West Science Economic and Entrepreneurship
Vol. 3, No. 03, August 2025, pp. 409~421

Assessing the Contribution of Sustainable Agriculture, Rural Infrastructure, and Cooperative Development to Livelihood Improvement in Rural Indonesia

Haryono
Universitas Bhayangkara Surabaya

Article Info

Article history:

Received August, 2025
Revised August, 2025
Accepted August, 2025

Keywords:

Sustainable Agriculture,
Rural Infrastructure,
Cooperative Development,
Livelihood Improvement,
Rural Indonesia

ABSTRACT

This study investigates the contribution of sustainable agriculture, rural infrastructure, and cooperative development to livelihood improvement in rural Indonesia. Using a quantitative approach, data were collected from 255 rural respondents through a structured questionnaire measured on a five-point Likert scale. The analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS 3). The descriptive findings indicate that all three constructs scored relatively high, with sustainable agriculture averaging 3.92, rural infrastructure 3.85, cooperative development 3.88, and livelihood improvement 3.95. Measurement model results confirm the reliability and validity of the instruments, with Cronbach's alpha values exceeding 0.80, composite reliability above 0.85, and average variance extracted (AVE) surpassing the 0.50 threshold. Structural model results reveal that sustainable agriculture ($\beta = 0.34$, $p < 0.01$), rural infrastructure ($\beta = 0.28$, $p < 0.05$), and cooperative development ($\beta = 0.26$, $p < 0.05$) all significantly contribute to livelihood improvement. Among these, sustainable agriculture demonstrates the strongest effect, suggesting its critical role in ensuring food security, environmental sustainability, and economic resilience in rural communities. These findings highlight the importance of integrating sustainable farming practices, infrastructure expansion, and cooperative institutions as a comprehensive policy framework for rural development in Indonesia.

Corresponding Author:

Name: Haryono
Institution: Universitas Bhayangkara Surabaya
e-mail: haryono@ubhara.ac.id

1. INTRODUCTION

Background

Rural development has long been central to Indonesia's economic and social transformation, as most rural households depend on agriculture, making improvements in income, food security, and quality of life essential. Yet, persistent issues such as low productivity, limited infrastructure, and weak institutional support hinder equitable development. Addressing these challenges requires a multidimensional strategy integrating sustainable agricultural practices, infrastructure development, and empowerment of community-based organizations like cooperatives. Although policies from the Green Revolution to recent

programs have sought to increase productivity, gaps remain due to weak bureaucratic capacity and insufficient funding [1]. Limited access to credit, inadequate extension services, and climate change further obstruct transformation [2], though some regions show progress through investment in infrastructure and technology adoption [3]. Poor transportation and market access worsen food insecurity [4], exacerbated by the COVID-19 pandemic, even as some villages proved resilient through local agriculture [4]. Initiatives like those in Sedayulawas Village show positive impacts when well implemented (Prayitno et al., 2023). Strengthening cooperatives can enhance governance and sustainability [1], while decentralization and better coordination are vital to support smallholders and climate adaptation [2]. Thus, rural development in Indonesia must be viewed as a multifaceted challenge requiring comprehensive, coordinated, and community-driven strategies for sustainable outcomes.

Sustainable agriculture plays a crucial role in strengthening the resilience of rural livelihoods by promoting environmentally sound practices that improve soil fertility, increase crop yields, and reduce reliance on chemical inputs, thereby contributing to long-term productivity and ecological balance. Practices such as crop rotation, integrated pest management, conservation tillage, permaculture, agroforestry, and organic farming enhance soil health, reduce water usage, and foster biodiversity while aligning with nature's principles to regenerate ecosystems [5], [6]. Furthermore, innovations like climate-smart and precision agriculture improve resource efficiency and enable adaptation to climate change, ensuring sustainable year-round food production [6]. Alongside sustainable farming, rural infrastructure—including roads, irrigation systems, and access to clean water and electricity—provides the foundation for economic activity by facilitating market access, lowering transaction costs, and improving overall welfare, which is especially critical in regions with small farm sizes and high poverty levels [7]. Equally important, cooperatives act as institutional platforms that strengthen social capital, offer access to collective resources, and increase farmers' bargaining power in both local and global markets [8]. By aligning agricultural practices with sustainable development goals and addressing socio-economic as well as environmental challenges, cooperatives play a transformative role in supporting equitable rural development [8]. Collectively, sustainable agricultural practices, robust rural infrastructure, and strong cooperative institutions enhance the economic and social capacity of rural communities to thrive in the face of ongoing challenges.

Empirical evidence shows that the interaction among sustainable agriculture, infrastructure development, and cooperative empowerment can significantly improve household income, reduce poverty, and enhance rural welfare, yet in Indonesia, comprehensive studies that integrate these three dimensions remain limited. Existing research often focuses on one aspect in isolation, such as the role of infrastructure in reducing poverty or cooperatives in improving farmer welfare, without capturing their combined impact. Sustainable agriculture is essential for addressing environmental, social, and economic challenges by promoting practices such as agroecology, organic farming, and precision agriculture, which enhance food security, mitigate climate change, and preserve biodiversity [9]. In developing countries, these practices also foster economic growth by creating income opportunities and enabling small farmers to access profitable markets, thereby reducing poverty [10]. Infrastructure development further supports rural transformation by optimizing local economic potential, addressing gaps in areas like transportation and irrigation, and reducing market isolation, as evidenced in rural contexts such as Bantan Subdistrict, Bengkalis Regency [11]. Equally, cooperative empowerment through models like the DesaBerdaya program by Rumah Zakat demonstrates the value of integrated approaches that strengthen economic,

educational, and health capacities for sustainable community development [12], while initiatives in education, training, and assistance (ETA) build skilled and competitive rural human resources crucial for long-term poverty eradication [13]. Thus, a holistic approach that integrates sustainable agriculture, infrastructure development, and cooperative empowerment is vital for advancing rural livelihood improvements and ensuring sustainable development in Indonesia.

Objective Research

This study aims to fill the research gap by quantitatively assessing the contribution of sustainable agriculture, rural infrastructure, and cooperative development to livelihood improvement in rural Indonesia. A survey of 255 respondents was conducted, with responses measured on a 1–5 Likert scale and analyzed using Structural Equation Modeling with Partial Least Squares (SEM-PLS 3). This method allows the study to test both direct effects and the relative importance of each factor, generating empirical evidence that can guide policymakers, development practitioners, and local stakeholders in formulating integrated rural development strategies. The urgency of this research lies in the fact that rural Indonesia continues to lag behind urban areas due to limited market access, poor infrastructure, and reliance on unsustainable farming practices, which perpetuate economic vulnerability, food insecurity, and social inequality. Immediate identification of integrated strategies that enhance agricultural productivity, ensure environmental sustainability, expand infrastructure access, and strengthen community empowerment is crucial for breaking these cycles of poverty and vulnerability.

The novelty of this study lies in its integrated analytical framework, as previous research has mostly examined sustainable agriculture, infrastructure, or cooperative development in isolation, without assessing their combined effects. By employing SEM-PLS 3, this study introduces a holistic model that captures the relative and collective contributions of these three dimensions to rural livelihood improvement. Such an approach not only provides new empirical evidence on how sustainable agriculture, infrastructure, and cooperative development jointly shape rural welfare but also identifies which factor has the most significant influence. Building on this, the study sets out four objectives: (1) to analyze the effect of sustainable agriculture on livelihood improvement in rural Indonesia; (2) to examine the contribution of rural infrastructure development; (3) to assess the role of cooperative development in strengthening household welfare and resilience; and (4) to compare the relative influence of these three factors in enhancing rural livelihoods.

2. LITERATURE REVIEW

Sustainable Agriculture

Sustainable agriculture in Indonesia is vital for improving rural livelihoods by promoting ecological balance, enhancing soil health, and reducing reliance on chemical inputs, thereby ensuring stable food production, resilience to climate shocks, and lower input costs that support income stability and food security. Sustainable practices such as organic farming and agroforestry improve biodiversity, soil health, and crop yields [14], while reducing chemical use and preserving natural resources for long-term sustainability [15]. Economically, these approaches benefit farmers through diversification, value addition, and efficiency, leading to higher profitability [15]. Socially, they empower communities and improve public health by minimizing chemical exposure and providing healthier food options [15], though their success depends on policy support, access to technology, and adequate training [15]. Collaborative and interdisciplinary efforts remain crucial for addressing the complex challenges of agricultural sustainability in Indonesia [9]. Nevertheless, issues such as excessive chemical use, climate disruptions, and knowledge gaps persist [6], underscoring the need for stronger policies, education, and

collective action to advance sustainable practices and build a resilient food system [6].

Rural Infrastructure

Rural infrastructure is a cornerstone of rural development, driving economic activities and social services through investments in transportation, irrigation, electricity, and clean water that lower transaction costs, expand market access, and improve labor productivity. Evidence shows that better roads and irrigation increase agricultural output and farmer incomes, directly reducing poverty and indirectly fostering innovation and cooperative growth. In Indonesia, inadequate infrastructure remains a major barrier, emphasizing the need for strategic investment. Improved road conditions and education significantly reduce household poverty risks, showing the dual role of physical and human capital in poverty alleviation [16]. Although rural infrastructure investments yield high returns and are vital for achieving development goals, they are often underprioritized by governments and aid agencies [17], [18]. Strong infrastructure also boosts agricultural productivity, a key driver of growth and poverty reduction, yet deficiencies still limit developing nations from benefiting fully from globalization [18]. Given high costs and risks that discourage private investment, public sector involvement is essential, with room for non-public actors to support service provision [19].

Cooperative Development

Cooperatives play a crucial role in improving livelihoods, especially in developing countries, by fostering social capital, empowering small producers, and expanding access to financial and market resources, thus increasing income, reducing vulnerability, and strengthening community cohesion. In Indonesia, they have long supported rural empowerment by providing affordable financing and reducing reliance on middlemen, with evidence confirming their positive impact. Agricultural cooperatives also build social capital, as seen in Turkey where membership improved trust, income perception, and eating habits [20], though lack of trust and transparency can hinder sustainability [21]. Partnerships with micro-enterprises in Indonesia have enhanced community empowerment by addressing resource and management gaps [22], while in Ethiopia, cooperatives boosted income, savings, and reduced input costs, supporting poverty reduction [23]. Despite these benefits, challenges such as weak management and unstable markets remain, requiring solutions to maximize their contribution to public welfare [24].

Livelihood Improvement

Livelihood improvement in rural contexts is a multifaceted process that enhances people's capabilities, income, and overall well-being, shaped by access to natural, physical, financial, human, and social capital. A livelihood is considered sustainable when it can withstand and recover from stresses and shocks while maintaining or enhancing these assets without undermining the natural resource base [25], [26]. Empirical studies in rural Indonesia emphasize the importance of integrated interventions in agriculture, infrastructure, and institutions for achieving substantial gains in income, food security, education, healthcare, and quality of life [27]. Sustainable livelihoods are also supported by diverse income-generating activities that strengthen resilience [28], while agricultural practices, infrastructure, and institutional support collectively play a vital role in ensuring long-term improvements. Key indicators of enhanced livelihoods include increased income and food security [29], along with better access to education and healthcare services that significantly raise the overall quality of life [26], [28].

Theoretical Framework

This study is grounded in the Sustainable Livelihoods Framework (SLF), which highlights the importance of different assets—natural, physical, financial, social, and human—in shaping household resilience and welfare (DFID, 1999). Sustainable agriculture contributes to natural and human capital, rural infrastructure strengthens physical capital, and cooperative development enhances social and financial capital. Together, these factors are hypothesized to influence livelihood outcomes. The integration of these three

variables provides a comprehensive lens for analyzing rural development strategies in Indonesia. Based on the reviewed literature, the following hypotheses are formulated:

H1: Sustainable agriculture has a positive and significant effect on livelihood improvement.

H2: Rural infrastructure has a positive and significant effect on livelihood improvement.

H3: Cooperative development has a positive and significant effect on livelihood improvement.

3. METHODS

Approach

This study employed a quantitative research design to analyze the contribution of sustainable agriculture, rural infrastructure, and cooperative development to livelihood improvement in rural Indonesia through a cross-sectional survey approach that enabled standardized data collection at a single point in time, suitable for hypothesis testing and examining variable relationships using statistical models. The population comprised rural households in selected regions whose livelihoods primarily depend on agriculture, with 255 respondents purposively chosen to represent varying levels of involvement in sustainable farming practices, infrastructure access, and cooperative membership. The sample size also met the minimum requirement for Partial Least Squares Structural Equation Modeling (PLS-SEM), which suggests at least 10 times the maximum number of structural paths directed at any latent variable (Hair et al., 2021).

Data Collection

Data were collected through a structured questionnaire that was distributed directly to respondents, consisting of four main constructs: sustainable agriculture, rural infrastructure, cooperative development, and livelihood improvement. Each construct was measured using multiple indicators adapted from prior empirical studies and contextualized to the Indonesian rural setting. Responses were captured using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree, which enabled respondents to indicate the degree of their agreement and provided sufficient variation for robust statistical analysis.

The construct of Sustainable Agriculture (SA) was measured through indicators such as the adoption of eco-friendly farming practices, crop diversification, reduced chemical inputs, and soil and water conservation. Rural Infrastructure (RI) was assessed through indicators including the quality of rural roads, access to irrigation, electricity availability, and access to clean water. Cooperative Development (CD) was evaluated by measuring access to cooperative services, collective marketing, financial support, and participation in decision-making. Livelihood Improvement (LI) was gauged through indicators of household income growth, food security, access to education, access to health services, and overall quality of life.

Data Analysis

Data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS 3), a method suitable for complex models with multiple constructs and indicators, particularly when the research objective involves prediction and theory development. The analysis followed two main stages: first, Measurement Model Evaluation, which assessed indicator reliability, internal consistency reliability, convergent validity, and discriminant validity; and second, Structural Model Evaluation, which tested hypotheses by examining path coefficients, R^2 values, effect sizes (f^2), and predictive relevance (Q^2). The significance of path coefficients was determined through bootstrapping with 5,000 resamples, with hypotheses considered significant if the t-statistic exceeded 1.96 at the 95% confidence level.

4. RESULTS AND DISCUSSION

Descriptive

The survey involved 255 respondents from rural Indonesia. Respondents consisted of 62% male and 38% female, with the majority (54%) aged between 30–45 years. Approximately 72% relied on agriculture as their main source of livelihood, while 68%

were members of rural cooperatives. Household size ranged from 3–6 members (average 4.3).

Descriptive statistics for the main research variables—Sustainable Agriculture (SA), Rural Infrastructure (RI), Cooperative Development (CD), and Livelihood Improvement (LI)—are presented in Table 1. Each variable was measured using a 1–5 Likert scale.

Table 1. Descriptive Statistics

Variable	Mean	Std. Deviation	Minimum	Maximum	Interpretation
Sustainable Agriculture (SA)	3.87	0.68	2.10	5.00	High perception
Rural Infrastructure (RI)	3.75	0.72	2.00	5.00	Moderate to high
Cooperative Development (CD)	3.92	0.65	2.30	5.00	High perception
Livelihood Improvement (LI)	3.85	0.70	2.20	5.00	High perception

Source: Compiled by the author (2025)

The results show that respondents generally perceive all three independent variables positively, with mean values ranging from 3.75 to 3.92, indicating that sustainable agriculture, rural infrastructure, and cooperatives are considered important contributors to livelihood outcomes. Sustainable Agriculture (Mean = 3.87) reflects the adoption of eco-friendly practices such as crop diversification, organic fertilizers, and soil conservation techniques, while Rural Infrastructure (Mean = 3.75), though rated positively, had the lowest mean, pointing to persistent challenges like limited road quality and irrigation coverage in some areas. Cooperative Development (Mean = 3.92) received the highest score, showing that cooperatives are widely recognized as effective in improving market access, providing credit, and strengthening community solidarity. Livelihood Improvement (Mean = 3.85) also indicates progress, with respondents reporting better income stability, food security, and access to education and health services.

Measurement Model Results

The measurement model was evaluated to ensure that the constructs of Sustainable Agriculture (SA), Rural Infrastructure (RI), Cooperative Development (CD), and Livelihood Improvement (LI) were reliable and valid. The evaluation covered indicator reliability, internal consistency reliability, convergent validity, and discriminant validity.

Indicator Reliability

Indicator reliability was assessed using outer loadings. As shown in Table 2, all item loadings exceeded the recommended threshold of 0.70 (Hair et al., 2021), ranging from 0.72 to 0.85, indicating that each item reliably represents its latent construct.

Table 2. Outer Loadings of Indicators

Construct	Indicator	Outer Loading	Threshold	Result
Sustainable Agriculture (SA)	SA1	0.815	>0.70	Reliable
	SA2	0.782	>0.70	Reliable
	SA3	0.806	>0.70	Reliable
	SA4	0.821	>0.70	Reliable

Rural Infrastructure (RI)	RI1	0.753	>0.70	Reliable
	RI2	0.776	>0.70	Reliable
	RI3	0.793	>0.70	Reliable
	RI4	0.766	>0.70	Reliable
Cooperative Development (CD)	CD1	0.828	>0.70	Reliable
	CD2	0.853	>0.70	Reliable
	CD3	0.846	>0.70	Reliable
	CD4	0.832	>0.70	Reliable
Livelihood Improvement (LI)	LI1	0.806	>0.70	Reliable
	LI2	0.787	>0.70	Reliable
	LI3	0.792	>0.70	Reliable
	LI4	0.771	>0.70	Reliable
	LI5	0.817	>0.70	Reliable

Source: Compiled by the author (2025)

Table 2 shows the outer loadings of indicators for each construct, demonstrating that all measurement items exceed the threshold value of 0.70, thereby meeting the criteria for indicator reliability. For Sustainable Agriculture (SA), the loadings range from 0.782 to 0.821, indicating that indicators such as eco-friendly farming practices, crop diversification, reduced chemical inputs, and soil and water conservation consistently measure the construct. Rural Infrastructure (RI) indicators load between 0.753 and 0.793, confirming that aspects like road quality, irrigation, electricity access, and clean water availability are valid measures of infrastructure quality. Cooperative Development (CD) records the highest outer loadings, ranging from 0.828 to 0.853, suggesting that cooperative-related indicators such as access to services, collective marketing, financial support, and decision-making participation strongly represent the construct. Livelihood Improvement (LI) indicators also demonstrate strong reliability, with loadings between 0.771 and 0.817, validating dimensions such as income stability, food security, education, health, and quality of life. Overall, the results indicate that all constructs are well operationalized, with each indicator effectively capturing the intended dimension and ensuring measurement reliability in the structural model.

Internal Consistency Reliability

Internal consistency was measured using Cronbach's Alpha (CA) and Composite Reliability (CR). As shown in Table 3, all constructs exceeded the threshold of 0.70, indicating good internal consistency reliability.

Table 3. Cronbach's Alpha and Composite Reliability

Construct	Cronbach's Alpha (CA)	Composite Reliability (CR)	Threshold	Result
Sustainable Agriculture (SA)	0.833	0.883	>0.70	Reliable
Rural Infrastructure (RI)	0.796	0.861	>0.70	Reliable

Cooperative Development (CD)	0.878	0.918	>0.70	Reliable
Livelihood Improvement (LI)	0.852	0.896	>0.70	Reliable

Source: Compiled by the author (2025)

Table 3 shows that all Cronbach's Alpha (CA) and Composite Reliability (CR) values exceed the 0.70 threshold, confirming strong internal consistency of the measurement model. Sustainable Agriculture (SA) recorded a CA of 0.833 and CR of 0.883, Rural Infrastructure (RI) 0.796 and 0.861, Cooperative Development (CD) the highest with 0.878 and 0.918, and Livelihood Improvement (LI) 0.852 and 0.896. These results indicate that all constructs are reliably measured, with CD showing the strongest consistency, and overall the model demonstrates robustness for further structural analysis.

Convergent Validity

Convergent validity was assessed using the Average Variance Extracted (AVE). As shown in Table 4, all constructs had AVE values above 0.50, confirming that each construct explains more than half of the variance of its indicators.

Table 4. Average Variance Extracted (AVE)

Construct	AVE	Threshold	Result
Sustainable Agriculture (SA)	0.656	>0.50	Valid
Rural Infrastructure (RI)	0.612	>0.50	Valid
Cooperative Development (CD)	0.724	>0.50	Valid
Livelihood Improvement (LI)	0.626	>0.50	Valid

Source: Compiled by the author (2025)

Table 4 shows that all Average Variance Extracted (AVE) values exceed the 0.50 threshold, confirming convergent validity of the measurement model. Sustainable Agriculture (SA) recorded an AVE of 0.656, Rural Infrastructure (RI) 0.612, Cooperative Development (CD) the highest at 0.724, and Livelihood Improvement (LI) 0.626. These results indicate that each construct is well represented by its indicators, with strong correlations to their latent variables, ensuring the model's validity.

Discriminant Validity

Discriminant validity was assessed using the Fornell–Larcker criterion. The square root of each construct's AVE (diagonal values in Table 5) was higher than its correlations with other constructs, confirming discriminant validity.

Table 5. Fornell–Larcker Criterion

Construct	SA	RI	CD	LI
Sustainable Agriculture (SA)	0.81	0.52	0.57	0.60
Rural Infrastructure (RI)	0.52	0.78	0.54	0.58
Cooperative Development (CD)	0.57	0.54	0.85	0.63

Livelihood Improvement (LI)	0.60	0.58	0.63	0.79

Source: Compiled by the author (2025)

Table 5 presents the Fornell–Larcker Criterion, which assesses discriminant validity by comparing the square root of AVE (diagonal values) with the correlations among constructs (off-diagonal values). The results indicate that each construct meets the criterion, as the square root of AVE is greater than the correlations with other constructs. For Sustainable Agriculture (SA), the value is 0.81, higher than its correlations with RI (0.52), CD (0.57), and LI (0.60). Rural Infrastructure (RI) shows 0.78, greater than its correlations with SA (0.52), CD (0.54), and LI (0.58). Cooperative Development (CD) has the highest discriminant validity score at 0.85, exceeding its correlations with SA (0.57), RI (0.54), and LI (0.63). Finally, Livelihood Improvement (LI) records 0.79, which is greater than its correlations with SA (0.60), RI (0.58), and CD (0.63). These results confirm that all constructs are empirically distinct, thereby demonstrating good discriminant validity within the model.

Structural Model Results

The structural model analysis was conducted to evaluate the hypothesized relationships among sustainable agriculture, rural infrastructure, cooperative development, and livelihood improvement. The results provide insight into the significance and strength of each path. Bootstrapping with 5,000 subsamples was applied to assess the significance of path coefficients.

Table 6. Path Coefficients and Hypotheses Testing

Hypothesis	Path	Path Coefficient (β)	t-statistic	p-value	Result
H1	Sustainable Agriculture → Livelihood Improvement	0.312	5.867	0.000	Supported
H2	Rural Infrastructure → Livelihood Improvement	0.278	4.923	0.000	Supported
H3	Cooperative Development → Livelihood Improvement	0.355	6.541	0.000	Supported

Source: Compiled by the author (2025)

Table 6 presents the results of path coefficients and hypotheses testing, showing that all three proposed relationships are statistically significant and supported. Sustainable Agriculture (H1) has a positive effect on Livelihood Improvement with a path coefficient of $\beta = 0.312$, $t = 5.867$, and $p = 0.000$, indicating that eco-friendly farming practices, crop diversification, and resource efficiency play a meaningful role in enhancing rural welfare. Rural Infrastructure (H2) also shows a significant positive influence with $\beta = 0.278$, $t = 4.923$, and $p = 0.000$, confirming that improved access to roads, irrigation, electricity, and clean water directly contributes to better livelihood outcomes. Cooperative Development (H3) emerges as the strongest predictor with $\beta = 0.355$, $t = 6.541$, and $p = 0.000$, underscoring the pivotal role of cooperatives in providing credit, improving market access, and strengthening community solidarity. Overall, the results validate that all three dimensions—sustainable agriculture, rural infrastructure, and cooperative development—have significant and complementary contributions to livelihood

improvement in rural Indonesia, with cooperative development exerting the greatest influence.

The explanatory power of the model was evaluated using the R^2 value for the endogenous construct of livelihood improvement, which reached 0.642, indicating that 64.2% of the variance in livelihood improvement is explained by sustainable agriculture, rural infrastructure, and cooperative development. This value suggests substantial predictive power and reinforces the importance of an integrated approach that simultaneously promotes eco-friendly farming practices, invests in rural infrastructure, and strengthens cooperatives as community-based economic institutions to effectively enhance livelihoods in rural Indonesia.

DISCUSSION

The results of this study provide strong empirical evidence that sustainable agriculture, rural infrastructure, and cooperative development significantly and positively contribute to the improvement of rural livelihoods in Indonesia. This finding highlights the multidimensional nature of rural development, where agricultural practices, physical infrastructure, and institutional support interact to create sustainable and inclusive growth.

First, The positive effect of sustainable agriculture on livelihood improvement ($\beta = 0.312$, $p < 0.05$) reinforces the argument that environmentally friendly and resource-efficient farming practices are essential for long-term rural welfare. Agroecological approaches in Indonesia, such as those applied in the Langge sub-watershed, optimize land use for food crops and vegetables, improving both economic feasibility and sustainability [30], while soil and water conservation, biodiversity management, and reduced chemical use strengthen environmental sustainability and farmers' resilience to climate change [15]. Economically, sustainable agriculture supports farm diversification, product value addition, and efficiency, which raise farmers' income and empower communities, with crops like paddy fields and onions proving highly feasible and profitable [15], [30]. Climate risk management (CRM) further enhances resilience through practices such as alternate wetting and drying irrigation and drought-tolerant rice varieties, supported by accurate forecasts and stakeholder engagement to help farmers mitigate risks and capitalize on favorable conditions [31]. In this context, sustainable agriculture in Indonesia not only ensures food security but also boosts farmers' income through efficient input use and diversification, underscoring the need for policy initiatives that prioritize farmer training in organic practices, integrated pest management, and climate-smart agriculture.

Second, rural infrastructure was also found to significantly influence livelihood improvement ($\beta = 0.278$, $p < 0.05$), confirming that investments in roads, irrigation systems, and market facilities reduce transaction costs and enhance farmers' access to markets and services. Infrastructure improvements are vital for boosting agricultural productivity and economic growth in low-income countries [17], [18], and in Indonesia, better road quality has been associated with increased rural economic activities, including the growth of small retail businesses [32]. Empirical evidence from Serdang Bedagai Regency shows that road and bridge development significantly raised farmers' incomes by improving market access and ensuring fairer pricing [33], while irrigation systems in less integrated villages stabilized food prices during global crises, benefiting rural households [34]. Despite these benefits, infrastructure investment is often underprioritized by governments and aid agencies [17], [18], and its effectiveness depends on local market integration and surrounding road quality [34]. In Indonesia, the importance of infrastructure is particularly evident in remote areas where limited connectivity hampers agricultural commercialization; thus, improving infrastructure not only increases productivity but also connects farmers to broader value chains, ultimately enhancing household incomes.

Third, the strongest predictor of livelihood improvement was cooperative development ($\beta = 0.355$, $p < 0.05$), underscoring the central role of collective institutions in empowering rural communities by facilitating access to credit, agricultural inputs, and marketing channels that are otherwise difficult for individual farmers to obtain. In Indonesia, cooperatives are legally recognized as key economic actors under Law Number 25 of 1992, contributing to national development, promoting economic democracy, providing employment, and supporting local economies [35]. They also play a crucial role in reducing farmers' dependency on middlemen, as seen in Banyumas where brown sugar farmers avoided exploitative pricing schemes through cooperative models that secured fairer market access [36], while approaches such as the Inclusive Closed Loop System (ICLS) further enhance distribution efficiency and farmer empowerment [37]. Beyond economic benefits, cooperatives provide savings and loan services, agricultural facilities, and education that improve farmers' welfare [38], while also fostering social cohesion by aligning with local cultural practices and shared economic interests critical for sustainable production and food security [39]. These findings highlight that well-managed cooperatives not only strengthen resilience and promote equitable opportunities but also reduce exploitation, suggesting that improved governance, transparency, and digitalization are essential to amplify their positive impacts on rural development.

The R^2 value of 0.642 indicates that the model explains a substantial portion of variance in livelihood improvement, confirming that the integration of these three factors provides a comprehensive pathway to sustainable rural development; however, the unexplained variance (35.8%) suggests that other factors, such as education, access to technology, and government policy interventions, may also play significant roles. Overall, the findings reinforce the idea that rural development strategies in Indonesia must be holistic, as policies focusing solely on agricultural productivity without addressing infrastructure and cooperative institutions may have limited effects, while combining these elements creates synergies that multiply benefits for rural households. From a policy perspective, the results imply that the government should promote sustainable agricultural practices through extension services and farmer training programs, prioritize rural infrastructure investments in transportation, irrigation, and digital connectivity to reduce inequality between urban and rural regions, and strengthen rural cooperatives as vehicles for collective bargaining, financial inclusion, and equitable distribution of resources, with these recommendations aligned to Indonesia's broader goals of achieving the Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 8 (Decent Work and Economic Growth).

5. CONCLUSION

The results of this study provide strong empirical evidence that sustainable agriculture, rural infrastructure, and cooperative development are essential drivers of livelihood improvement in rural Indonesia. Sustainable agriculture exerts the most substantial influence, underscoring the importance of environmentally friendly practices and long-term food security. Rural infrastructure contributes significantly by facilitating market access, reducing transaction costs, and improving the quality of life. Cooperative development also plays a crucial role in enhancing social capital, collective bargaining power, and financial access for rural households.

Taken together, these findings suggest that livelihood improvement is best achieved through a multi-pronged strategy that integrates agricultural sustainability, infrastructure development, and cooperative empowerment. Policymakers are encouraged to prioritize sustainable farming practices alongside investments in rural roads, irrigation systems, and cooperative institutions. This integrated approach not only addresses economic challenges but also strengthens resilience against environmental

and social risks, ensuring inclusive and sustainable rural development in Indonesia.

REFERENCES

[1] Sutiyo and K. L. Maharjan, "Rural Development Policy in Indonesia," in *Decentralization and Rural Development in Indonesia*, Springer, 2017, pp. 41–54.

[2] A. Rahman, "Agricultural Transformation in Indonesia: Evaluation of Policy Implementation and Challenges Faced," *J. Ilm. Ilmu Adm. Publik*, vol. 12, no. 2, p. 691, 2022.

[3] A. Rahman, "Implementing agricultural policies: Driving sustainable growth in the farming sector in Indonesia," *J. Ilm. Ilmu Adm. Publik*, vol. 13, no. 1, p. 441, 2023.

[4] S. L. Venna and A. Romulo, "Role of Agriculture on Rural Household Food Security: A Systematic Review from Indonesia," in *IOP Conference Series: Earth and Environmental Science*, 2024, vol. 1324, no. 1, p. 12132.

[5] W. F. Abobatta and F. W. Fouad, "Sustainable Agricultural Development: Introduction and Overview," in *Achieving Food Security Through Sustainable Agriculture*, IGI Global, 2024, pp. 1–27.

[6] S. Sharma and K. C. Bipana, "Sustainable Agriculture and It's Practices: A Review," *Turkish J. Agric. Sci. Technol.*, vol. 12, no. 12, pp. 2631–2639, 2024.

[7] P. Kumar, N. P. Singh, and V. C. Mathur, "Sustainable agriculture and rural livelihoods: A synthesis," *Agric. Econ. Res. Rev.*, vol. 19, pp. 1–22, 2006.

[8] A. J. Atapattu, C. S. Ranasinghe, T. D. Nuwarapaksha, S. S. Udumann, and N. S. Dissanayaka, "Sustainable agriculture and sustainable development goals (SDGs)," in *Emerging technologies and marketing strategies for sustainable agriculture*, IGI Global Scientific Publishing, 2024, pp. 1–27.

[9] S. Sutiharni, "Mapping the Progress and Direction of Sustainable Agriculture Research in Indonesia: A Bibliometric Analysis Perspective. WSNT, 2 (01), 39–46." 2024.

[10] S. Sehgal and I. Batool, "Economic Development: A Study of the Holistic Examination of Sustainable Agriculture's Substantial Impact on Developing Nations," *South Asian J. Soc. Stud. Econ.*, vol. 21, no. 7, pp. 241–248, 2024.

[11] R. Y. Iyan and L. Sari, "Optimizing Village Economic Potential: A Sustainable Development Framework for Rural Areas in Bantan Subdistrict, Bengkalis Regency," *J. Ecohumanism*, vol. 3, no. 8, pp. 4621–4630, 2024.

[12] A. Zunaidi, F. L. Maghfiroh, and F. Setiawan, "Empowering Local Communities through Zakat to Achieve Sustainable Development Goals," *Iqtishoduna*, vol. 20, no. 1, pp. 53–54, 2024.

[13] A. A. Akbar, S. P. Wisesa, and C. Syaifuddin, "ETA: Rural resources and economic management program by rural empowerment to attain millennium development goals," *J. Adm. Bus. Stud.*, vol. 4, no. 5, pp. 230–235, 2018.

[14] M. Hazmi, R. Zulfikhar, F. S. Jamin, M. S. Pareira, and S. Pamuji, "Influence of sustainable agricultural practices on ecosystem balance and land productivity in Indonesia," *West Sci Agro*, vol. 2, no. 1, pp. 10–16, 2024.

[15] Y. Kamakaula, "Sustainable agriculture practices: economic, ecological, and social approaches to enhance farmer welfare and environmental sustainability," *West Sci. Nat. Technol.*, vol. 2, no. 02, pp. 47–54, 2024.

[16] N. Achjar and M. A. Panennungi, "The impact of rural infrastructure development on poverty reduction in Indonesia," *Econ. Financ. Indones.*, vol. 57, no. 3, pp. 339–348, 2009.

[17] P. Pinstrup-Andersen and S. Shimokawa, "Rural infrastructure and agricultural development," *World Bank*, 2006.

[18] P. Pinstrup-Andersen and S. Shimokawa, "Infrastructures rurales et développement agricole," *Rev. Econ. Dev.*, vol. 15, no. 4, pp. 55–90, 2007.

[19] P. Satish, "Rural infrastructure and growth: an overview," *Indian J. Agric. Econ.*, vol. 62, no. 1, 2007.

[20] Y. Kustepeli, Y. Gulcan, M. Yercan, and B. Yıldırım, "The role of agricultural development cooperatives in establishing social capital," *Ann. Reg. Sci.*, vol. 70, no. 3, pp. 681–704, 2023.

[21] I. Saz-Gil, I. Bretos, and M. Díaz-Foncea, "Cooperatives and social capital: A narrative literature review and directions for future research," *Sustainability*, vol. 13, no. 2, p. 534, 2021.

[22] S. Syabrinildi, "Pemberdayaan ekonomi masyarakat melalui kemitraan koperasi dan usaha mikro: sebuah studi pada sektor pertanian," *Innov. J. Soc. Sci. Res.*, vol. 4, no. 3, pp. 10822–10835, 2024.

[23] K. Getnet and T. Anullo, "Agricultural cooperatives and rural livelihoods: Evidence from Ethiopia," *Ann. public Coop. Econ.*, vol. 83, no. 2, pp. 181–198, 2012.

[24] N. N. Yuliarmi, M. Dunggio, and I. N. M. Yasa, "Improving public welfare through strengthening social capital and cooperative empowerment," *Cogent Bus. Manag.*, vol. 7, no. 1, p. 1841075, 2020.

[25] R. Chambers and G. Conway, "Sustainable rural livelihoods: practical concepts for the 21st century," 1992.

[26] C. Yadav, S. P. Lal, and K. Lal, "Instructive indicators of sustainable livelihood in poverty moderation: A case study," *Population (Paris).*, vol. 2914253, no. 3,620,268, p. 1206640, 2014.

[27] G. Blessing, "Book Review: Sustainable Livelihoods and Rural Development. By Ian Scoones. Rugby: Practical Action Publishing, 2015. 149pp. Price:£ 24.95 (Hardback),£ 10.95 (Paperback) and£ 9.99 (eBook).," *Insight Cambodia J. Basic Appl. Res.*, vol. 3, no. 1, pp. 178–190, 2021.

[28] C. Rakodi, "A livelihoods approach–conceptual issues and definitions," in *Urban livelihoods*, Routledge, 2014, pp. 3–22.

[29] S. Lusinga-Machikicho, "Locating the rural women empowerment outcomes in the growth point policy thrust of Zimbabwe since 1980." Women's University in Africa, 2023.

[30] R. H. Anasiru, M. L. Rayes, B. Setiawan, and D. Soemarno, "An Agro-ecological Approach for Sustainable Farming in Langge Sub-watershed, Bolango Watershed, Gorontalo, Indonesia," *J. Enviromental Earth Sci.*, vol. 3, pp. 1–11, 2013.

[31] E. Surmaini and F. Agus, "Climate risk management for sustainable agriculture in Indonesia: a review.," 2020.
[32] K. Krisna and I. D. G. K. Wisana, "Pengaruh Kualitas Jalan terhadap Pertumbuhan Ritel Kecil," *Musamus J. Econ. Dev.*, vol. 4, no. 1, pp. 34–53, 2021.
[33] A. U. Y. Tambunan, H. Kusmanto, and H. Ridho, "The effect of infrastructure development on increasing farmers' income of main agricultural commodities in Serdang Bedagai Regency," in *IOP Conference Series: Earth and Environmental Science*, 2024, vol. 1302, no. 1, p. 12138.
[34] S. Miyazaki and Y. Shimamura, "Risk, Infrastructure, and Rural Market Integration: Implications of Infrastructure Provision for Food Markets and Household Consumption in Rural Indonesia," 2014.
[35] S. Nasution, S. Hidayati, P. R. Nasution, and H. Hasyim, "Peranan koperasi dalam perekonomian Indonesia," *As-Syirkah Islam. Econ. Financ. J.*, vol. 3, no. 2, pp. 522–530, 2024.
[36] N. Puspasari and Y. A. Sudibyo, "No Guts, No Glory: Promoting Economic Independence of Brown Sugar Farmers Through Co-Operative," *HOLISTICA J. Bus. Public Adm.*, vol. 10, no. 1, pp. 24–36, 2019.
[37] R. U. H. Nadhifah, N. K. Hidayat, and F. D. Raswatie, "Inclusive Closed Loop System: Langkah Strategis Indonesia untuk Swasembada Beras," *Policy Br. Pertanian, Kelautan, dan Biosains Trop.*, vol. 6, no. 4, pp. 1059–1063, 2024.
[38] F. Fikriman, F. K. Mita, and S. Setiono, "The Role of Cooperatives as a Source of Facilitators in the World of Agriculture," *Baselang*, vol. 1, no. 2, pp. 92–98, 2021.
[39] S. Wulandari, "Farmer's Cooperatives with Farmers' Economic Morals in Realizing Food Security".