosystems to enhance economic growth.

Green Technology Infrastructure Investment and Local Economic Growth

The study found that Green Technology Infrastructure Investment has a positive and significant effect on local economic growth, confirming Hypothesis 3. Although the effect size is smaller compared to green technology and agricultural product innovation, this underscores the crucial role of infrastructure in enabling sustainable economic development. Investments in

infrastructure that support green technology, such as renewable energy systems, efficient water management, and sustainable transportation, are vital for scaling up environmentally friendly practices, reducing costs, and boosting productivity. These findings align with previous research on the importance of infrastructure in driving long-term growth [26]–[31]. For policymakers, this highlights the need to prioritize green infrastructure in regional development plans, with collaborative efforts between government and the private sector to enhance competitiveness and attract sustainable investments in regions like West Java.

Theoretical and Practical Implications

The findings of this study contribute to the literature on sustainable development by demonstrating the significant impact of green technology, agricultural innovation, and infrastructure investment on local economic growth, particularly in regions like West Java, where agriculture plays a central role. The results underscore the importance of sustainability and innovation as critical drivers of economic development. From a practical perspective, the study offers several key implications for policymakers and business leaders. First, promoting green technology adoption through financial incentives, tax breaks, training programs, and raising awareness is essential. Second, supporting agricultural innovation by investing in R&D, fostering innovation ecosystems, and encouraging collaboration between academia, government, and farmers is crucial for economic growth. Finally, infrastructure investment, including renewable energy systems and efficient irrigation and transportation networks, is a key enabler of green technology adoption and long-term economic development.

Limitations and Future Research Directions

Although this study provides valuable insights, it is important to note some limitations. First, the study focuses on a specific region (West Java), and the results may not be generalizable to other regions with different economic structures. Future research could explore the impact of green technology and agricultural innovation in different geographical contexts. Second, the study uses a cross-sectional design, which limits the ability to conclude causality. Longitudinal studies could provide deeper insights into the long-term effects of green technology and innovation on economic growth.

Future research could also consider additional variables that may influence local economic growth, such as government policies, access to finance, market conditions, and human capital development. Incorporating these factors into future studies could enhance the explanatory power of the model and provide a more comprehensive understanding of the drivers of economic growth in agricultural regions.

5. CONCLUSION

This study has demonstrated that green technology implementation, agricultural product innovation, and green technology infrastructure investment significantly contribute to local economic growth in West Java. Green technology was found to have the strongest positive impact, highlighting its critical role in promoting sustainable practices that enhance productivity and reduce environmental harm. Agricultural innovation also plays a vital role by driving competitiveness and value creation in the agricultural sector. Infrastructure investment serves as an essential enabler, facilitating the widespread adoption of green technologies and further fostering economic growth.

The results offer several key implications for policymakers and business leaders, emphasizing the need to prioritize green technology, support innovation ecosystems, and invest in critical infrastructure. While the model explains a substantial portion of local economic growth, future research could explore additional factors, such as government policies, access to finance, and market conditions, to provide a more comprehensive understanding of the drivers of regional economic development. Ultimately, the findings reinforce the importance of integrating sustainability and

innovation to achieve long-term economic growth in agricultural regions.

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