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Sustainable Certification Implementation and Its Economic Value in Gayo Coffee Farming

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ABSTRACT

Improving farmers' entrepreneurial orientation and strengthening informal social networks are crucial for increasing the adoption rate of certification schemes in the future. Simultaneously, targeted interventions for older and higher-income farmers are necessary to address the specific barriers to adoption. Furthermore, certification programs must be carefully evaluated to ensure maximum economic and environmental benefits. This study aims to examine the determinants of sustainable certification adoption in Gayo coffee farming and its economic value. A sample of 305 Gayo coffee farmers was analyzed using logistic regression and an economic value assessment. The findings indicate that age and participation in cooperatives negatively affect certification adoption, whereas income, number of employees, land size, total production, and engagement with informal communities have positive and significant effects. From an economic perspective, certified farmers perform better in terms of production, income, and profit and demonstrate a higher willingness to invest in inputs and labor, suggesting that certification contributes to improved farm efficiency despite higher production costs. However, the presence of high-performing non-certified farmers indicates that certification is not the only pathway to success in this field. This study provides new empirical evidence on how sustainable certification influences the economic performance of coffee farmers, highlighting its important role in promoting inclusive and sustainable rural development in Colombia. Moreover, these results imply that public policy should design targeted support mechanisms, such as training subsidies, extension services, and financial incentives.

Keywords: Economic value, gayo coffee, green entrepreneurial, sustainable certification

INTRODUCTION

Coffee is one of Indonesia's most important commodities, contributing significantly to the country's foreign exchange earnings and employing approximately one and a half million coffee farmers (Rahardjo 2012). One of the world's most renowned Arabica coffee production centers is the Gayo Highlands in Aceh. In recent years, various efforts have been made to cultivate Gayo coffee and thereby increase its productivity and quality, making Indonesia more competitive in the global market (Mawardi *et al.* 2020). Increasingly dynamic market demand requires exporting countries to adhere to various standards, including implementing sustainable agricultural systems. Sustainable agricultural practices are crucial for addressing challenges in the agricultural sector, such as limited land use, environmental degradation, and population growth (Ardiyani & Erdiansyah 2012). Sustainability certifications are an important tool for strengthening coffee product competitiveness. Certifications not only enable farmers to improve product quality and image but also help them achieve more stable incomes. This is relevant because most Indonesian Arabica coffee exports target the specialty coffee market, which offers higher prices and relatively lower bean density, positively impacting farmers' welfare and contributing to the country's foreign exchange balance (Saragih 2010). Furthermore, sustainable coffee farming practices can increase the added value of this commodity (Murthy & Madhava 2012) while creating incentives for farmers to switch to more environmentally friendly farming methods. The sustainability of certified coffee farming depends heavily on farmers' adherence to established certification standards (Potts 2007). Studies have shown that certified farms have better environmental conditions than non-certified farms on some, though not all, indicators (Haggar *et al.* 2017). A sustainable entrepreneurial approach in the agricultural sector is also an important aspect to consider. Sustainable entrepreneurship enables entrepreneurs to achieve economic benefits while simultaneously improving social and environmental conditions (Belz & Binder 2017). However, companies implementing this principle often face significant challenges in reconciling environmental, social, and economic logic (Laasch

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2018). Therefore, the introduction of sustainable certification is seen not only as an economic strategy but also as a step toward socially and ecologically responsible agricultural entrepreneurship in the region. In the Gayo context, the introduction of sustainable certification is becoming increasingly urgent, as it meets global environmental standards and raises consumer awareness of the importance of supply chain sustainability. Certifications also contribute to strengthening the economic resilience of smallholder farmers, who are vulnerable to price volatility and the impacts of climate change (Jones *et al.* 2024; Fitri *et al.* 2023).

Research has shown that socioeconomic factors, such as access to education, market information, resources, and institutional support, significantly influence farmers' decisions to adopt sustainable practices (Oya *et al.* 2017; Arifin 2022). For example, farmers with access to training and mentoring are more likely to implement conservation measures, such as water management, which are critical for ecosystem sustainability (Oya *et al.* 2017). In addition to the benefits for farmers, certification also impacts communities and markets. Studies have shown that certified coffee has a higher sales value because consumers perceive it as meeting quality and ethical standards (Fitri *et al.* 2023; Merbah & Hernández 2024). These economic incentives can be used to support local development and strengthen the economic structure of rural communities (Winter *et al.* 2020; Merbah & Hernández 2024). In the long term, the adoption of more ecological farming practices also contributes to improving soil quality and increasing biodiversity, ensuring the sustainability of coffee production, especially in ecologically sensitive areas such as Gayo (Jones *et al.* 2024; Negre 2023; Lazuardi *et al.* 2021). However, implementing sustainable certification systems is not without its complex challenges. Several studies have shown that the success of these systems depends on various factors, such as the effectiveness of policy measures, farmers' capacities, institutional commitment, and local socioeconomic dynamics (Agustino *et al.* 2020; Yasyak *et al.* 2020; Suroso *et al.* 2023).

The Gayo Highlands in Aceh Province are the largest producers of Arabica coffee in Indonesia, covering Central Aceh, Bener Meriah, Gayo Lues, and Southeast Aceh. Central Aceh and Bener Meriah are the main production centers in terms of land area, output, and number of farming households in Aceh. Aceh ranks among the top Arabica-producing regions in Indonesia. Specifically, Central Aceh has the largest Arabica coffee plantation area, measuring 49,997 hectares. Conversely, the regency that produces the least coffee in the Gayo Highlands is Southeast Aceh, with approximately 159 tons in 2021. Furthermore, the number of farmers involved in coffee plantations is the largest in Central Aceh, with 38,091 heads of families cultivating Arabica coffee. Nationally, Aceh is the largest center of Arabica coffee production, contributing 32.02 percent of national production, followed by North Sumatra at 31.98 percent, South Sulawesi at 12.27 percent, and West Java at 5.62 percent. While Indonesia's total coffee production remains below that of Brazil, Vietnam, and Colombia, it holds a strong competitive advantage in the specialty coffee market owing to its distinct flavor profile, particularly the rich aroma, fragrant spicy notes, and moderate acidity of Gayo Arabica. With the growing global focus on environmental and social sustainability, sustainable entrepreneurship in Gayo coffee farming has become increasingly important to meet the evolving market demands. However, the actual situation of Gayo coffee farmers at the farm level remains unclear, as issues related to the adoption of sustainability certifications have not yet been fully addressed in the literature. Therefore, it is important to thoroughly understand the factors that influence coffee farmers' adoption of sustainable certifications, especially in Gayo. Against this background, this study aims to identify the factors influencing the adoption of sustainable coffee certifications among Arabica coffee farmers in Gayo and analyze their economic value. By using an econometric model, the expected results of the study on the factors influencing sustainable certification adoption could be generalized for other study cases in the future. On the other hand, economic value analysis can produce the prospect of sustainable certified coffee utilized by farmers. The findings of this study are expected to provide important inputs for stakeholders, both in policymaking and in developing strategies to increase the competitiveness of Indonesian coffee through a sustainable approach.

METHODS

Research Design

Data collection in this study was conducted using a survey method through direct interviews guided by a pre-prepared questionnaire. A survey was conducted to obtain primary data that could represent the research population. The population in this study consisted of Gayo Arabica coffee farmers in Central Aceh Regency who owned land areas of less than or equal to 2 hectares (Figure 1). Data collection will be conducted from May to June 2025. Central Aceh was chosen because it is the largest producer of Arabica coffee in the Gayo Highlands of Aceh Province. In 2023, Central Aceh had 50,034.10 hectares of Gayo Arabica coffee plantations with a total production of 37,008.34 tons (BPS 2024). To determine the research sample, sub-districts with the largest Arabica coffee plantation areas in Central Aceh were grouped, resulting in the selection of the Pegasing and Jagong Jeget sub-districts. The area of Gayo Arabica coffee plantations in Pegasing Sub-district was 8,287.40 hectares with a production of 5,168.00 tons (BPS 2024), while Jagong Jeget Sub-

Figure 1 The Location of Study, in Central Aceh Regency (Source: Google Maps (2026)).

district had 6,839.50 hectares with a production of 5,540.00 tons (BPS 2024). The determination of the number of respondents in this study referred to Hair *et al.* (2011), who stated that for a reliable estimation in quantitative research, the number of respondents should exceed 300. In this study, 305 respondents became the sample of this study, meet these criteria and reach Gayo Arabica coffee farmers in Aceh.

Data Analysis

Logistic Regression Analysis

Logistic regression is a regression analysis used to model the relationship between a dichotomous (binary) or polychotomous response variable and a group of continuous or categorical explanatory variables (Agresti 2015). Parameter estimation was performed using the Maximum Likelihood Estimation (MLE) method. Essentially, the MLE method provides an estimate value of β that maximizes the likelihood function (Sepang *et al.* 2012). The logistic regression equation used in this study was as follows:

$$SEL_i = Ln\frac{P_i}{1-P_i} = a_0 + a_1AGE_i + a_2EDU_i + a_3LAB_i + a_4INC_i + a_5FAMS_i + a_6TINF_i + a_8LL_i + a_9PRD_i + a_{10}PNR_i + a_{11}GEO_i + a_{12}GEC_i + e_i$$

Hypothesis

α1	< 0
α2, α3, α4, α5, α6, dan α7	> 0

The hypotheses of this study were developed by considering three main factors:

- Socioeconomic factors: Farmers with better socioeconomic conditions, such as higher income levels and greater access to education, are more likely to adopt sustainable certification because they have more resources to meet certification requirements and perceive the long-term benefits (Rossi *et al.* 2024). However, younger farmers have also been found to be more adaptable to technology (Suroso *et al.* 2023; Ayalew & Girma 2025).
- Farmers' participation in agricultural organizations or cooperatives is believed to provide important information and training. Thus, it could increase the likelihood of adopting sustainable practices recommended by certification (Rodthong *et al.* 2020).
- Farmers' perceptions of green entrepreneurship also play a significant role. Farmers who have a positive view of environmental issues can improve the quality of their products, leading to sustainable certification adoption (Nanggong 2019).

Where SEIi is the respondent farmer's opportunity to implement sustainable coffee certification, with a value of 1 indicating that the farmer has implemented sustainable certification, and 0 otherwise. AGEi represents the farmer's age, which can influence their experience and openness to innovation. EDUi, or education level, reflects the farmer's capacity to understand the benefits and procedures of certification. LABi indicates the number of workers involved in coffee farming, INCi describes the farmer's total income, and PNRi indicates the total income from coffee farming. Furthermore, FAMSi reflects the number of family members in the farmer's household who can contribute both as laborers and as an economic burden. The variable TINFi is a dummy variable that represents whether the farmer has contact with influential informal figures, with a value of 1 if there is contact, and 0 otherwise. COPi describes the farmer's participation in cooperatives, which serve as supporting institutions for accessing information and facilitating certification. LLi represents the area of land managed by the farmer, and PRDi represents the total coffee production. In addition, two perception variables were included: GEO (Green Entrepreneurial Orientation), which indicates the green entrepreneurial orientation of farmers towards environmentally friendly practices, and GEC (Green Entrepreneurial Competence), which is the farmers' perception of their competence in running a sustainable agricultural business. All these variables were analyzed using a logistic regression equation, assuming that the relationship between the probability of certification adoption (SEIi) and these determinants

is log-linear and that there is a level of error (ei) in the model estimation.

Economic Value Analysis

This study also examines the economic value of Gayo coffee farming, referring to Mavsar *et al.* (2014), who defined the market price method as an approach to assessing economic value by estimating the value of goods or services produced and traded. This method was used to estimate the economic value derived from product sales, including sustainably certified coffee. The economic benefit of coffee production was determined by calculating the total annual production, which was then multiplied by the coffee market price. Next, the revenue from sales was multiplied by the land area used to calculate the economic value of the benefits generated by the local community as a sustainable coffee producer. The economic valuation estimate is as follows:

$$NE = P \times H \times L$$

The economic value (NE) is calculated as the product of the commodity's production volume and its selling price per unit of land area. Variable P represents the total coffee production yielded by farmers during one growing season, while H refers to the selling price of coffee received by farmers at the producer level. L denotes the land area cultivated for coffee farming by each respondent. Thus, economic value provides an overview of how productivity and price contribute to farmers' income within a given land size.

RESULTS AND DISCUSSION

Figure 2 describes the number of smallholders who adopted sustainable certification in Gayo Coffee Farming. The field data collection results indicated a discrepancy between the target proportions and actual field conditions. Based on direct confirmation and statements from the farmers, a total of 117 respondents (38%) had implemented sustainable certification, while 188 respondents (62%) had not. Specifically, the respondents, both those who have implemented sustainable certification and those who have not, are spread across two sub-districts in the research area, Jagong Jeget and Pegasing. Among the certified group, 90 individuals reside in Jagong Jeget and 27 in Pegasing, with the following village-level distribution: Gegarang with 43 respondents (36.75 per cent), Berawang Dewal with 34 respondents (29.06 per cent), Merah Said with 13 respondents (11.11 per cent), Arul Badak with 15 respondents (12.82 per cent), Wih Terjun with 7 respondents (8.51 per cent), and Wih Ilang with 5 respondents (4.27 per cent). Meanwhile, in the non-certified group, 117 respondents are located in Pegasing and 71 in Jagong Jeget, with the same distribution across villages: Gegarang 43 respondents (36.75 per cent), Berawang Dewal 34 respondents (29.06 per cent), Merah Said 13 respondents (11.11 per cent), Arul Badak 15 respondents (12.82 per cent), Wih Terjun 7 respondents (8.51 per cent), and Wih Ilang 5 respondents (4.27 per cent).

Table 1 reveals the results of the logistic regression on the determinants of sustainable certification adoption in Gayo coffee farming. The results of the logistic regression analysis demonstrate that several variables significantly influence the likelihood of adopting sustainable certifications. The model demonstrates a moderate level of goodness-of-fit, as reflected by an R-squared value of 0.542, indicating that the remaining 45.8 percent of the variance is influenced by other factors not included in this research model.

Among the socioeconomic factors, income positively and significantly influenced the probability of certification adoption (coefficient = 0.645, p = 0.019), indicating that respondents with higher income levels were more likely to adopt certification, with an odds ratio of 1.906. Economically, higher income provides greater financial flexibility to cover certification-related

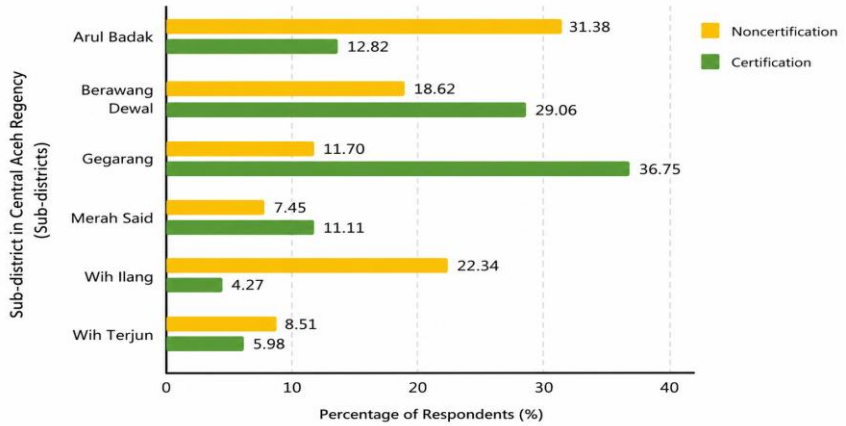

Figure 2 The Percentage of respondents who implement sustainable certification and those who do not, by sub-district in Central Aceh Regency.

costs, including compliance investments, audit fees, and adjustments to farm management practices (Liu *et al.* 2024). This aligns with the idea that sustainability standards may inadvertently exclude low-income farmers who lack sufficient capital reserves, raising concerns about the inclusivity of certification programs. Age is also negatively associated with certification adoption at the 10% significance level (p = 0.096), with an odds ratio of 0.753, indicating that older respondents are less inclined to adopt certification. The younger age of farmers has implications for the tendency to adopt sustainable certification among Gayo Coffee Farmers, supporting previous studies (Abidin *et al.* 2024; Renner *et al.* 2024). Conversely, the number of employees positively and significantly influences adoption at the 1% level (coefficient = 0.067, p = 0.001), implying that farms with more labor tend to be more engaged in certification (odds ratio = 1.070). This result is in line with previous findings regarding the positive nexus between the number of workers and the adoption of sustainable certification (Aidoo & Fromm 2015; Nupueng *et al.* 2023). Contact with informal publics is another positive and highly significant factor (coefficient = 0.415, p < 0.001), with an odds ratio of 1.514, indicating the importance of informal social interactions in promoting sustainable practices, similar to the previous result based on the subjective norm (Suroso *et al.* 2023). In contrast, participation in cooperation shows a strong negative effect (coefficient = -1.760, p < 0.001), reducing the likelihood of certification with an odds ratio of 0.172. Land size is positively associated with certification adoption (coefficient = 0.097, p = 0.018), as is total production, which is significant at the 10% level (coefficient = 1.180, p = 0.074). This suggests that larger-scale operations are more likely to pursue certification, supporting previous findings (Rodthong *et al.* 2020). Importantly, Green Entrepreneurial Orientation (GEO) emerged as the most influential variable (coefficient = 1.232, p < 0.001), with an odds ratio of 3.429, emphasizing the critical role of an environmentally oriented entrepreneurial mindset in certification adoption. In contrast, Green Entrepreneurial Competences (GEC) do not have no significant impact (p = 0.628). Other variables, such as education, number of family members, and total revenue, did not show significant effects in this model. Overall, the model underscores the multidimensional nature of certification adoption, which is shaped by both structural and cognitive-entrepreneurial factors.

The descriptive analysis results show differences in farming performance between farmers who have implemented sustainable certification and those who have not (Table 2). The average land area of certified farmers is slightly larger, at 1.66 hectares, compared to 1.54 hectares for non-certified farmers. In terms of production, the certified group produced an average of 1,702 kg/hectare, which was higher than that of the non-certified group, which only achieved 1.491 kg. This difference is also reflected in the total revenue and profit. Certified farmers earned an average revenue of IDR 26,037,564 and a profit of IDR 21,944,815, while non-certified farmers earned IDR 23,813,798 and IDR 20,656,431, respectively. However, certified farmers also bore higher production costs, with an average of Rp4,104,287 compared to IDR 3,157,368 for the non-certified group. Variations in the minimum and maximum values also indicate disparities between farmers within and between groups. For example, the maximum total production in the certified group reached 11000 kg with revenues of up to IDR 175,000,000, while the maximum production in the non-certified group was only 9,000 kg and revenues of Rp132,765,000. These findings indicate that, despite the higher costs, implementing sustainable certification has the potential to increase the productivity and profitability of farming businesses. Based on the production cost data presented, there are differences in expenditure patterns between certified and non-

Table 1 Factors influencing the adoption of sustainable certification in gayo coffee farmers in Central Aceh Regency

Variable	Coefficient	Sig. (P-value)	Odds Ratio
Constant	0.823	0.523	2.276
Education	0.118	0.499	1.125
Income	0.645**	0.019	1.906
Age	-0.284*	0.096	0.753
The Number of Family Household	0.161	0.191	1.175
The Number of Employee	0.067***	0.001	1.070
Contact with Informal Publics	0.415***	0.000	1.514
Participation with Cooperation	-1.760***	0.000	0.172
Land Size	0.097**	0.018	1.102
Total Production	1.180*	0.074	3.255
Total Revenue	1.081	0.100	2.948
Green Entrepreneurial Orientation (GEO)	1.232***	0.000	3.429
Green Entrepreneurial Competences (GEC)	0.138	0.628	1.148
R-Square	0.542		
Model Chi-Square (p-value)	0.059		

Note: *; **; and *** are significant at 10%, 5%, and 1%.

Table 2 The summary statistics of economic value between certified and non-certified gayo arabica coffee farmers in Central Aceh Regency.

Variable	Average		Minimum		Maximum	
	Certification (S)	Non-Certification (NS)	S	NS	S	NS
Land Size (ha)	1.66	1.54	0.50	0.50	8.00	8.00
Total Production (kg)	1702	1491	10	10	11000	9000
Total Revenue (IDR)	26,037,564	23,813,798	150.00	140.00	175,000,000	132,765,000
Total Profit (IDR)	21,944,815	20,656,431	412.50	140.00	162,812,500	122,763,500
Total Cost (IDR)	4,104,287	3,157,368	0	0	26,202,500	46,050,000

Note: S = Certification farmers and NS = Non-certification farmers.

Table 3 The summary statistics of production costs between certified and non-certified gayo arabica coffee farmers in Central Aceh Regency.

Variable	Average		Min		Max	
	Certification (S)	Non-Certification (NS)	S	NS	S	NS
Chemical Fertilizer Cost (Rp)	2,518,120	2,203,176	0	0	25,340,000	21,000,000
Herbicide Cost (Rp)	354.15	339.36	0	0	1,800,000	4,900,000
Land and Building Tax Cost (Rp)	470.73	39.04	0	0	160.00	600.00
Loan Interest Cost (Rp)	1,378,461	841.26	0	0	720.00	9,600,000
Non-Family Labor Cost (Rp)	11,849,498	575.79	0	0	9,218,750	5,962,000
Equipment Cost (Rp)	2,826,752	2,759,242	465.00	785.00	6,020,000	6,079,000

Note: S = Certification farmers and NS = Non-certification farmers.

certified farmers in several key cost components (Table 3). The average cost of chemical fertilizers incurred by certified farmers is Rp2,518,120, higher than that of non-certified farmers, who spend Rp2,203,176. A similar pattern was also observed in the costs of herbicides and land and building tax (PBB), although the differences were relatively small. The average PBB tax cost for certified farmers is IDR 470.73, slightly higher than the Rp399.04 for the non-certified group. Similarly, loan interest costs are higher for the certified group (Rp1,378,461) than for the non-certified group (IDR 841.26), reflecting the possibility of greater access to or dependence on financial institutions. The most striking difference is the cost of non-family labor. Certified farmers spent an average of IDR 11,849,498, significantly higher than the IDR 575.79 spent by the non-certified group. This suggests that certified farmers tend to be more intensive in employing non-family labor, which may be related to their larger business scale and higher operational standards. In terms of equipment costs, both groups showed relatively comparable averages, namely IDR 2,826,752 (certified) and IDR 2,759,242 (non-certified).

The minimum and maximum values for all components showed considerable variation, reflecting the diversity of conditions and production strategies among farmers within each group. Overall, these findings indicate that the implementation of sustainable certification tends to be associated with increased intensity and variation in production cost.

Figure 3 provides a summary of the statistics on Gayo Coffee selling prices. A comparison of coffee commodity selling prices between certified and uncertified farmers shows interesting variations in the results. Research findings indicate that for several crop categories, including red cherries, certified farmers receive lower selling prices than uncertified farmers (IDR 14.71 vs. IDR 15.37/kg). In the context of Gayo coffee, the certification premium is not fully transmitted in the form of direct price increases at the farm level because differentiation occurs more at the cooperative or exporter level, and some benefits are managed

collectively at the cooperative level. The added value indicated by a Benefit-Cost Ratio (BCR) that is well

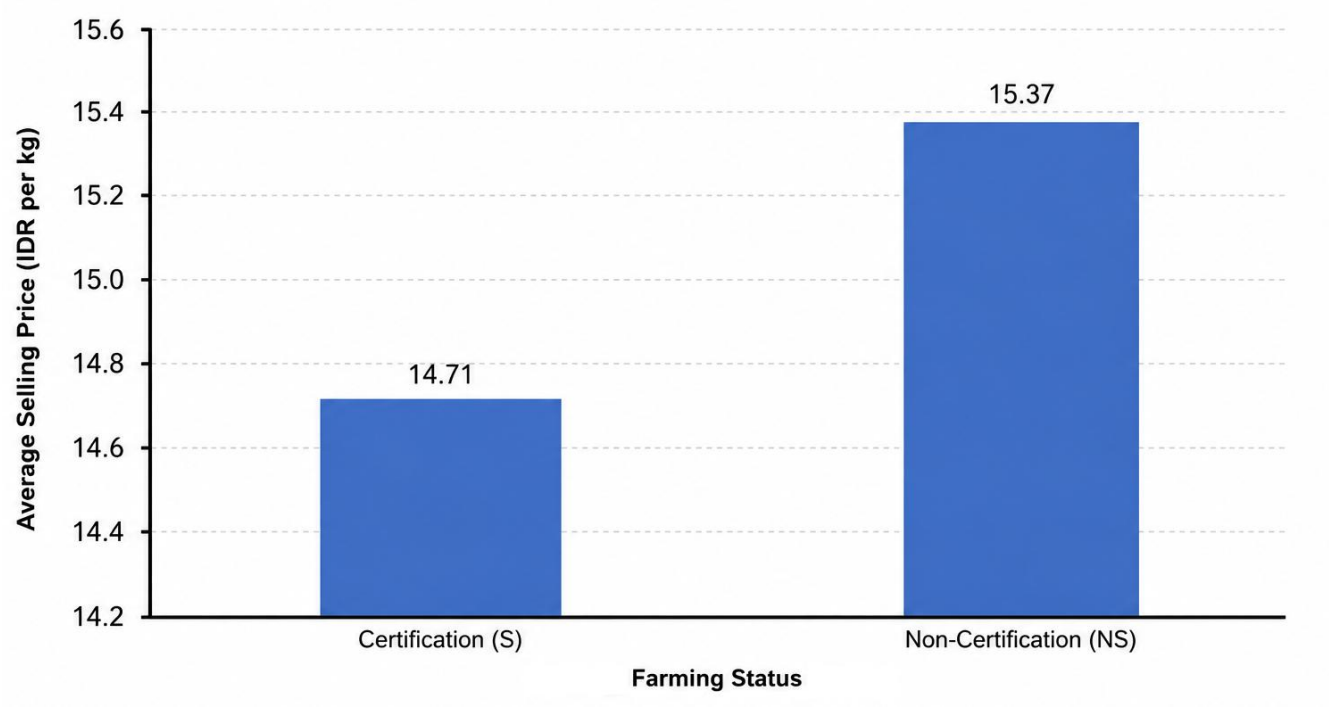

Figure 3 Average Selling Price Red Cherries in Central Aceh Regency (IDR per kg)

Table 4 Economic performance of coffee farming (average per farmer per year)

Farming status	Total revenue (IDR)	Total cost (IDR)	Profit (IDR)	BCR
Certification	26,037,564	4,104,287	21,933,277	6.34
Non-Certification	23,813,798	3,157,368	20,656,430	7.54

Note: BCR = Benefit-Cost Ratio. Economic values were calculated based on farmers' annual production and financial data collected during the 2025 survey period.

of certification is largely returned to farmers in non-cash forms, such as input assistance, technical assistance, access to financing, and increased cultivation capacity of the farmers. Therefore, certification in this study plays a more significant role as an instrument to improve agricultural efficiency and productivity than as a mechanism that directly increases farm-level prices. Ba sed on several previous studies, there is a positive and significant relationship between certification adoption and farmer productivity (Salman *et al.* 2021; Yang *et al.* 2023). The sustainability of farmers must be ensured through socialization and provision of good market access, encouraging interest in participating in sustainable certification (Chitja & Mabaya 2014; Codjae *et al.* 2025). There are some key strategies for implementing sustainable practices, namely training, supportive policies, and collaborative action (Ibnu *et al.* 2018; Nazarro 2021).

The economic value for certified coffee farmers reached IDR 41,560,457, while the economic value for non-certified coffee farmers was around IDR 35,291,671. This shows that farmers who have adopted certification have a higher economic value than those who have not. The results of the calculations (Table 4) show that Gayo Arabica coffee farming, both certified and non-certified, is economically viable, as above one.

However, there are differences in the economic performance characteristics between the two groups of farmers. Farmers who implement sustainable certification obtain higher absolute profits, amounting to IDR 21,933,277 per year, compared to non-certified farmers who earn IDR 20,656,430. This shows that sustainable certification has the potential to improve the economic performance of farming through increased production and income, even though it is accompanied by higher production costs than conventional farming.

In contrast, the BCR value for the non-certified farmer group was higher than that for the certified group. This finding indicates that, relatively speaking, every rupiah spent by non-certified farmers generates greater returns than that spent by certified farmers. This condition reflects that sustainable certification requires higher input intensity and costs, thereby reducing relative cost efficiency in the short term, even though it can increase absolute profits. In an economic theoretical framework, these results reinforce the argument that the decision to adopt certification is not only based on short-term cost efficiency, but also on expectations of increased profits and business stability in the medium to long term. The integration of profit

calculations and BCR ratios with the logistic regression model provides a more comprehensive explanation of sustainable-certification adoption behavior. Specifically, the relationship between farm economic performance and certification adoption decisions can be understood through the variables of income, land size, and labor used in this model. Thus, the calculation of profits and BCR not only strengthens the descriptive analysis of farm economic performance but also provides a clear economic basis for interpreting the logistic regression coefficients. The decision to adopt sustainable certification reflects a rational response by farmers to differences in absolute profits, relative cost efficiency, and production capacity, which are proxied by income, land area, and labor use. This integration confirms that the empirical results of the study are consistent with the theoretical economic framework used and provides a coherent explanation of the certification adoption behavior of Gayo Arabica coffee farmers.

CONCLUSION

The factors influencing the adoption of sustainable certification in Gayo coffee farming and its economic value shows that farmer age and participation in cooperatives negatively influence the decision to adopt certification, while income, employment, land area, total production, and involvement in informal communities have positive and significant effects. Economically, certified farmers perform better than non-certified farmers in terms of production, income, and profits. They are also more willing to invest in inputs and labor, reflecting increased business efficiency despite higher production costs. This confirms that certification is not the sole path to success, and a more inclusive approach is needed to reach a diverse range of farmer profiles in the study area. These findings have several important implications for management. First, certification institutions and relevant stakeholders need to implement segmentation strategies that consider farmers' age. A more adaptive and educational approach to groups that tend to reject certification could increase their participation in the program. Second, engagement in informal communities has proven to be an effective channel for influencing adoption, strengthening social networks, and developing community-based entrepreneurial orientation. Third, because certification provides tangible economic benefits, promotional campaigns should highlight these added values to build positive perceptions and encourage voluntary adoption. Moreover, from a government perspective, these results imply that public policy should not only encourage the expansion of certification but also design targeted support mechanisms such as training subsidies, extension services, and financial incentives. Nevertheless, this study had several limitations that should be considered. The research utilized a cross-sectional design, which means that it was unable to capture the long-term dynamics of adoption. Additionally, the quantitative method used did not explore the subjective motivations or obstacles that may affect farmers' decisions. The study's limited geographic focus, particularly on the Gayo region, restricts the ability to generalize the findings to other regions or commodities with different characteristics. Consequently, future research should adopt a longitudinal approach and incorporate qualitative methods to provide a more thorough understanding of the dynamics of adopting sustainable certification in agriculture.

REFERENCES

Abidin M, Fatah F, Noor W, Aris N. 2024. A review on adoption of the Malaysian Sustainable Palm Oil (MSPO) certification scheme. *IOP Conference Series: Earth and Environmental Science.* 1397(1): 012035. https://doi.org/10.1088/1755-1315/1397/1/012035

Agresti A. 2015. *Foundations of linear and generalized linear models.* New Jersey (US): John Wiley & Sons.

Aidoo R, Fromm I. 2015. Willingness to adopt certifications and sustainable production methods among small-scale cocoa farmers in the Ashanti Region of Ghana. *Journal of Sustainable Development.* 8(1): 33. https://doi.org/10.5539/jsd.v8n1p33

Arifin B. 2022. Impacts of coffee agroforestry and sustainability certification on farmers' livelihood in sumatra-indonesia. *Sustainability Science and Resources.* 2(1): 77–95. https://doi.org/10.55168/ssr2809-6029.2022.2005

Ayalew A, Girma Y. 2025. The Effect of Age on Agricultural Technology Adoption by Smallholder Farmers in Ethiopia: A Systematic Review and Meta-Analysis. *Advances in Agriculture*. 2025(1): 8881484. https://doi.org/10.1155/aia/8881484

Codjoe FNY, Mathe S, Soullier G, Blundo-Canto G, Asante FA, Sarpong DB. 2025. The journey from technological change to livelihood: effectual behaviour and farmers' compliance with certification standards in Ghana's cocoa sector. *Agricultural and Food Economics*. 13(1): 20. https://doi.org/10.1186/s40100-025-00362-w

Chitja JM, Mabaya E. 2015. Institutional innovations linking small-scale farmers to produce markets in South Africa. In *Innovative institutions, public policies and private strategies for agro-enterprise*

development (pp. 1–23). https://doi.org/10.1142/9131

Fitri I, Maryunianta Y, Barus R, Supriana T. 2023. Analysis of difference in sales price of arabica coffee certified by sustainable agriculture institutes rainforest alliance and fairtrade in central aceh (case study of rahmat kinara multi-purpose cooperative). *Agric.* 35(1): 61–72. https://doi.org/10.24246/agric.2023.v35.i1.p61-72

Hair JF, Ringle CM, Sarstedt M. 2011. PLS-SEM: Indeed a silver bullet. *Journal of Marketing theory and Practice.* 19(2): 139–152. https://doi.org/10.2753/MTP1069-6679190202

Ibnu M, Offermans A, Glasbergen P. 2018. Certification and farmer organisation: Indonesian smallholder perceptions of benefits. *Bulletin of Indonesian Economic Studies*. 54(3): 387–415. https://doi.org/10.1080/00074918.2018.1506093

Jena P, Grote U. 2022. Do certification schemes enhance coffee yields and household income? lessons learned across continents. *Frontiers in Sustainable Food Systems.* 5. https://doi.org/10.3389/fsufs.2021.716904

Jones K, Njeru E, Garnett K, Girkin N. 2024. Assessing the impact of voluntary certification schemes on future sustainable coffee production. *Sustainability.* 16(13): 5669. https://doi.org/10.3390/su16135669

Lazuardi P, Jati A, Pratama R. 2021. Sustainability of wonosobo's coffee agriculture and industry from community-based conservation perspective. *E3s Web of Conferences.* 317: 01097. https://doi.org/10.1051/e3sconf/202131701097

Liu Y, Chen R, Chen Y, Yu T, Fu X. 2024. Impact of the degree of agricultural green production technology adoption on income: evidence from Sichuan citrus growers. *Humanities and Social Sciences Communications*. 11(1): 1–12. https://doi.org/10.1057/s41599-024-03693-z

Merbah N, Hernández S. 2024. Consumer willingness-to-pay for sustainable coffee: evidence from a choice experiment on fairtrade and utz certification. *Sustainability.* 16(8): 3222. https://doi.org/10.3390/su16083222

Nazzaro C, Uliano A, Marotta G. 2021. Drivers and barriers towards social farming: a systematic review. *Sustainability*. 13(24): 14008. https://doi.org/10.3390/su132414008

Negre L. 2023. The world of coffee: 21st century solutions for a commodity facing climate change risks. *Consilience.* (26). https://doi.org/10.52214/consilience.vi26.10936

Nanggong A. 2019. Perceived benefit, environmental concern and sustainable customer behavior on technology adoption. *The Asian Journal of Technology Management*. 12(1): 31–47. https://doi.org/10.12695/ajtm.2019.12.1.3

Nupueng S, Oosterveer P, Mol AP. 2023. Global and local sustainable certification systems: Factors influencing RSPO and Thai-GAP adoption by oil palm smallholder farmers in Thailand. Environment, Development and *Sustainability.* 25(7): 6337–6362. https://doi.org/10.1007/s10668-022-02306-6

Oya C, Schaefer F, Skalidou D, McCosker C, Langer L. 2017. Effects of certification schemes for agricultural production on socio-economic outcomes in low- and middle-income countries: a systematic review. *Campbell Systematic Reviews.* 13(1): 1–346. https://doi.org/10.4073/csr.2017.3

Renner S, Ruml A, Lakemann T, Nuryartono N, Tjoa A, Corre M, Lay J. 2024. Smallholder rspo certification, economic benefits and agrochemical use. *Environmental Research Letters.* 19(11): 114093. https://doi.org/10.1088/1748-9326/ad8367

Rodthong W, Kuwornu JK, Datta A, Anal AK, Tsusaka TW. 2020. Factors influencing the intensity of adoption of the roundtable on sustainable palm oil practices by smallholder farmers in Thailand. *Environmental Management.* 66(3): 377–394. https://doi.org/10.1007/s00267-020-01323-3

Rossi C, Shen L, Junginger M, Wicke B. 2024. Sustainability certification of bio-based products: Systematic literature review of socio-economic impacts along the supply chain. *Journal of Cleaner Production*. 468: 143079. https://doi.org/10.1016/j.jclepro.2024.143079

Salman D, Mahyuddin, Summase I, Fudjaja L, Tiring DN, Rusmidin, Rayuddin. 2021. Productivity and income analysis of certified cacao farmers (UTZ certified) and non-certified cacao farmers. In *IOP Conference Series: Earth and Environmental Science.* 681(1): 012049). https://doi.org/10.1088/1755-1315/681/1/012049

Suroso AI, Tandra H, Haryono A. 2023. Adoption of sustainable certification in West Borneo palm oil farmers: The role of environmental concern. *Cogent Food & Agriculture.* 9(2): 2266196. https://doi.org/10.1080/23311932.2023.2266196

Suroso AI, Fahmi I, Tandra H. 2023. Adoption of Mobile Internet and the Implication on Palm Oil Productivity: Case Study in Siak Regency. *International Journal of Sustainable Development & Planning*. 18(1). https://doi.org/10.18280/ijsdp.180135

Tucker C, Zelaya M. 2023. Fostering sustainability through environmentally friendly coffee production and alternative trade: the case of café orgánico de marcala (comsa), honduras. *Critique of*

Anthropology. 43(3): 231–251. https://doi.org/10.1177/0308275x231194253

Winter E, Marton S, Baumgart L, Curran M, Stolze M, Schader C. 2020. Evaluating the sustainability performance of typical conventional and certified coffee production systems in brazil and ethiopia based on expert judgements. *Frontiers in Sustainable Food Systems.* 4. https://doi.org/10.3389/fsufs.2020.00049

Yang D, Wang X, Tang Y, Liu Z, Yu X. 2023. How has the new round of farmland certification in China affected farmers' economic welfare?. *International Food and Agribusiness Management Review*. 26(2): 287–308. https://doi.org/10.22434/IFAMR2022.0009