How to Cite:
Andhayani, K. E. D. S., Sudarma, I. M., & Widhianthini, W. (2026). Assessing the sustainability of arabica coffee farming: Evidence from Subak Abian Suka Maju in Bali, Indonesia. *Tennessee Research International of Social Sciences*, *8*(1), 176–184. Retrieved from https://triss.org/index.php/journal/article/view/145

Assessing the sustainability of arabica coffee farming: Evidence from Subak Abian Suka Maju in Bali, Indonesia

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***Abstract*---**This study aimed to analyze the sustainability status of Arabica coffee farming in Subak Abian Suka Maju, Landih Village, Bangli Regency, Bali Province, identify sensitive sustainability attributes, and formulate sustainability improvement strategies using Multiaspect Sustainability Analysis (MSA) and Interpretative Structural Modeling (ISM). A mixed qualitative–quantitative approach was employed using purposive sampling involving 11 key informants, including farmer group leaders, village officials, agricultural extension officers, and farmers. Data were collected through observations, interviews, focus group discussions, questionnaires, and documentation. The sustainability assessment covered ecological, economic, socio-cultural, institutional, and technological dimensions using the MSA approach with the Exsimpro application. The results showed that the overall sustainability index reached 62.53, categorized as sustainable. The sustainability values for ecology, economy, socio-cultural, institutional, and technology dimensions were 66.89, 62.14, 60.20, 60.20, and 63.22, respectively. Sensitive attributes influencing sustainability included coffee plant maintenance systems, soil organic matter, financial institutions, product value addition, market access, agricultural extension services, institutional legality, pest and disease management, certified

ISSN 2766-7464 (Online)
Publisher: Smoky Mountain Publishing
Manuscript submitted: 09 Feb 2026, Manuscript revised: 18 March 2026, Accepted for publication: 27 April 2026

seedlings, and harvesting methods. Furthermore, the ISM analysis identified coffee plant maintenance systems, access to extension and training, and financial institutions as the main driving variables with high driver power and low dependence. The integration of MSA and ISM demonstrated that sustainability constraints were structurally interconnected and influenced by weak supporting systems. Sustainability improvement can be achieved through integrated interventions focusing on cultivation management, farmer training, financial access, and coffee product value addition.

***Keywords*---**Arabica coffee, sustainability, MSA, ISM, Bali**.**

Introduction

The agricultural sector plays a strategic role in supporting rural economic development in Indonesia, particularly through plantation-based farming systems. One of the most important plantation commodities is coffee, which contributes significantly to national income, export earnings, and rural livelihoods (Badan Pusat Statistik, 2016). Among various coffee species cultivated in Indonesia, Arabica coffee is recognized for its superior quality, distinctive aroma, and high market demand (Martini & Retno, 2013; Muzaifa & Setiawan, 2016). Bali Province, especially Bangli Regency, has become one of the major production centers of Arabica coffee due to its favorable agroclimatic conditions, including highland areas with suitable temperatures and rainfall patterns for coffee cultivation.

Data from the Central Bureau of Statistics indicate that Arabica coffee production in Bali experienced fluctuations during the 2018–2024 period, with Bangli Regency consistently recording the highest production compared to other regions in Bali. However, the overall production trend in Bali tended to decline, suggesting the existence of challenges affecting the sustainability of Arabica coffee farming systems, such as climate change, land availability, pest attacks, market instability, and limited technological adaptation. In this context, Subak Abian Suka Maju in Landih Village, Bangli Regency, represents an important traditional farming institution that has implemented environmentally friendly coffee cultivation practices. The group previously obtained organic certification and applies production standards consistent with the Geographical Indication (GI) certification of Kintamani Arabica Coffee, including red cherry picking, fermentation, drying, roasting, and packaging processes.

The sustainability of Arabica coffee farming in Subak Abian Suka Maju can be assessed through multidimensional perspectives, including ecological, economic, socio-cultural, technological, and institutional aspects. Ecologically, the farming system emphasizes environmentally sustainable practices through organic cultivation and land conservation. Economically, Arabica coffee farming contributes to farmers' income and benefits from the added value of GI certification. Socio-culturally, the Subak Abian system reflects local wisdom, collective participation, and traditional values in agricultural management. Institutionally, the farmer group plays an important role in coordinating

production and maintaining product quality standards, while technologically, the group applies post-harvest processing techniques that support coffee quality improvement.

Despite these potentials, several constraints continue to threaten the sustainability of Arabica coffee farming in the study area. Environmental challenges include climate change and pest infestations, while economic problems relate to fluctuating coffee prices and limited capital access. In addition, the declining interest of younger generations in coffee farming, limited post-harvest facilities, and inconsistent implementation of production standards remain significant issues. Therefore, it is important to analyze the sustainability status of Arabica coffee farming in Subak Abian Suka Maju comprehensively through ecological, economic, socio-cultural, technological, and institutional dimensions in order to identify sensitive factors affecting the continuity of the farming system and formulate appropriate sustainability strategies.

Methods

This study employed a mixed qualitative–quantitative approach to evaluate the sustainability status of Arabica coffee farming in Subak Abian Suka Maju, Landih Village, Bangli Regency, Bali Province. The research was conducted from March to May 2025 using a purposive sampling technique. Data were collected through field observations, questionnaires, in-depth interviews, focus group discussions (FGD), and documentation involving 11 key informants consisting of the head of Subak Abian Suka Maju, the village head, agricultural extension officers, and farmer members. The sustainability assessment focused on five dimensions, namely ecological, economic, socio-cultural, institutional, and technological aspects. Each dimension was evaluated using ordinal-scale indicators adapted from previous studies and relevant agricultural sustainability standards.

The study applied the Multiaspect Sustainability Analysis (MSA) method using the Exsimpro application, an analytical development of RAPFISH, to determine sustainability status and identify sensitive factors influencing the sustainability of Arabica coffee farming. Sustainability scores were classified into four categories: unsustainable, low sustainable, sustainable, and very sustainable. Furthermore, sensitivity analysis was conducted to identify the most influential attributes affecting sustainability performance, while Interpretive Structural Modeling (ISM) was employed to formulate strategic priorities and policy recommendations for improving the long-term sustainability of Arabica coffee farming in Subak Abian Suka Maju.

Result and Discussion

This study aimed to analyze the sustainability status of Arabica coffee farming in Subak Abian Suka Maju, Landih Village, Bangli Regency, Bali Province, identify sensitive sustainability attributes, and formulate strategic recommendations through the integration of Multiaspect Sustainability Analysis (MSA) and Interpretative Structural Modeling (ISM). The results indicate that the overall sustainability status of Arabica coffee farming was categorized as sustainable, with an average sustainability index of 62.53. However, several sensitive variables

still require improvement, particularly in the ecological, economic, socio-cultural, institutional, and technological dimensions.

Sustainability Scenario Analysis

The scenario analysis demonstrated that sustainability performance could be improved through gradual and optimal intervention strategies. Scenario 1 represented a moderate improvement approach, while Scenario 2 reflected a more comprehensive and integrated sustainability strategy.

Table 1. Sustainability Values Based on Scenarios

Aspect	**Existing**	**Scenario 1**	**Scenario 2**
Economy	66.86	70.67	78.00
Ecology	62.14	67.00	76.43
Socio-cultural	60.20	67.00	80.20
Institutional	60.20	67.00	73.60
Technology	63.22	67.00	70.67
Average	**62.53**	**67.73**	**75.78**
Status	Sustainable	Sustainable	Very Sustainable

Primary Data, 2026

The results show that Scenario 2 generated the highest sustainability improvement, increasing the sustainability status from *sustainable* to *very sustainable*. The socio-cultural and economic dimensions experienced the most significant improvements, indicating that institutional strengthening, farmer participation, training access, market access, and financial support are essential for long-term sustainability.

Priority Sustainability Scenarios

Table 2. Sustainability Scenario Priorities

Aspect	**ΔS1S**	**ΔS2S**	**ΔS2S/ΔS1S**
Ecology	3.78	11.11	2.94
Economy	4.86	14.29	2.94
Socio-cultural	6.80	20.00	2.94
Institutional	6.80	13.40	1.97
Technology	3.78	7.45	1.97

Primary Data, 2026

The ratio values indicate that Scenario 2 was substantially more effective than Scenario 1, particularly in ecological, economic, and socio-cultural aspects. This finding confirms that sustainability improvement requires integrated interventions rather than partial improvements.

Sensitive Sustainability Attributes

The MSA analysis identified several sensitive attributes influencing sustainability performance. Ecological sustainability was highly affected by coffee plant maintenance systems and soil organic matter content. Economic sustainability depended on access to financial institutions, product value addition, and market access. Socio-cultural sustainability was influenced by agricultural extension services, farmer participation, education level, and farmer regeneration. Institutional sustainability depended on farmer group legal status and institutional effectiveness, while technological sustainability was strongly influenced by pest management, pruning practices, certified seedlings, and harvesting methods.

These findings indicate that Arabica coffee sustainability in Subak Abian Suka Maju is not only determined by environmental conditions but also by institutional capacity, farmer knowledge, technology adoption, and economic accessibility. The results are consistent with sustainability theory, which emphasizes the interdependence between ecological, social, economic, institutional, and technological systems in agricultural sustainability.

Interpretative Structural Modeling (ISM) Analysis

The ISM analysis was conducted to identify the structural relationships among key sustainability variables. Six major variables were analyzed, namely coffee plant maintenance systems, soil organic matter content, access to extension and training, financial institutions, pest and disease management, and coffee product value addition.

The MICMAC analysis classified the variables into two major groups: independent variables and dependent variables. Coffee plant maintenance systems (E1), access to extension and training (E3), and financial institutions (E4) were identified as the main driving variables with high driver power and low dependence. Meanwhile, soil organic matter (E2), pest and disease management (E5), and product value addition (E6) were categorized as dependent variables.

Table 3. Key Variables in ISM Analysis

Code	Variable
E1	Coffee plant maintenance system
E2	Soil organic matter
E3	Access to extension and training
E4	Financial institutions
E5	Pest and disease management
E6	Coffee product value addition

Primary Data, 2026

The hierarchical ISM structure demonstrated that sustainability improvement should begin with strengthening the primary driving variables. Improvements in financial access, farmer training, and plant maintenance systems would

subsequently improve soil quality, pest management effectiveness, and product value addition.

Integration of MSA and ISM Results

The integration of MSA and ISM analyses revealed that sustainability constraints in Arabica coffee farming are rooted in weak supporting systems rather than solely production outcomes. Limited financial access, irregular extension services, and suboptimal cultivation practices were identified as the main structural problems affecting sustainability.

Although Arabica coffee from Subak Abian Suka Maju has strong market potential and geographical indication certification, most farmers still sell coffee in cherry form with relatively low economic value. This condition is associated with limited capital, inadequate post-harvest technology, and insufficient technical knowledge. Therefore, sustainability improvement strategies should prioritize strengthening financial institutions, improving extension services, enhancing cultivation management, implementing integrated pest management, and increasing product value addition through post-harvest processing and market expansion.

Conclusion

The results revealed that the overall sustainability index of Arabica coffee farming reached 62.53, which falls into the sustainable category. The sustainability performance across ecological, economic, socio-cultural, institutional, and technological dimensions also indicated sustainable conditions, although several aspects still require improvement to achieve a more optimal and resilient farming system.

The study identified several sensitive attributes influencing sustainability in each dimension. Ecological sustainability was strongly affected by coffee plant maintenance systems and soil organic matter content. Economic sustainability was influenced by financial institutions, product value addition, and market access. Socio-cultural sustainability depended on access to agricultural extension services, farmer participation, education level, and farmer regeneration. Institutional sustainability was associated with business institutions and farmer group legality, while technological sustainability was influenced by pest and disease management, pruning practices, certified seedlings, and harvesting methods. These attributes represent key factors that determine changes in sustainability performance.

Furthermore, the ISM analysis demonstrated that coffee plant maintenance systems, access to extension and training, and financial institutions were the main driving variables within the sustainability system. These variables possessed high driver power and low dependence, indicating that they serve as the root factors influencing other variables, including soil organic matter, pest and disease management, and coffee product value addition, which were categorized as dependent variables.

The integration of MSA and ISM analyses confirmed that the sustainability challenges faced by Arabica coffee farmers are not isolated problems but are structurally interconnected. Limited product value addition and weak economic conditions are closely related to inadequate supporting systems, particularly limited financial access, insufficient extension services, and suboptimal cultivation management. Therefore, sustainability improvement strategies should prioritize strengthening these key driver variables to generate broader positive impacts on the overall farming system.

Managerial Implications

The findings of this study provide several managerial implications for stakeholders involved in the sustainability development of Arabica coffee farming in Subak Abian Suka Maju, Landih Village, Bangli Regency, Bali Province. Since the sustainability status was categorized as sustainable but not yet optimal, improvement efforts should focus on strengthening the key driving variables identified through the integration of Multiaspect Sustainability Analysis (MSA) and Interpretative Structural Modeling (ISM). The study confirms that sustainability enhancement cannot rely solely on production improvement, but requires integrated managerial interventions involving ecological, economic, socio-cultural, institutional, and technological dimensions.

Strengthening sustainable coffee farm management should become a primary priority through balanced fertilization, organic fertilizer use, pruning, soil conservation, and environmentally friendly cultivation practices to improve soil quality, ecosystem stability, and coffee productivity. Continuous technical assistance and monitoring are needed to ensure consistent implementation of sustainable farming standards. In addition, improving access to agricultural extension services and farmer training is essential to enhance farmers' knowledge and adaptive capacity in sustainable cultivation, pest management, post-harvest processing, and business management. The involvement of younger generations is also important to support farmer regeneration and ensure the long-term sustainability of Arabica coffee farming.

Furthermore, strengthening financial institutions and improving farmers' access to capital are necessary to support cultivation improvement and value-added coffee production. Collaboration among farmer groups, cooperatives, financial institutions, and government credit programs should be enhanced through simplified financing schemes and financial literacy support. Efforts should also focus on increasing coffee product value addition and market expansion through post-harvest processing, roasting, packaging, and specialty coffee development. Strengthening the branding of Kintamani Arabica Coffee through Geographical Indication (GI) certification and digital marketing can improve competitiveness in national and international markets while expanding economic opportunities for local farmers.

Finally, the integration of MSA and ISM demonstrates that sustainability management should adopt a systemic and integrated approach. Policymakers and farmer institutions should prioritize interventions on key driver variables, namely coffee plant maintenance systems, access to extension and training, and financial

institutions, because improvements in these variables will generate multiplier effects on other sustainability dimensions. Consequently, sustainability programs should be designed collaboratively among government agencies, farmer organizations, financial institutions, researchers, and private sector actors to ensure long-term sustainability and resilience of Arabica coffee farming systems in Bali.

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