Original Research Article

EVALUATION OF THE SUSTAINABILITY STATUS OF ARABICA COFFEE-BASED ECO-FARMING ON SEMBALUN'S DRYLANDS, EAST LOMBOK REGENCY

ABSTRACT

Aims:
This study aims to evaluate the application of eco-farming practices to support the sustainability of Arabica coffee farming in the drylands of Sembalun, East Lombok Regency. Specifically, it aims to: (1) assess the effectiveness of eco-farming in creating a sustainable agricultural system, (2) evaluate the sustainability status of Arabica coffee farming in Sembalun, and (3) identify solutions that enhance the sustainability of Arabica coffee farming and the well-being of local farmers.
Study Design:
The study follows a mixed-methods design, integrating both qualitative and quantitative approaches.
Place and Duration of Study:
The research was conducted in the Arabica coffee farming areas of Sembalun, East Lombok Regency, over a period of two months
Methodology: Arabica coffee farmers in Sembalun were selected as the primary unit of analysis. Data collection involved direct interviews, field observations, and documentation of farming practices. The gathered data were analyzed using Multiaspect Sustainability Analysis (MSA) with Exsimpro software to assess the sustainability across five dimensions: ecology, economy, sociocultural aspects, institutional factors, and technology.
Results:
The findings reveal varying levels of sustainability across the evaluated dimensions. The sustainability status of Arabica coffee farming in Sembalun is considered good, with an average score of 64.58, indicating that current farming practices meet sustainability standards. Sustainability solutions for Arabica coffee farming in Sembalun involve a holistic approach, including agroforestry, farmer empowerment through training and cooperatives, product diversification, and support from government and private sectors to balance economic and environmental goals.
Conclusion:
The study provides a comprehensive evaluation of the sustainability status of Arabica coffee farming in Sembalun, highlighting the role of eco-farming practices in improving ecological balance, economic viability, social welfare, institutional support, and technological advancement in farming. The findings suggest several actionable recommendations for policy enhancements to support long-term sustainability and improve farmer well-being in this region.

Keywords: Arabica Coffee, Dry Lands, Eco-farming, Sustainability

1. INTRODUCTION

The village of Sembalun is located in the Sembalun District, East Lombok Regency, West Nusa Tenggara. Known for its natural beauty, Sembalun is one of Lombok's premier tourist destinations. It sits on a high plateau surrounded by mountains, offering stunning landscapes and a cool climate that contrasts with the warmer regions of Lombok. The minimum temperature in Sembalun is 7ºC, while the maximum is 20ºC (Haryantini *et al*., 2023).

The climate conditions support Sembalun's fertile soil, making it suitable for various crops. This ideal climate makes Sembalun a strategic area for sustainable agricultural development, particularly on drylands. Approximately 74% of Sembalun's land consists of dryland, presenting opportunities for agricultural sector development (Riniwati *et al*., 2023; Primadana, 2023). According to data from the Department of Agriculture and Animal Husbandry, East Lombok Regency, in 2010, Sembalun District's dryland covered about 20,603 hectares, though only 17.91% was utilized (DPUPR NTB, 2017). Despite this significant potential, optimal use of the land remains constrained by various challenges (Karnilawati *et al*., 2022). Including limited human resources, as many locals lack the skills to maximize land productivity(Rika, 2023). Nonetheless, this land holds potential for agroecosystem development, supporting various types of agriculture, including food crops, horticulture, perennial crops, and livestock (Helviani *et al*., 2021). Growing demand for sustainable agricultural production in this region also necessitates good residue management to maximize the economic potential of drylands without harming the environment (Desta *et al.*, 2020). With the right approach, this land could be transformed into a productive area, particularly for cultivating Arabica coffee, a high-value crop.

Sembalun Arabica coffee is known for its quality. Based on physical and sensory tests by the Lombok Coffee Research Center Puslitloka (2023), Sembalun Arabica scored 82.25%, marking it as excellent quality (Chandra *et al*., 2023). This quality recognition has been reinforced by registering a geographical indication, enhancing its potential as a valuable commodity (Lomboktimurkab.go.id, 2022). This geographical indication protects Sembalun coffee's unique characteristics and quality from claims by similar products from other regions. This recognition positions Sembalun Arabica coffee for national and international markets. Arabica coffee has high economic potential, accounting for 57.5% of global coffee trade, compared to 42.5% for Robusta (Ramirez *et al*., 2024). This development benefits local farmers and supports the regional economy, necessitating the adoption of sustainable agricultural technology.

Incorporating several indicators on a suitable spatial scale is the primary obstacle to assessing environmental sustainability in agriculture and tracking advancements toward sustainable agricultural systems (Butikofer *et al*., 2024). Adopting ecological agricultural technology is an effective step to ensure food security and environmental protection (Desta *et al*., 2020). Sustainable agriculture technology includes innovations like efficient irrigation systems, organic fertilizers, and environmentally friendly cultivation techniques. Eco-friendly farming aims to improve product quality while preserving natural resources (Tono, 2022). In contrast, conventional farming often produces significant waste and environmental pollution, harming ecosystems (Zhao *et al*., 2024). Environmental degradation due to intensive farming threatens agricultural sustainability, product quality, and human health (Muhie, 2022; Phung & Dao, 2024). Thus, sustainable development is essential to ensure food security, advance eco-friendly practices, and improve farmers' welfare (Yin *et al*., 2024).

Sustainable agriculture practices are recommended as a strategy to address environmental degradation from intensive farming, including approaches that restore land to its natural state. This approach is crucial to preserve biodiversity and maintain ecosystem health (Monger *et al*., 2024). Combining sustainable agricultural technology with eco-farming allows farmers to manage land more effectively, reduce harmful chemical use, and improve soil fertility in the long term, enhancing productivity and sustainability on drylands.

Eco-farming combines resource efficiency with ecologically friendly farming methods. This system applies the concept of sustainable agriculture, known in Indonesia as Eco-friendly Agriculture (PRL) (Administrator, 2022a). Its goal is to maintain soil quality and the ecosystem as a whole while improving agricultural yields. This approach is particularly suitable for drylands like those in Sembalun, as it helps farmers minimize environmental impacts and increase land resilience to climate change. Eco-farming can also optimize dryland use and boost sustainable Arabica coffee production.

Given these issues, this research aims to investigate the "Evaluation of the Sustainability Status of Arabica Coffee-Based Eco-Farming on Sembalun's Drylands, East Lombok Regency." This research provides a new approach to understanding how eco-farming practices influence sustainability across multiple dimensions, including ecology, economy, socio-culture, institutions, and technology. This strategic approach promotes agricultural practices that not only boost production but also maintain environmental integrity. Moreover, this research is crucial as it identifies key factors affecting the sustainability of Arabica coffee farming, helping farmers optimize their yields without harming local ecosystems. The success of eco-farming on drylands like those in Sembalun could serve as a model for other regions facing similar environmental challenges.

This study is novel compared to previous research. For example, Agustin *et al.,* (2020) in "Sustainability Analysis of Smallholder Coffee Farming in Silo District, Jember Regency" focuses on sustainability analysis without emphasizing eco-farming technology or dryland adaptation. Similarly, Nurmansah *et al*., 2022 study, titled "Ecological Sustainability Analysis of Agroforestry in Kerinci Regency," analyzes farm income and sustainability using Multi-Dimensional Scaling (MDS) with the Rap-forest program. In contrast, the study "Evaluation of the Sustainability Status of Arabica Coffee-Based Eco-Farming on Sembalun's Drylands, East Lombok Regency" focuses on evaluating eco-farming on drylands using Multi-Aspect Sustainability Analysis (MSA). This approach differs from previous methods, which commonly use the Multi-Dimensional Scaling (MDS) RAPFISH method. Hence, this study provides a new perspective in agricultural land management that is both specific and contextual, making it an important area of research.

Based on the background issues outlined, the research questions are as follows:

1. How does eco-farming contribute to agricultural sustainability on Sembalun's drylands, especially in the context of Arabica coffee cultivation?
2. What is the sustainability status of Arabica coffee in Sembalun, East Lombok Regency?
3. What solutions can support the sustainability of Arabica coffee farming to ensure continuity and farmer welfare?

2. MATERIAL AND METHODS

This study employs a mixed-methods approach, combining qualitative and quantitative methodologies to provide a comprehensive understanding of eco-farming practices and the sustainability of Arabica coffee farming in Sembalun. The unit of analysis is Arabica coffee farmers in Sembalun, selected through purposive sampling, with data collection conducted over two months. The study involves 60 respondents chosen using purposive random sampling, ensuring a representative and unbiased sample. Primary data were gathered through interviews, observations, and surveys, while secondary data were obtained from literature reviews and official records. Sustainability analysis was conducted using Multi-aspect Sustainability Analysis (MSA) with Exsimpro software, assessing five dimensions: ecology, economy, socio-culture, institutional structure, and technology.

3. RESULTS AND DISCUSSION

3.1. Arabica Coffee Farming in Sembalun, East Lombok

Arabica coffee farming in Sembalun, East Lombok, has become a promising agricultural sector, with various initiatives aimed at boosting the local economy and improving coffee quality. Research was conducted in the villages of Sajang and Sembalun Lawang. In Sajang, there are three active farming groups: Gerok Sokong, Bumi Lestari, and Orong Pentereng. Meanwhile, in Sembalun Lawang, the Arabica coffee community oversees cultivation from planting to marketing. The organizational structure in both villages reflects strong collaboration in enhancing coffee productivity and quality. The farmer groups in Sajang work with Control Union USDA from the United States to monitor pesticide use and certify farmland. Violations of guidelines result in sanctions, ensuring coffee quality and attracting a wider market. Certification also supports sustainable farming practices, providing opportunities for farmers to achieve better prices as consumer awareness of sustainable products grows.

Although coffee cultivation initially did not attract much interest from farmers, the success of their peers has led to a shift, making Arabica coffee a flagship crop. Farmers typically plant the Cobra and Typica varieties with spacing of 1.5 to 2 meters. In 2024, the price of Arabica coffee reached IDR 150,000 to IDR 180,000 per kilogram. Demand from private sectors, both local and international, is high; however, production limitations make it difficult for farmers to meet the demand. Many farmers opt to sell coffee in powdered form for higher prices, with 100 grams of Arabica coffee powder sold at IDR 40,000. From one kilogram of dried green beans, approximately 5,600 coffee beans are ready for harvest after 1.5 to 2 years, yielding less than 1 kg per tree in the first harvest, increasing to 1-2 kg in subsequent harvests.

3.2. The Contribution of Eco-farming to the Sustainability of Arabica Coffee Farming in Sembalun, East Lombok

Eco-farming, or environmentally friendly farming, is a crucial strategy for achieving sustainability in Arabica coffee farming, especially in Sembalun, East Lombok. This approach emphasizes sustainable natural resource management and minimizes environmental impact. This study analyzes the application of sustainable farming practices in dryland areas, aiming to improve soil fertility and support local ecosystems. Through surveys and interviews with farmers, the study evaluates the contribution of eco-farming across five dimensions: ecology, economy, socio-culture, institutional support, and technology. Ecologically, eco-farming has shown a positive impact by maintaining soil health and reducing erosion. Practices like organic fertilization and cover cropping help enhance soil fertility and biodiversity. Economically, the quality of coffee produced has improved, yielding higher selling prices. Farmers also report reduced input costs due to the use of natural fertilizers and eco-friendly pest control methods. The socio-cultural aspect of eco-farming is evident in the enhanced well-being of farmers, supported by training and education that improve their skills and knowledge. This fosters strong bonds among farmers and builds solidarity within the community. Institutionally, support from government and non-governmental organizations has facilitated the adoption of eco-farming by providing training and access to essential resources. Finally, the technological dimension reveals that the use of high-quality seeds and efficient farming methods strengthens environmentally friendly practices and boosts productivity. Overall, eco-farming in Sembalun not only supports environmental sustainability but also offers significant economic and social benefits for Arabica coffee farmers.

3.3. Sustainability Status of Arabica Coffee in Sembalun, East Lombok Regency

The sustainability of Arabica coffee farming in Sembalun, East Lombok, is highly relevant in the context of modern agriculture, which faces environmental and social

challenges. As an Arabica coffee-producing region, Sembalun must balance efficient production with environmental preservation and community welfare. One method for assessing sustainability is the Multiaspect Sustainability Analysis (MSA), supported by Exsimpro software. MSA integrates various indicators across five dimensions ecology, economy, socio-culture, institutional support, and technology to provide a comprehensive view of the sustainability status of coffee farming. The MSA analysis results indicate an average sustainability score of 64.58, suggesting that Arabica coffee farming practices in Sembalun meet sustainability standards.

Table 1. Category of Sustainability Level of Arabica Coffee Development

Value	Sustainability Status
0 - 25	Unsustainable
> 25 - 50	Low Sustaianable
> 50 - 75	Sustainable
> 75 - 100	Very Sustainable

Source: MSA Analysis, Eximpro 2024

The ecological dimension scored 70, indicating that farming practices effectively maintain ecosystem balance through eco-farming methods and sustainable management. Conversely, the economic dimension received a lower score of 54.7, highlighting challenges such as price fluctuations and limited market access, suggesting a need for improved economic competitiveness and stronger policy support. The social and cultural dimension scored 64.1, reflecting positive efforts to preserve local values and enhance farmers' welfare; however, further improvements are needed to ensure equitable economic benefits. The institutional dimension scored 57.5, showing progress but highlighting the need to strengthen institutional structures and coordination among relevant stakeholders. Finally, the technology dimension received the highest score, 76.6, indicating that technology is effectively utilized in coffee production. It is essential to continually update technology and ensure all farmers have access to it to enhance production efficiency and quality.

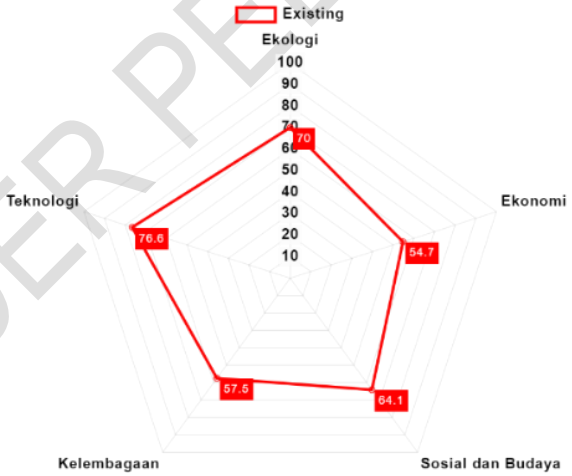

Figure 1. Kite diagram of the sustainability of Arabica coffee in Sembalun, East Lombok Regency

The results of the Multiaspect Sustainability Analysis (MSA), visualized through a Sustainability Radar Chart, indicate that the sustainability status of Arabica coffee farming in Sembalun, East Lombok, varies across different dimensions. The technology dimension scored the highest, at 76.6, suggesting that technology implementation in coffee farming practices in this region is well-advanced, supporting long-term sustainability. However, despite the positive outcome in the technology dimension, the analysis also reveals lower sustainability index scores in other dimensions. These areas require attention and targeted

interventions to enhance their sustainability status. Therefore, improvement efforts should focus on the weaker attributes within each dimension to ensure the sustainability of all aspects of Arabica coffee farming in the future.

3.4. Solutions for Arabica Coffee Farm Sustainability in Sembalun, East Lombok

Addressing sustainability challenges in Arabica coffee farming in Sembalun, East Lombok, requires a comprehensive strategic policy. An initial step is to strengthen market infrastructure and improve accessibility for farmers. By expanding both domestic and international market access, farmers can achieve more stable and fair prices, reducing dependence on intermediaries who often reduce farmer profits. Collaboration between the government, the private sector, and coffee exporters is essential to establish efficient distribution networks, allowing Sembalun Arabica coffee to compete in the global market. Additionally, subsidies or price intervention policies are crucial to protect farmers from price fluctuations. Strengthening local institutional capacity in Sembalun is also essential. Building local institutions through continuous training will equip farmers with knowledge on sustainable farming practices and more efficient farm management. This is expected to enhance the institutional framework that supports sustainability, improving production efficiency and strengthening farmers' bargaining power in the market.

Utilizing current technology is very important for the sustainability of Arabica coffee cultivation. Optimized agricultural technology will enhance coffee productivity and quality. Government support for research and technology development is crucial, especially to address climate change challenges and environmental issues. Ecological conservation and waste management practices are also necessary. Eco-friendly practices, such as using coffee waste for compost, can improve soil fertility and reduce pollution. Policies encouraging these practices will support the sustainability of Sembalun's coffee ecosystem. Community involvement is key to maintaining social and cultural sustainability. Supporting farmers' participation in decision-making and preserving local traditions is essential. Improving social welfare is also important, including empowering women's farming groups to strengthen their roles in agriculture. The implementation of these policies is expected to bring sustainable economic, social, and ecological benefits to the Sembalun community.

4. CONCLUSION

Based on the results of this research, the following conclusions can be drawn:

1. Eco-farming makes a significant contribution to the sustainability of Arabica coffee farming in Sembalun, East Lombok, through an environmentally friendly approach encompassing five dimensions: ecology, economy, socio-culture, institutional, and technology. This approach not only improves product quality and production efficiency but also preserves soil health, empowers the local community, and protects cultural values. Institutional support and innovative technology enhance this success, ensuring sustainable growth for coffee farming.
2. Arabica coffee farming in Sembalun demonstrates a good level of sustainability with an average score of 64.58, indicating that the practices applied are generally sustainable. However, improvements are still needed in economic, institutional, and social participation aspects to ensure long-term sustainability.
3. Solutions for the sustainability challenges of Arabica coffee farming in Sembalun requires strategic policies that include increasing market access, strengthening local institutions through continuous training, adopting modern technology, and environmental conservation efforts. These measures will improve production efficiency, enhance farmers' bargaining power, and support social and ecological well-being in the region.

5. DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author hereby declares that generative AI technologies such as Large Language Model, etc. has been used during the writing or editing of the manuscript, used to help convert the manuscript into English. This description will include the name, version, model, and source of the generative AI technology as well as all input provided to the generative AI technology.

Details of the AI usage are given below:

1. ChatGPT-4
2. OpenAI for ChatGPT
3. Generative AI technology ChatGPT-4 by OpenAI was used in this manuscript to assist with grammar editing, provide an example of the instruction given, such as 'Check for grammatical errors in the following paragraph'

REFERENCES

Agustin, A., Yunitasari, D., Adenan, M., Ekonomi, J. I., Ekonomi, F., Bisnis, D., & Jember, U. (2020). Sustainability Analysis of Smallholder Coffee Farm Management in Silo District, Jember Regency. Number, 4, 701–714. https://doi.org/10.21776/ub.jepa.2020.004.04.01

Administrator. (2022). Benefits of Eco Farming for Indonesian Agriculture. Upland. https://upland.psp.pertanian.go.id/artikel/1672371011/manfaat-Eco-farming-bagi-pertanian-indonesia#:~:text=UPLAND Project - Eco-farming is, Environmentally Friendly Agriculture (PRL)

Assidiki, H., Rochdiani, D. R., & Yusuf, M. N. Y. N. (2021). Analysis of Starfruit Farming Sustainability in Waringinsari Village, Langensari District, Banjar City. Agroinfo Galuh Student Scientific Journal, 8(1), 59. https://doi.org/10.25157/jimag.v8i1.4608

Awaluddin, Nuraeni, M. (2018). Awaluddin: Analysis of Bawakaraeng Arabica Coffee Farming Sustainability, West Sinjai District, Sinjai Regency. 2(2), 73–84. Butikofer, L., Goodwin, C. E., Evans, P. M., Redhead, J. W., Bullock, J. M., Pywell, R., Mead, A., Richter, G. M., & Storkey, J. (2024). Pathways to sustainable farming using archetypes and multi-objective optimisation. Environmental Research Letters, 166(In review), 112433. https://doi.org/10.1016/j.ecolind.2024.112433

Chandra, L. Y. K., Linggarweni, B. I., & Novida, S. (2023). Analysis of Arabica Coffee Powder Business Income in Sajang Village, Sembalun District, East Lombok Regency. Journal of Economics and Business, 3(2), 148–155. https://doi.org/10.56145/jurnalekonomidanbisnis.v3i2.71

Desta, Y., Haile, M., Gebresamuel, G., & Sibhatleab, M. (2020). Potential, quality and quantity assessment of sesame plant residue in dry land vertisols of Tigrai, Ethiopia; Approach for sustainability of dry-land farming. Heliyon, 6(10), e05234. https://doi.org/10.1016/j.heliyon.2020.e05234

Helviani, H., Juliatmaja, A. W., Bahari, D. I., Masitah, M., & Husnaeni, H. (2021). Utilization and Optimization of Dry Land for the Development of Secondary Crop Cultivation in Puday Village, Wongeduku District, Konawe Regency, Southeast Sulawesi Province. Mitra Mahajana: Journal of Community Service, 2(1), 49–55. https://doi.org/10.37478/mahajana.v2i1.806

Karnilawati, Sari, C. M., & Musfirah. (2022). Changes in Soil Chemical Characteristics in the Gle Gapui Dryland Research Development Area. Journal of Research Science, 12(1), 96–101. https://www.neliti.com/id/publications/485561/

Lomboktimurkab.go.id. (2022). Indonesian coffee and cocoa research testing laboratory, Results of 2023 Sembalun coffee quality test. Lomboktimurkab.Go.Id. https://portal.lomboktimurkab.go.id/baca-berita-1259-penbesaran-indication-geografis-arabika-sembalun.html Monger, C., Michéli, E., Aburto, F., & Itkin, D. (2024). Soil classification as a tool for contributing to sustainability at the landscape scale and forecasting impacts of management practices in agriculture and forestry. Soil and Tillage Research, 244, 106216. https://doi.org/10.1016/J.STILL.2024.106216 Muhie, S. H. (2022). Novel approaches and practices to sustainable agriculture. Journal of Agriculture and Food Research, 10(August), 100446. https://doi.org/10.1016/j.jafr.2022.100446

Nurmansah, R., Hamzah, H., & Edison, E. (2022). Sustainability Analysis of Ecological Aspects of Community Forest Activities in Agroforestry Patterns in Kerinci Regency. Journal of Silva Tropika, 5(2), 446–452. https://doi.org/10.22437/jsilvtrop.v5i2.15454

Paulus C A, Damianus Adar, Yahyah, Rayzcha M I Hotty, Eddy Rusdiyanto, F. (2023). MULTI-ASPECT SUSTAINABILITY ANALYSIS OF FRESHWATER FISH AQUACULTURE IN KUPANG CITY OF EAST NUSA TENGGARA PROVINCE, INDONESIA. 1184(8), 53–54.

Phung, Q. A., & Dao, N. (2024). Farmers' perceptions of sustainable agriculture in the Red River Delta, Vietnam. Heliyon, 10(7), e28576. https://doi.org/10.1016/j.heliyon.2024.e28576

Primadana, Zeila, O. (2023). Chapter IV Overview. University of Muhammadiyah Malang, 3(1), 10–27.

Puslitloka, L. (2023). Sembalun coffee quality test results in 2023. https://iccri.net/service/analysis-lab/ Ramirez-Builes, V. H., Küsters, J., Thiele, E., & Lopez-Ruiz, J. C. (2024). Physiological and Agronomical Response of Coffee to Different Nitrogen Forms with and without Water Stress. Plants, 13(10), 1387. https://doi.org/10.3390/plants13101387 Riniwati, H., Inaba, I., Viantika, R., & Galisong, R. D. (2023). Micmac Analysis of Improving Social Variables of Expected Years of Schooling (EYS) in Coastal and Non Coastal Areas in Pasangkayu Regency, West Sulawesi. Economic and Social of Fisheries and Marine Journal, 010(02), 262–276. https://doi.org/10.21776/ub.ecsofim.2023.010.02.11

TONO, T. (2022). Environmentally Friendly Agriculture: Increasing Productivity and Reducing Costs. Al-Iqtishad, 14(1), 51–65. https://doi.org/10.30863/aliqtishad.v14i1.2983

Yin, Y., Zhang, Y., Wang, S., Xu, K., Zhang, Y., Dogot, T., & Yin, C. (2024). Integrating production, ecology and livelihood confers an efficien cy-driven farming system based on the sustainable farmland framework. Agricultural Systems, 220, 104049. https://doi.org/10.1016/J.AGSY.2024.104049

Yusuf, R., Pato, U., Tang, U. M., & Karnila, R. (2019). 7458-16253-1-Sm. 2009, 85–94.

Zhao, G., Jiang, W., Ren, C., & Zhen, L. (2024). Environmentally friendly agricultural technology based on discrete selection experiment. Journal of Biotech Research, 17, 11–22.