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SUSTAINABLE AGROPRENEURSHIP MODEL AND MSME PERFORMANCE THROUGH SCIENCE AND TECHNOLOGY BASED ECO FRIENDLY AGRICULTURAL PRODUCT INNOVATION IN A WATERSHED AREA

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Abstract

Agricultural micro, small, and medium enterprises (MSMEs) in watershed areas face limitations in product innovation, technology utilization, competitiveness, and the adoption of environmentally friendly production practices, while watershed areas themselves are under ecological pressure. This study aims to analyze the effect of sustainable agropreneurship on MSME performance and science- and technology-based eco-friendly agricultural product innovation, and to examine product innovation as an intervening variable. A quantitative approach was employed using purposive sampling of agricultural MSMEs in the Kahayan watershed area, Palangka Raya City. Data were collected through questionnaires and structured interviews and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results show that sustainable agropreneurship has a positive and significant effect on MSME performance ($\beta = 0.472$; $p < 0.001$) and on product innovation ($\beta = 0.545$; $p < 0.001$). Product innovation also has a positive and significant effect on MSME performance ($\beta = 0.254$; $p = 0.004$). Furthermore, product innovation partially mediates the effect of sustainable agropreneurship on MSME performance ($\beta = 0.138$; $p = 0.010$). These findings indicate that strengthening sustainable entrepreneurship, accompanied by science- and technology-based product innovation, can improve MSME performance while supporting the environmental sustainability of watershed areas.

Keywords: *Eco-Friendly* Technology; *MSME Performance*; *Product Innovation*; *Sustainable Agropreneurship*; Watershed.

1. INTRODUCTION

Tropical peatland and watershed areas present both challenges and opportunities for the development of economies based on local resources. Palangka Raya City, part of which lies in a peatland area and is traversed by the Kahayan River, has potential for businesses based on local agriculture, household agro-industry, and product diversification from agricultural commodities, river fisheries, and resources specific to peatlands. MSMEs play a strategic role in creating jobs, increasing income, and driving the local economy; however, agricultural MSMEs still face limitations in product innovation, technology utilization, market competitiveness, and environmentally friendly production practices. At the same time, watershed areas are under ecological pressure in the form of declining peatland quality and water pollution. These conditions underscore the need for a business model that integrates economic, social, and environmental interests through sustainable agropreneurship.

Previous studies show that agropreneurship encompasses entrepreneurial skills and behavior, business and community strategies, and activities along the agricultural value chain. Otache (2017) emphasizes the ability to recognize opportunities, mobilize resources, and launch agricultural ventures, whereas Dias et al. (2019) position entrepreneurial skills and behavior, entrepreneurial strategy, and community as the main themes of agropreneurship. Awa et al. (2024) show that the digitalization of agricultural MSMEs can improve operational efficiency and market reach; Wan Mustapa et al. (2022) find a positive relationship between sustainability orientation and the performance of micro-enterprises; Yang et al. (2023) demonstrate the importance of innovation and the image of green agricultural products; Yahaya and Nadarajah (2023) identify innovation and access to digital technology as important factors in SME performance; and Ahmed et al. (2022) show that participatory watershed management can deliver economic benefits while reducing environmental degradation. However, these studies generally examine agropreneurship, innovation, technology, MSME performance, or watershed management separately. This leaves a gap: sustainable agropreneurship, science- and technology-based eco-friendly agricultural product innovation, and MSME performance have not yet been integrated within the context of watershed areas, particularly in Central Kalimantan.

The novelty of this study lies in developing a model that integrates these three aspects within a single analytical framework in the Kahayan watershed area, Palangka Raya City. The study not only tests the relationship between sustainable agropreneurship and MSME performance but also positions eco-friendly agricultural product innovation as an intervening variable linking the two. The research framework uses sustainable agropreneurship as the independent variable, eco-friendly agricultural product innovation as the intervening variable, and MSME performance as the dependent variable. It also combines quantitative and qualitative analysis so that the relationships among variables can be understood statistically as well as in the context of their implementation in MSMEs in the watershed area.

Conceptually, sustainable agropreneurship is agricultural entrepreneurship that integrates economic, social, and environmental sustainability, encompassing the ability to identify opportunities, manage resources, build business networks, and develop production, distribution, and marketing within the agricultural value chain. This concept is linked to eco-friendly agricultural product innovation through the development of products with lower environmental impact, the use of environmentally friendly materials or packaging, waste reduction, and quality improvement through technology. MSME performance, in turn, is understood in terms of sales growth, profitability, productivity, competitiveness, and business sustainability. The integration of science and technology is expected to improve input efficiency and market access, while sustainable MSME development in watershed areas requires strengthening the capacity of business actors, technological infrastructure, supply chain partnerships, and policy support.

Based on these problems and gaps, this study aims to analyze the relationships among sustainable agropreneurship, science- and technology-based eco-friendly agricultural product innovation, and MSME performance in the Kahayan watershed area, Palangka Raya City. Specifically, it examines the effect of sustainable agropreneurship on MSME performance and product innovation, the effect of product innovation on MSME performance, and the role of product innovation as the mechanism linking sustainable

agropreneurship to MSME performance. This study is expected to contribute academically to the development of sustainability-based agricultural entrepreneurship that integrates sustainable entrepreneurship, green innovation, and agricultural technology. It also aims to provide a basis for strengthening MSMEs built on local potential, improving competitiveness and product value added, and implementing efficient, environmentally friendly economic activities that support the sustainability of the watershed, peatlands, and the welfare of local communities.

2. RESEARCH METHODS

This study employs a descriptive quantitative approach to analyze the relationships among sustainable agropreneurship, science- and technology-based eco-friendly agricultural product innovation, and MSME performance. A quantitative approach is used because the study aims to measure relationships among variables systematically and to test the direct and indirect effects in the research model. The study involves three main constructs: sustainable agropreneurship (X1), science- and technology-based eco-friendly agricultural product innovation (Z), and MSME performance (Y). Sustainable agropreneurship is operationalized through business sustainability orientation, environmental concern, production efficiency, technology utilization, waste management, and commitment to the green economy. Product innovation covers the use of environmentally friendly raw materials, waste reduction, processing of waste into economic value, the use of eco-friendly packaging, product diversification, and the application of environmentally friendly technology. MSME performance is measured through increases in sales, profit, market share, productivity, product competitiveness, customer satisfaction, asset growth, and the welfare of business owners.

The study was conducted on agricultural MSMEs operating in the watershed area of Palangka Raya City, which is characterized by a tropical peatland ecosystem and local agricultural potential. The research was planned to run for six months, covering the preparation, data collection, and data analysis stages. The population comprises all MSMEs engaged in the agricultural sector in the Palangka Raya watershed area. Respondents were selected using purposive sampling, with the criteria that the MSME is engaged in agricultural products and is willing to provide information on innovation, technology utilization, and business performance. According to the research design, the target sample was 100 MSMEs, from which data were obtained through questionnaires and structured interviews.

Data were collected through questionnaires and structured interviews. The questionnaire was used to obtain quantitative data based on the indicators of each research variable, while structured interviews were used to obtain more in-depth information on product innovation practices and technology utilization in agricultural MSMEs. The research process followed the flow shown in the research diagram, beginning with the identification of the problem concerning the relationship between sustainable agropreneurship and agricultural MSMEs in the Palangka Raya watershed area, followed by problem formulation, data collection through questionnaires and interviews, identification of the effects among variables, data analysis, and the preparation of research outputs and recommendations.

Data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) because this method can analyze relationships among latent variables

simultaneously and test direct and indirect effects. The analysis began with descriptive statistics to describe the characteristics of the data and the state of sustainability principles, eco-friendly innovation, and business management in agricultural MSMEs in the watershed area. This was followed by evaluation of the measurement model (outer model), comprising tests of convergent validity and indicator reliability. Convergent validity was evaluated through outer loadings and Average Variance Extracted (AVE). Outer loading values ≥ 0.70 are considered to indicate very good indicators, whereas values of 0.60–0.69 remain acceptable, particularly in exploratory research. An AVE value ≥ 0.50 was used as the criterion for good convergent validity.

The next stage was the evaluation of the structural model (inner model) to determine the strength of the relationships among sustainable agropreneurship, science- and technology-based eco-friendly agricultural product innovation, and MSME performance. The evaluation included the R-square (R^2) values to determine the ability of the independent variables to explain the dependent variable, and hypothesis testing based on t-statistics and p-values. A relationship was considered significant when the t-statistic was greater than 1.96 at the 5% significance level, and the p-value was less than 0.05. Through this procedure, the analysis tested the effect of sustainable agropreneurship on MSME performance, its effect on science- and technology-based eco-friendly agricultural product innovation, the effect of innovation on MSME performance, and the indirect effect of sustainable agropreneurship on MSME performance through product innovation as an intervening variable.

3. RESULTS AND DISCUSSION

Results

The study was conducted on agricultural MSMEs in the Kahayan watershed area, Palangka Raya City, Central Kalimantan Province. The study area is dominated by a tropical peatland ecosystem and features economic activities that include agricultural product processing, swamp-land horticulture, inland fisheries and river product processing, and businesses based on non-timber forest products and peat. These ecological conditions make the sustainability of economic activity an important concern, particularly because the area faces pressures in the form of land-use change, pollution, and the threat of fires in the dry season. On the business side, MSMEs still face limitations in innovation, technology adoption, waste management, product standardization, eco-friendly packaging, and access to digital markets.

3.1 Descriptive Statistics Results

This study analyzes the sustainable agropreneurship model, with sustainable agropreneurship as the independent variable and MSME performance as the dependent variable, through science- and technology-based eco-friendly agricultural product innovation as the intervening variable, in watershed areas of Central Kalimantan Province. The descriptive statistics show that all three research constructs fall into the high to very high categories.

Table 1. Descriptive statistics of the research variables

Variable	Mean	Category	Highest indicator	Value	Lowest indicator	Value
Sustainable Agropreneurship	4.106	High	X1.3	-	-	-
Eco-Friendly Agricultural Product Innovation Based on Science and Technology	4.184	High	Z1.4	4.45	Z1.2	4.01
MSME Performance	4.276	Very high	Y1.1	4.45	Y1.5	4.06

Source: Processed data, 2026

The results show that the Sustainable Agropreneurship variable obtained a mean of 4.106, in the high category, indicating that respondents have a fairly strong orientation toward sustainable entrepreneurship through responsible resource use, reduced environmental impact, and business sustainability. The variable of Eco-Friendly Agricultural Product Innovation Based on Science and Technology has a mean of 4.184, in the high category, reflecting MSMEs' tendency to develop and improve products with attention to environmental aspects and by utilizing technology; the highest indicator is Z1.4 at 4.45, and the lowest is Z1.2 at 4.01, although all indicators remain in the high category. Meanwhile, MSME Performance obtained the highest mean of 4.276, in the very high category, with the highest value on indicator Y1.1 at 4.45 and the lowest on Y1.5 at 4.06, indicating respondents' positive assessment of business performance in its economic, operational, marketing, and sustainability aspects. Overall, these conditions indicate that agricultural MSMEs in the study area have sufficiently strong internal capital to develop sustainability-oriented business models.

3.2 Evaluation of the Measurement Model

Convergent Validity Test Based on Outer Loading

Evaluation of the measurement model shows that all indicators meet the convergent validity criteria. All outer loading values are above 0.70, with the highest values on indicator X1.3 (0.873) for Sustainable Agropreneurship, Z1.3 (0.886) for product innovation, and Y1.3 (0.896) for MSME performance. These values indicate that the indicators used are able to represent the latent constructs being measured.

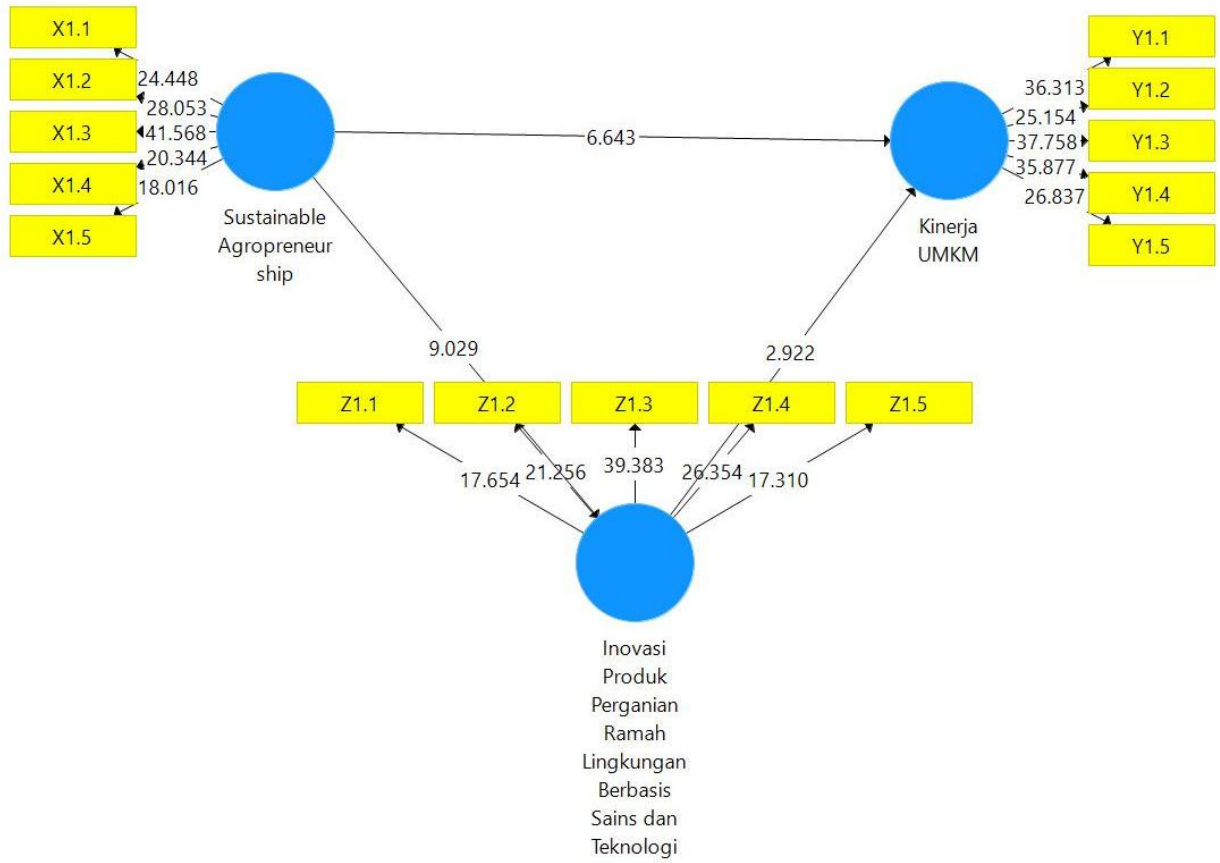
Table 2. Outer loading test results

Construct	Indicator	Outer loading
Sustainable Agropreneurship	X1.1	0.853
	X1.2	0.849
	X1.3	0.873
	X1.4	0.803
	X1.5	0.792

Eco-Friendly Agricultural Product Innovation Based on Science and Technology	Z1.1	0.794
	Z1.2	0.820
	Z1.3	0.886
	Z1.4	0.830
	Z1.5	0.790
MSME Performance	Y1.1	0.867
	Y1.2	0.819
	Y1.3	0.896
	Y1.4	0.872
	Y1.5	0.845

Source: Processed data, 2026

Figure 1. Outer Loading



Source: Processed data, 2026

Average Variance Extracted (AVE) and Construct Reliability Test

The construct validity and reliability tests show that all AVE values are above 0.50, while Composite Reliability and Cronbach's Alpha are above 0.70. Sustainable Agropreneurship has an AVE of 0.697, Composite Reliability of 0.920, and Cronbach's Alpha of 0.891. Eco-Friendly Agricultural Product Innovation Based on Science and Technology has an AVE of 0.680, Composite Reliability of 0.914, and Cronbach's Alpha of 0.882. MSME Performance has an AVE of 0.740, Composite Reliability of 0.934, and Cronbach's Alpha of 0.912. Accordingly, all constructs are declared valid and reliable.

Table 3. Construct validity and reliability test results

Variable	AVE	Composite Reliability	Cronbach's Alpha	Remarks
Sustainable Agropreneurship	0.697	0.920	0.891	Valid and reliable
Eco-Friendly Agricultural Product Innovation Based on Science and Technology	0.680	0.914	0.882	Valid and reliable
MSME Performance	0.740	0.934	0.912	Valid and reliable

Source: Processed data, 2026

The test results show that all research constructs, namely Sustainable Agropreneurship, Eco-Friendly Agricultural Product Innovation Based on Science and Technology, and MSME Performance, meet the validity and reliability requirements. The highest AVE value is found for MSME Performance (0.740) and the lowest for Eco-Friendly Agricultural Product Innovation Based on Science and Technology (0.680); all are above the 0.50 threshold, indicating very good convergent validity and the ability of the indicators to represent the constructs measured. Furthermore, the Composite Reliability values of 0.920, 0.914, and 0.934 and the Cronbach's Alpha values of 0.891, 0.882, and 0.912 are all above the 0.70 threshold, indicating high internal consistency and construct reliability. Thus, no problems were found in the validity or reliability of the instrument, and the measurement model (outer model) is considered adequate to proceed to testing of the structural model (inner model).

3.3 Structural Model Test (Inner Model)

R-Square (R^2) Test

Evaluation of the inner model was carried out through the coefficient of determination (R-square) test to determine the model's ability to explain the endogenous variables. Based on the data processing results, the R^2 values are presented in the following table.

Table 4. R-square test results

Endogenous variable	R^2	R^2 adjusted	Category
Eco-Friendly Agricultural Product Innovation Based on Science and Technology	0.502	0.492	Moderate
MSME Performance	0.655	0.644	Moderate

Source: Processed data, 2026

Based on the coefficient of determination test, the R^2 value for Eco-Friendly Agricultural Product Innovation Based on Science and Technology is 0.502, with an adjusted R^2 of 0.492. This indicates that 50.2% of the variation in product innovation can be explained by Sustainable Agropreneurship, while 49.8% is influenced by other factors outside the model. This R^2 value falls in the moderate category and shows that the application of business sustainability principles, environmental concern, production efficiency, technology utilization, waste management, and commitment to the green economy is associated with MSMEs' ability to develop science- and technology-based eco-friendly agricultural products. Meanwhile, the R^2 value for MSME Performance is 0.655, with an adjusted R^2 of 0.644, indicating that Sustainable Agropreneurship and Eco-Friendly Agricultural Product Innovation Based on Science and Technology together explain 65.5% of the variation in MSME Performance, while 34.5% is explained by other factors outside the model. This value falls in the moderate category with relatively strong explanatory power, indicating that the two variables are sufficiently important factors in explaining changes in MSME performance in Central Kalimantan.

2. Hypothesis Testing

Hypothesis testing was conducted using SmartPLS. A relationship between variables is considered significant when the t-statistic is > 1.96 and the p-value is < 0.05.

Table 5. Hypothesis testing results

Hypothesis	Relationship	Path coefficient	t-statistic	p-value	Remarks
H1	Sustainable Agropreneurship → MSME Performance	0.472	6.643	<0.001	Accepted
H2	Sustainable Agropreneurship → Product Innovation	0.545	9.029	<0.001	Accepted
H3	Product Innovation → MSME Performance	0.254	2.922	0.004	Accepted
H4	Sustainable Agropreneurship → Product Innovation → MSME Performance	0.138	2.599	0.010	Accepted; partial mediation

Source: Processed data, 2026

The hypothesis tests using SmartPLS show that all hypotheses are accepted. Sustainable Agropreneurship has a positive and significant effect on MSME Performance, with a path coefficient of 0.472, a t-statistic of 6.643, and a p-value < 0.001. Sustainable Agropreneurship also has a positive and significant effect on Eco-Friendly Agricultural Product Innovation Based on Science and Technology, with a coefficient of 0.545, a t-statistic of 9.029, and a p-value < 0.001. Furthermore, product innovation has a positive and significant effect on MSME Performance, with a coefficient of 0.254, a t-statistic of 2.922, and a p-value of 0.004. The indirect effect of Sustainable Agropreneurship on MSME Performance through product innovation has a coefficient of 0.138, a t-statistic of 2.599, and a p-value of 0.010, indicating partial mediation.

Discussion

The positive effect of Sustainable Agropreneurship on MSME Performance indicates that the stronger MSMEs' orientation toward sustainability, the higher the business performance they report. Applying this principle includes efficient use of resources, use of local raw materials, attention to the environment, long-term business development, and the creation of economic and social value. This finding is consistent with Wan Mustapa et al. (2022), who showed that sustainability orientation is positively related to the performance of micro-enterprises in developing countries. In the Kahayan watershed context, this approach is relevant because MSMEs have access to local resources such as swamp-land agricultural products, horticulture, and river fishery products that can be processed into value-added products. However, limitations in innovation, technology, waste management, standardization, eco-friendly packaging, and access to digital markets remain factors that need attention.

The positive relationship between Sustainable Agropreneurship and product innovation indicates that sustainability orientation can encourage MSMEs to develop products by considering resource efficiency, reduced environmental impact, the use of alternative raw materials, waste processing, quality improvement, and the use of technology. This finding is consistent with Awa et al. (2024), who position technology utilization as an important part of improving the operational efficiency and market reach of agropreneurship. The result also supports Yang et al. (2023) on the importance of agricultural product innovation with environmentally friendly characteristics. Thus, sustainable agropreneurship in this study is understood not merely as a normative orientation toward the environment but also as a business approach that drives the transformation of conventional agricultural products into value-added products.

The positive effect of science- and technology-based eco-friendly agricultural product innovation on MSME performance indicates that product development can serve as one mechanism for improving business competitiveness. Products with quality, new characteristics, added value, and eco-friendly attributes have the potential to increase market appeal. On the production side, the application of technology can help improve efficiency, quality consistency, and the ability to meet consumer needs. For agricultural MSMEs, innovation also supports downstreaming, so that raw materials do not remain primary commodities but can be developed into processed products with higher economic value. This is important for MSMEs in Central Kalimantan because local identity and eco-friendly character can become part of product differentiation.

The mediation test shows that science- and technology-based eco-friendly agricultural product innovation partially mediates the relationship between Sustainable Agropreneurship and MSME Performance. This finding indicates that the effect of sustainable agropreneurship on performance operates not only through a direct path but also, in part, through MSMEs' ability to develop product innovation. Sustainability orientation encourages the search for new ways of using resources, developing products, applying technology, and reducing environmental impact; this process, in turn, produces innovation that contributes to improved business performance. The results thus position product innovation as an important link between sustainable entrepreneurial orientation and MSME performance in the Kahayan watershed area.

Overall, the results show consistent relationships among the three constructs analyzed. The high descriptive values for Sustainable Agropreneurship, product innovation, and MSME Performance, supported by the results of the measurement and structural model tests, indicate that the research model has empirical support in the context of agricultural MSMEs in the Kahayan watershed area. The practical implication is that MSME strengthening should be directed in an integrated manner at improving sustainability orientation, developing eco-friendly product innovation, and utilizing science and technology. This approach can support increases in value added and business competitiveness while preserving the environmental sustainability of the Kahayan watershed area.

4. CONCLUSION

Based on the research objectives and the analysis results, this study shows that sustainable agropreneurship, science- and technology-based eco-friendly agricultural product innovation, and MSME performance are positively and significantly related. Sustainable agropreneurship has a positive and significant effect on both MSME performance and product innovation. Furthermore, science- and technology-based eco-friendly agricultural product innovation has a positive and significant effect on MSME performance and is shown to partially mediate the relationship between sustainable agropreneurship and MSME performance. Thus, MSME performance can be improved by strengthening sustainable entrepreneurship practices accompanied by the development of science- and technology-based product innovation. Practically, these findings indicate that the development of agricultural MSMEs in the Kahayan watershed area should be directed not only at improving economic performance but also at resource efficiency, waste reduction, the use of local raw materials, product innovation, and the application of eco-friendly technology. Further development requires strengthening the capacity of MSME actors through training and mentoring, technological and financial support, facilitation of certification and marketing, and stronger partnerships among MSMEs, government, universities, research institutions, and the business sector. These efforts are expected to strengthen the competitiveness and sustainability of MSMEs while supporting the sustainable environmental management of the watershed area.

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