

The Impact of Sustainable Certification on, Arabica Coffee's Competitiveness and Regional Development in Aceh, Indonesia

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Abstract

This study explores the role of sustainable certification in enhancing the competitiveness and regional development of Arabica coffee in Aceh, Indonesia. By employing Location Quotient (LQ) analysis, the study assesses the coffee sector's economic contribution, while the Policy Analysis Matrix (PAM) evaluates the comparative and competitive advantages of certified Arabica coffee. Data were collected through surveys, interviews, and observations involving 273 respondents from the Central Aceh and Bener Meriah districts, the primary production areas. The findings reveal that these regions possess high LQ values, underscoring the coffee sector's significance. The results indicate that sustainable certification significantly increases farmers' income, with a benefit-cost ratio (R/C ratio) of 3.36 for domestic budgets and 3.46 for social budgets. Additionally, the study finds strong comparative and competitive advantages, with a Domestic Resource Cost Ratio (DRCR) of 0.0089 and a Private Cost Ratio (PCR) of 0.0075. This demonstrates that sustainable certification not only boosts the market position of Aceh's Arabica coffee but also supports broader regional development. The study concludes by recommending continued support for certification initiatives, modern agricultural technology investments, and strategic promotion of Aceh coffee in both domestic and international markets.

Keywords: *Coffee, Certification, Economic Analysis, Sustainability, Aceh.*

Introduction

Agricultural development in Indonesia has evolved significantly since the reform era, shifting from a focus on merely increasing production to enhancing farmers' income through comprehensive agribusiness systems (Rozaki, 2021; Sudaryanto et al 2023; Pranadji et al 2023). As one of the world's leading coffee producers and exporters, Indonesia faces the necessity of adopting advanced cultivation practices to improve its competitiveness in global markets, particularly in the United States (Saptana et al, 2023). Coffee plays a vital role in the national economy, contributing to job creation and foreign exchange earnings. Notably, coffee plantations in Indonesia are primarily operated by smallholder farmers, covering 1.24 million hectares 933 hectares of robusta plantations, and 307 hectares of arabica plantations according to consulate general of the Republic of Indonesia in Chicago, The United States of America.

Indonesia's national development strategy aims to create a just and prosperous society, with the agricultural sector, including coffee, being pivotal in achieving these goals (Panggabean et al, 2022; Junais et al, 2023). The sector is tasked with increasing production to satisfy domestic food and industrial demands, boosting exports, raising farmers' incomes, and generating employment opportunities (Bathia, 2018; Mykytiuk, 2019). Research by Satia Negara Lubis and Arga Abdi Rafiud Darajat Lubis indicates that technological advancements have facilitated the expansion of Robusta coffee farming areas. However, farmers' slow response to price changes has sometimes led to decreased profitability and the risk of oversupply (Lubis, 2024). Sustainable development must balance economic growth with societal well-being and environmental conservation (Truong, 2021; Kumar et al, 2024).

Gayo coffee, an Arabica variety from the highlands of Aceh, is renowned globally and has earned international certifications, including Fairtrade and geographical indications (Fadhil, 2022). Such certifications are essential for promoting sustainable coffee production and marketing. They offer economic benefits to farmers, open access to broader markets, and command premium prices for certified products

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(Jones et al, 2024). Moreover, these certifications can improve environmental sustainability by encouraging eco-friendly farming practices (Ho, 2018).

Despite these advantages, the implementation of coffee certification in Indonesia is challenged by fluctuating market prices, limited access to markets, and a general lack of awareness among farmers about the importance of certification (Lubis, 2024). Farmers are often primarily motivated by financial benefits, with less emphasis on social and environmental aspects (Rahmah et al, 2023). Studies suggest that institutional support, such as cooperatives, can address these challenges by providing better training and market access for farmers (Velandia, 2022; Fontana, 2023).

This study aims to explore the role of sustainable certification in enhancing the competitiveness of Arabica coffee and its contribution to regional development in Aceh Province. Unlike previous research by Hamid (2023), which focused on the economic impact of certification on smallholder coffee farmers, our study broadens the scope by examining both economic and regional development outcomes. Hamid (2023) found that while certification schemes like Fairtrade and Organic improved coffee prices and increased farmers' per capita income, they did not significantly affect daily per capita expenditures. This study seeks to build on these findings by investigating how sustainable certification influences not only farmers' incomes but also broader economic growth and regional development.

Similarly, Anhar (2021) emphasized the importance of sustainable development strategies for Aceh's Arabica coffee, highlighting the need for policies that support coffee sustainability and productivity. Anhar's study focused on strategies like climate-smart coffee practices and social forestry to enhance coffee production. Our research extends this work by providing a comprehensive analysis of the potential, challenges, and strategies for implementing sustainable certification, considering both environmental and economic aspects.

By implementing certification, this study hopes to promote a more efficient and productive coffee farming system. Through a comprehensive and multidisciplinary approach, it offers valuable insights into the potential, challenges, and strategies for sustainable certification of Arabica coffee in Aceh Province. The findings are expected to assist policymakers, industry stakeholders, and farmers in fostering a more competitive and sustainable coffee sector. Additionally, the study underscores the importance of collaboration among government agencies, certification bodies, and farmers to ensure the success of certification programs. This holistic approach aims to provide a more nuanced understanding of the impacts of sustainable certification, offering policy recommendations that address current challenges and promote regional development and farmers' welfare in Aceh Province.

Material and Methods

Materials

This study was conducted in Central Aceh and Bener Meriah districts in 2023, selected purposively as the primary Arabica coffee-producing areas in Aceh Province. A quantitative approach was utilized, involving data collection through surveys, interviews, and observations (Kurniawan, 2023). The study population included coffee farmers, certification actors, coffee cooperatives, and related institutions. Using the Slovin formula with a 95% confidence level and a 5% error margin, a sample size of 273 respondents was determined. The research instruments comprised structured questionnaires to gather information on farming practices, certification experiences, and perspectives on sustainable certification (Wang, 2024). In-depth interviews with key stakeholders provided deeper insights into the challenges and opportunities of implementing certification. Secondary data were also collected from official documents, reports, and relevant literature.

Data Analysis

The data analysis incorporated several techniques to provide a comprehensive assessment of the implementation and impact of Arabica coffee certification. Location Quotient (LQ) analysis identified

leading economic sectors, emphasizing the significance of the coffee industry in the region. The Policy Analysis Matrix (PAM) was employed to assess comparative and competitive advantages, revealing the profitability and efficiency of coffee production under various conditions. The study further calculated the Domestic Resource Cost Ratio (DRCR) and Private Cost Ratio (PCR) to evaluate the sector's comparative and competitive advantages, with values below 1 indicating economic efficiency and competitiveness. Multidimensional Scaling (MDS) was used to assess the sustainability status of coffee certification across economic, environmental, social, institutional, and technological dimensions (Warlina, 2023). These analytical tools collectively offer a holistic understanding of the impact of sustainable certification on the Arabica coffee sector in Aceh, providing valuable insights for policymakers, industry stakeholders, and farmers.

Results

Location Quotient (LQ) Analysis of Arabica Coffee in Aceh Province

The Location Quotient (LQ) method measures the strength of a specific sector within a region's economy compared to the same sector at the provincial or national level. The LQ formula is as follows:

$$LQ = \frac{Lr/Ln}{Lt/Lp}$$

LQ = Location Quotient coefficient for coffee land in Aceh Province

Lr = Area of coffee land in the analyzed region (ha)

Ln = Total area of coffee land in Aceh Province (ha)

Lt = Area of plantation land in the analyzed region (ha)

Lp = Total area of plantation land in Aceh Province (ha)

Table 1: LQ Analysis of Arabica Coffee in Aceh Province Based on Districts/Cities From 2012 To 2022.

Regency/Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Aceh Tengah	5,992	5,899	6,051	6,023	5,964	6,031	6,007	6,011	5,972	5,979	6,633
Pidie	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,016	0,016	0,018
Aceh Utara	0,000	0,000	0,000	0,000	0,000	0,000	0,223	0,226	0,267	0,266	0,295
Gayo Lues	0,000	0,000	1,069	1,064	1,101	1,101	1,164	1,286	1,319	1,345	1,574
Bener Meriah	6,684	6,771	6,647	6,614	6,346	6,346	6,306	6,251	6,204	6,198	5,127

Central Aceh consistently shows dominance in Arabica coffee production. In 2012, Central Aceh's LQ was 5.992, indicating that the coffee sector contributed almost six times more to the local economy compared to the provincial average. By 2022, the LQ had reached 6.633, reinforcing coffee's role as the backbone of Central Aceh's economy. Small fluctuations from year to year indicate stability and continuous growth in the coffee sector.

Bener Meriah also shows significant contributions. In 2012, the LQ was 6.684, remaining high despite a slight decline to 5.127 in 2022. However, an LQ consistently above 5 indicates that coffee is a leading sector in this region.

Districts like Gayo Lues have shown significant contributions since 2014 with an LQ of 1.069, increasing to 1.574 in 2022. Conversely, Pidie and North Aceh have relatively small contributions with LQ values close to zero for most of the period.

In conclusion, Central Aceh and Bener Meriah are the main centers of Arabica coffee production in Aceh Province, with significantly higher contributions compared to other regions. Geographical factors and proactive local government policies play crucial roles in this success.

Analysis of Arabica Coffee Farmers' Profit Structure in Aceh Province

Table 2 shows the average profit structure of Arabica coffee farmers in Aceh Province. Revenues from the sale of cherry coffee, honey beans, and green beans indicate that green beans have the highest selling value, with domestic revenue of IDR 35,484,000. Revenues from the sale of honey beans and cherry coffee are IDR 24,202,593 and IDR 11,970,000, respectively. Socially, the revenue values are slightly higher for all three product types.

The production costs of Arabica coffee include costs for fertilizers, pesticides, machinery, fuel, and other farming tools. Labor is the largest cost component, with harvesting costs reaching IDR 11,391,926 and maintenance costs IDR 9,786,512. The total production cost for Arabica coffee is IDR 22,957,408 for domestic costs and IDR 406,845 for foreign costs. Socially, the total costs are IDR 22,978,079 for domestic costs and IDR 507,027 for foreign costs.

The profit obtained by farmers from Arabica coffee production is IDR 54,193,184 for domestic budgets and IDR 56,582,484 for social budgets. The benefit-cost ratio (R/C ratio) indicates that Arabica coffee farming is profitable, with an R/C of 3.36 for domestic budgets and 3.46 for social budgets. This shows that for every rupiah invested, farmers get back more than three times in revenue.

Table 2: Average Profit Structure of Arabica Coffee Farmers in Aceh Province (IDR/Ha/Year)

<i>Description</i>	<i>Amount</i>	<i>Private Budget (IDR)</i>		<i>Social Budget (IDR)</i>	
		<i>Domestic</i>	<i>Foreign</i>	<i>Domestic</i>	<i>Foreign</i>
<i>Revenue</i>					
<i>Sale of Cherry Coffee</i>	1.2	11,970,000	0	0	0
<i>Sale of Honey Bean</i>	750	24,202,593	0	0	0
<i>Sale of Green Bean</i>	150	35,484,000	0	0	0
<i>Costs</i>					
<i>a. Fertilizers (Kg)</i>	3500	14,625	4,368	4,368	4,368
<i>b. Pesticides (Kg)</i>	11000	46,750	14,420	14,420	14,420
<i>c. Machinery</i>	1.05	53,544	214,850	214,850	214,850
<i>d. Fuel (liter)</i>	50000	210,000	63,936	63,936	63,936
<i>e. Sprayer</i>	1.1	25,365	101,707	101,707	101,707
<i>f. Machete</i>	2.5	168,470	0	0	0
<i>g. Hoe</i>	3	202,560	0	0	0
<i>h. Saw</i>	1.3	8,616	0	0	0
<i>i. Tarpaulin</i>	0.75	188,872	0	0	0
<i>j. Shelter</i>	0.8	219,285	0	0	0
<i>k. Scissors</i>	1.8	38,649	0	0	0
<i>l. Cart</i>	1.1	327,035	0	0	0

Description	Amount	Private Budget (IDR)	Social Budget (IDR)
m. Boots	1.8	149,400	0
n. Marketing Costs		195,437	0
a. Labor			
Harvesting		11,391,926	0
Maintenance		9,786,512	0
Tax		40,716	0
Miscellaneous		68,458	102,685
Total Costs		22,957,408	406,845
Revenue		77,150,592	0
Profit		54,193,184	-406,845
R/C		3.36	0

Competitive Analysis of Certified Arabica Coffee in Aceh Province

The competitiveness of agricultural products can be assessed by the efficiency of resource use in the production process.

Figure 1: Certified Coffee



The Policy Analysis Matrix (PAM) method is used to calculate the levels of social and private profitability as well as competitive efficiency. The formulas used in PAM are:

$$\text{Private profit} = \text{Private revenue} - (\text{Private tradable input costs} + \text{Private non-tradable input costs})$$

$$\text{Social profit} = \text{Social revenue} - (\text{Social tradable input costs} + \text{Social non-tradable input costs})$$

Table 3: Policy Analysis Matrix (PAM) for Arabica Coffee in Aceh Province (IDR/Ha/Year)

Description	Revenue	Tradable Costs	Non-tradable Costs	Profit
Private Profitability (PP)	77,150,592	22,957,408	406,845	54,193,184
Social Profitability (SP)	79,560,563	22,978,079	507,027	56,582,484
Divergence	2,409,971	20,671	100,182	2,389,300

Private profit shows that the revenue from Arabica coffee farming in Aceh reaches IDR 77,150,592 with total costs of IDR 22,957,408 for tradable inputs and IDR 406,845 for non-tradable inputs, resulting in a profit of IDR 54,193,184. Social profit shows revenue of IDR 79,560,563 with total costs of IDR

22,978,079 for tradable inputs and IDR 507,027 for non-tradable inputs, resulting in a profit of IDR 56,582,484.

The difference between private and social profit indicates the impact of government policies, where revenues and profits increase due to these policies. The certification policy for Arabica coffee in Aceh enhances competitiveness and the selling price of coffee in global markets, as well as providing access to premium markets.

Sustainability of Certified Arabica Coffee in Aceh

Sustainable agricultural development in Aceh faces the fundamental challenge of balancing resource management with improving living standards. This study utilized the Rap-Coffee tool to assess the sustainability of certified Arabica coffee plantations across economic, environmental, social, institutional, and technological dimensions.

Economic Sustainability

The economic dimension achieved an index score of 60.92, categorizing it as "moderately sustainable." The study identified key factors such as coffee price stability, certification costs, and market access as crucial for economic sustainability. These findings suggest that while certified coffee contributes positively to the local economy, there is room for improvement, particularly in diversifying income sources and stabilizing market conditions.

Ecological Sustainability

The ecological dimension scored 70.2, indicating "moderately sustainable" practices. Key practices include the use of organic fertilizers, integrated pest management, and agroforestry techniques, which help maintain biodiversity and soil health. Certifications such as Rainforest Alliance and C.A.F.E. Practices are crucial in promoting these sustainable practices, reducing environmental impacts like soil erosion and water pollution.

Social Sustainability

Social sustainability, with an index score of 66.78, reflects improvements in social welfare, community participation, and educational outreach. Certifications like Fairtrade and Rainforest Alliance have contributed to fair pricing and safe working conditions, enhancing social equity and community well-being. However, further efforts are needed to improve educational opportunities and reduce conflicts within the coffee-growing communities.

Institutional Sustainability

Institutional sustainability scored 66.2, highlighting the role of cooperatives and local organizations in supporting sustainable practices. These institutions provide critical access to resources, training, and markets, thereby enhancing the farmers' capacity for sustainable farming. However, the need for stronger legal frameworks and better financial support mechanisms remains evident.

Technological Sustainability

Technological sustainability was rated at 58.7, reflecting moderate use of advanced agricultural technologies. The adoption of modern farming techniques, such as high-quality seedlings, proper handling practices, and efficient irrigation systems, is vital for improving productivity and sustainability. However, there is a need for greater investment in technology to enhance efficiency and reduce environmental impacts.

Comparative and Competitive Advantage Analysis

To measure comparative and competitive advantages, the Domestic Resource Cost Ratio (DRCR) and Private Cost Ratio (PCR) indicators are used. The DRCR formula is:

$$DRCR = \frac{\text{Non – Tradable Input Costs (G)}}{\text{Revenue (E) – Tradable Input Costs(F)}}$$

PCR Formula is:

$$PCR = \frac{\text{Non – Tradable Input Costs (C)}}{\text{Revenue (A) – Tradable Input Costs(B)}}$$

DRCR and PCR Calculation Results:

$$DRCR = \frac{22.957.408}{77.150.592 - 406.845} = 0,0089$$

$$PCR = \frac{22.978.079}{79.560.563 - 507.027} = 0,0075$$

DRCR and PCR values less than 1 indicate that domestic production costs are lower than the value of production at social prices and actual selling prices, suggesting that Aceh's Arabica coffee has strong comparative and competitive advantages.

Multidimensional Sustainability Analysis

The multidimensional sustainability index for certified Arabica coffee in Aceh was 64.56, categorized as "moderately sustainable." The S-Stress value of 0.12 and a high R² coefficient of 0.95 indicate a robust model. The analysis suggests a relatively balanced performance across various dimensions, with ecological sustainability being slightly higher than economic and social dimensions.

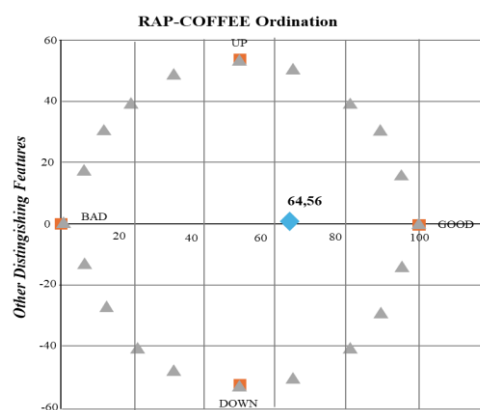


Figure 1. Multidimensional Sustainability Analysis coffee certification in Aceh Province

These findings underscore the importance of continued investment in sustainable practices, particularly in enhancing economic resilience and technological innovation. The role of certifications like C.A.F.E. Practices, Rainforest Alliance, and Fairtrade is crucial in setting benchmarks for sustainable practices, promoting social and economic justice, and maintaining environmental standards. A holistic approach,

integrating all five dimensions, is essential for achieving long-term sustainability and improving the livelihoods of coffee farmers in Aceh.

Discussion

The findings of this study provide a comprehensive understanding of the impact of sustainable certification on the Arabica coffee sector in Aceh Province. The analysis reveals that the certification process has had significant implications for both the economic viability and sustainability of coffee production in the region.

The results demonstrate that certified Arabica coffee in Aceh Province yields substantial economic benefits, as evidenced by the high benefit-cost ratios (R/C ratio) for both domestic and social budgets. The R/C ratios of 3.36 and 3.46 indicate that for every unit of currency invested, farmers receive more than threefold returns, highlighting the profitability of certified coffee farming. This finding is consistent with Hamid's (2023) study, which also reported increased income for certified farmers, though it noted that certification did not significantly impact daily expenditures. The robust profit margins suggest that certification can enhance economic resilience among coffee farmers, potentially providing a buffer against market volatility.

The Policy Analysis Matrix (PAM) analysis, along with the DRCR and PCR values, underscores the strong comparative and competitive advantages of certified Arabica coffee. DRCR and PCR values below 1 indicate that domestic production costs are significantly lower than the production's value at social and market prices. This competitive edge is further reinforced by the region's high Location Quotient (LQ) values, which highlight the concentration and specialization of the coffee sector in Central Aceh and Bener Meriah. These findings align with Anhar's (2021) emphasis on the importance of strategic planning and market-oriented policies to maintain and enhance competitiveness in global markets.

The multidimensional sustainability assessment reveals that certified Arabica coffee in Aceh Province exhibits a moderate level of sustainability across various dimensions. The ecological sustainability score of 70.2 indicates that the adoption of practices like organic fertilization, integrated pest management, and agroforestry is contributing to environmental conservation. Certifications such as Rainforest Alliance and C.A.F.E. Practices have been instrumental in promoting these sustainable practices, thereby reducing soil erosion and water pollution. However, the moderate score suggests that there is still room for improvement in implementing more stringent environmental standards.

Social sustainability, with an index score of 66.78, reflects significant improvements in social welfare, community engagement, and educational outreach. Programs like Fairtrade have been vital in ensuring fair wages and safe working conditions for farmers, contributing to social equity. Nonetheless, there are areas for further enhancement, particularly in expanding educational opportunities and minimizing conflicts within the coffee-growing communities. The role of institutional sustainability, rated at 66.2, highlights the critical function of cooperatives and local organizations in supporting sustainable practices. However, stronger legal frameworks and better financial support mechanisms are needed to bolster these institutions' capacity to promote sustainability effectively.

Technological sustainability scored 58.7, reflecting moderate adoption of advanced agricultural technologies. The use of high-quality seedlings, proper handling practices, and efficient irrigation systems is vital for improving productivity and sustainability. However, the relatively low score indicates a need for greater investment in technology and innovation to enhance efficiency and reduce environmental impacts. This is particularly crucial as the coffee sector faces challenges from climate change and market fluctuations.

Conclusion

This study highlights that Central Aceh and Bener Meriah are the primary centers of Arabica coffee production in Aceh Province, with these regions making significantly greater contributions to the local economy than other areas. The Location Quotient (LQ) analysis underscores the coffee sector's critical

importance to the economies of these districts, with consistently high LQ values observed from 2012 to 2022. The combination of favorable geographical factors and proactive local government policies has provided a strong foundation for the sector's development.

The analysis of farmers' profit structures reveals that Arabica coffee production is a profitable enterprise, with a substantial benefit-cost ratio (R/C ratio). Moreover, the competitive analysis using the Policy Analysis Matrix (PAM) method indicates that Aceh's Arabica coffee possesses strong comparative and competitive advantages, as evidenced by the low Domestic Resource Cost Ratio (DRCR) and Private Cost Ratio (PCR) values. The implementation of sustainable certification policies has played a pivotal role in enhancing the income and profits of farmers, thereby increasing the competitiveness of Aceh's Arabica coffee in global markets.

These findings suggest that sustainable certification not only supports regional development and improves farmers' welfare but also strengthens the competitive position of Aceh coffee internationally. To further develop the coffee sector in Aceh, it is crucial to continue supporting farmer-friendly policies, invest in modern agricultural technologies, and promote Aceh coffee products in both domestic and international markets. By doing so, the region can ensure the long-term sustainability and prosperity of its coffee industry.

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