

Sustainability Analysis of Dairy-Horticulture Integrated Farming System

M. Rosmiati¹, R. E. Putra¹, T. Lastini¹, E. Hernawan¹, Pujo¹, I. Rahmayunita¹, F. R. Maulana^{1*}, F. Liesdiana¹, M. A. Nurdiansyah¹ and A. Azis¹

Date Received: 15th December 2019 / Date Accepted: 25th January 2020

ABSTRACT

Purpose : The Integrated farming system offers better opportunities to be implemented in smallholder agriculture because it ensures productivity and profitability for sustainable livelihoods. However, the evaluation of this practice has not been clearly identified. This study is aimed at evaluating the ecological, economic, social, institutional, and technological aspects of sustainability of existing dairy-horticulture farming systems at farm level.

Research Method : Data were collected through survey design using questionnaire, observation, and literature review. This research used Multidimensional Scaling, leverage analysis and Monte Carlo called RAP-DHFS (Rapid Appraisal for Dairy-Horticulture Farming System) to analyze the data.

Findings : The results showed that the sustainability status of ecological dimension, economic dimension, social dimension, and technological dimension were classified as less sustainable which were 28.07%, 29.52%, 27.37%, and 29.15, respectively while the institutional dimension was considered as unsustainable (21.77%). There were also 10 attributes identified as the most influential attributes on the sustainability status.

Limitations : The study was conducted at one village, which is a small scope of area.

Value : This study provides a holistic assessment of the integrated farming system and shows the concern and risk for further development in rural areas.

Keywords: Integrated farming, Multidimensional scaling, RAP-DHFS, Sustainability status

INTRODUCTION

Integrated Farming System (IFS) is one of the agricultural systems that promotes sustainable agriculture through the maximization of local resources based on the concept of ecological soundness. This approach has brought several benefits particularly to small-scale farmers including enhanced farm productivity, increased farm incomes, reduced production cost and risk, and improved environmental health (Al Mamun *et al.*, 2011; Ansar and Fathurrahman, 2018; Netam *et al.*, 2019). The common type of combination in IFS that has been adopted by farmers is the integration of crop and trees, crop and aquaculture, poultry and fish farming, and crop and livestock (Al Mamun *et al.*, 2011; Gangwar *et al.*, 2013; Moraine *et al.*, 2017).

To attain the goal of sustainable agriculture, a

farming system must be understood holistically (Hayati, 2017) which is environmentally non-degrading, economically viable, and socially acceptable (FAO, 2014). It is also required to consider the technological process of the practice and institutional condition (Pretty, 2007). This interdisciplinary framework has to be linked with the management practice adopted by farmers and the identification of its sustainability level is necessary (Hayati, 2017; Hasanshahi, 2015). However, the sustainability assessment of integrated farming system at the farm level has gone through a lack of

^{1*} School of Life Sciences and Technology, Bandung Institute of Technology, Indonesia.

maulana.fakhira@gmail.com

 ORCID <http://orcid.org/0000-0002-7845-0015>

attention. Therefore, it is crucial to evaluate this practice by integrating the five dimensions of sustainability so that farmers can measure how the farming practice has satisfied their livelihood and impacted the environment on a long-term basis.

This study was aimed to determine the sustainability status of the horticultural farming systems integrated with a dairy farm based on ecological, economic, social, institutional and technological dimension. Information on sensitive attributes can be identified in this study and can be used as a consideration for stakeholders in developing a strategy to maximize the potential of its area.

MATERIALS AND METHODS

Study Site

The study was conducted in Suntenjaya village, Lembang subdistrict, West Bandung district, West Java Province, Indonesia in May - August 2019. This area is situated at 1,290 m above sea level and heavily dominated by horticultural production and dairy farming which has become the major source of income for local farmers. The average rainfall in this village is 2,027 mm with an average temperature of 17- 25 °C.

Data Collection

Primary data were collected from a survey design using questionnaire as a tool. The survey was conducted with 25 farmers engaged in

the integration of horticultural crops and dairy farming which were taken from simple random sampling. The data were also gathered through field observation. The secondary data were obtained from literature.

Data Analysis

To identify the sustainability status of dairy-horticulture integrated farming system, the data were analyzed using Multidimensional Scaling (MDS) with RAP-DHFS (Rapid Appraisal Horticulture For Dairy-Farming System) method which is a modification from RAPFISH (Rapid Appraisal for Fisheries) program developed by The Fisheries Center, University of British Columbia since 1998 to assess the status of fisheries sustainability (Kavanagh, 2001; Pitcher *et al.*, 2013). The ordination technique was performed based on the five dimensions of sustainability including ecological, economic, social, institutional and technological dimensions with a set of 8-10 attributes from each dimension (Pitcher *et al.*, 2013). The position of sustainability status will be based on the category in the range of 0-100% (Table 01).

In the RAP-DHFS approach, the leverage and Monte Carlo analysis were also examined. Leverage Analysis (sensitivity) was performed to determine the most influential attributes to the ordination process while Monte Carlo analysis is used to predict errors in the process of analysis (Pitcher *et al.*, 2013).

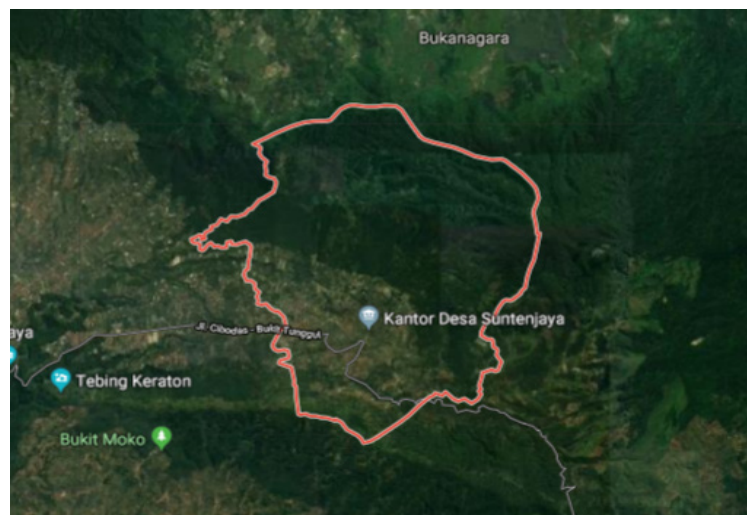


Figure 01: Study area at Suntenjaya Village, West Bandung District, West Java, Indonesia.

Table 01: The Category of The Sustainability Index Scales (Arofi *et al.*, 2015)

No	Index Scale (%)	Category
1	0.00 – 25.00	Poor (unsustainable)
2	25.01 – 50.00	Less (less sustainable)
3	50.01 – 75.00	Quite (fairly sustainable)
4	75.01 – 100.00	Good (very sustainable)

RESULT AND DISCUSSION

Ecological Sustainability

RAP-DHFS analysis shows that the sustainability index of ecological dimension is 28.07% which falls into the less sustainable category (Figure 02a). Based on leverage analysis, there are two dominant attributes affecting the index which are the separation distance between cowshed and farmer’s house and dairy cattle production systems (Figure 02b).

Based on the survey, 56% of cowshed is situated adjacent to the farmer’s house in just 0-50 meters due to the limited space, livestock safety, and ease of access to manage their cattle. However, this situation did not follow the standard of separation distance with a minimum of 250 meters (Directorate General for Livestock Services Decree No. 776/1982). Several problems can arise by manure production generating odour and emission and containing *E. coli* and *Salmonella sp.* that lead to major health problems (Agus *et al.*, 2014; Haryanto and Thalib, 2009). Therefore, farmers

should implement a proper cowshed hygiene and appropriate farm waste disposal to reduce health and environmental impacts (FAO, 2011).

All of the respondents rear their cattle in cowsheds. In this intensive dairy production system, cattle can get better routine treatment such as feeding, sanitation, and disease controlling. Farmers still need to ensure cattle welfare in confined spaces based on freedom principles and physiological needs. The measurement that can take into account is providing with adequate space to feed and drink, safe place (steep and slippery pathway), clean and comfortable bedding, and ventilation (FAO, 2011). The local government can also ensure the availability of dairy farming land issues.

Economic Sustainability

sustainability status of economic dimension is considered to be less sustainable (29.52%) (Figure 03a). The most sensitive attributes identified are market availability and farm income allocation (Figure 03b).

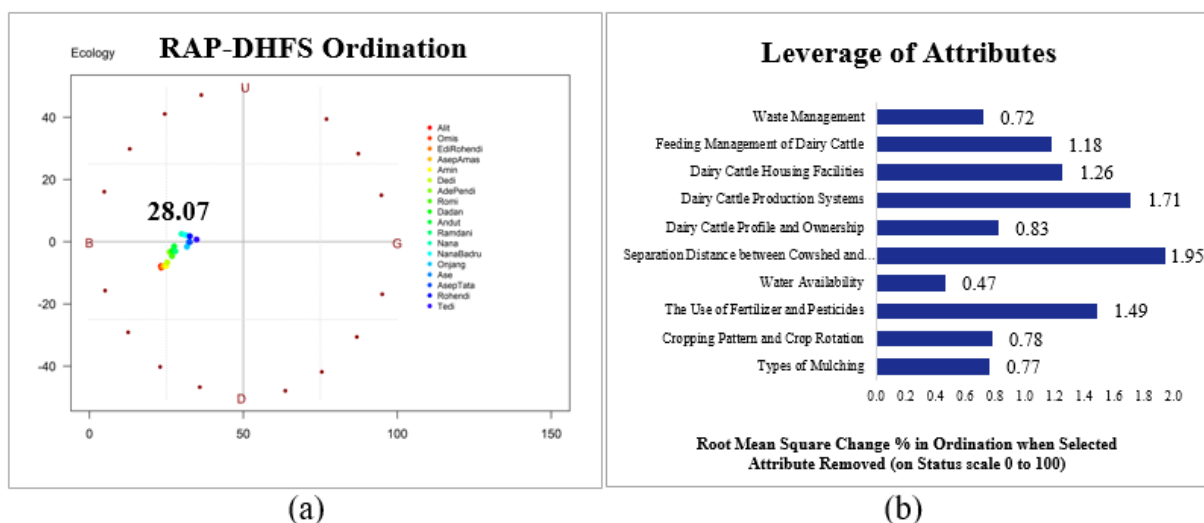


Figure 02: Sustainability index (a) and leverage analysis results (b) of the ecological dimension.

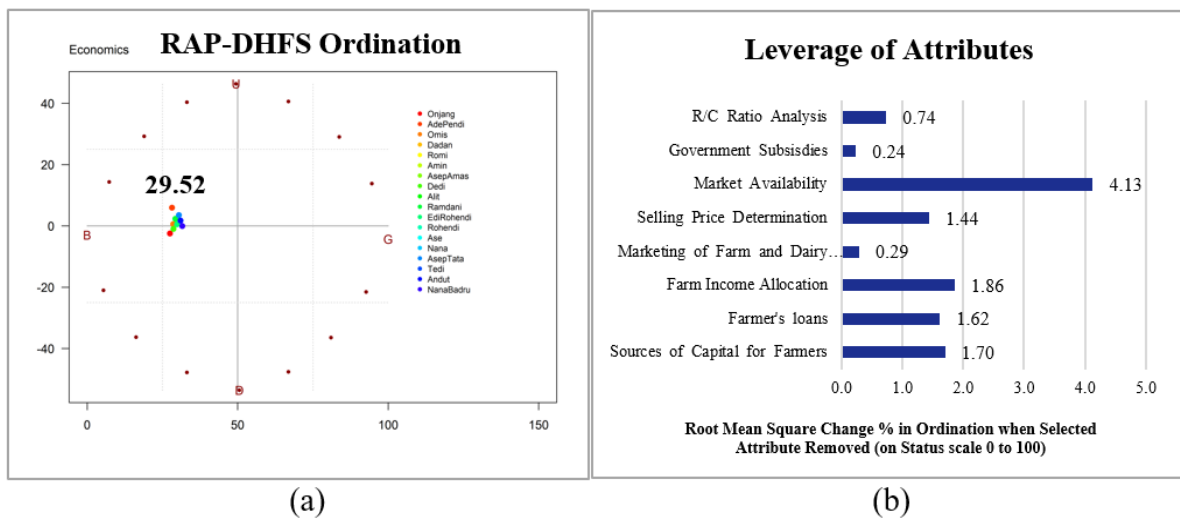


Figure 03: Sustainability index (a) and leverage analysis results (b) of the economic dimension.

A food market near the village in which farmers can sell their farm products immediately after harvest (100% of respondents) is absence. Therefore, more than half of farmers (61%) sell the products directly to middlemen and 39% of farmers, in some locations, joined in a farmer's group have performed contract farming with several firms. In agricultural marketing, the intervention of intermediaries can cause farmers to have the low bargaining power and share. The formation of farming group can help them to negotiate better to increase the bargaining power, reduce the risk of middlemen, and achieve desirable prices for farmers (Ranjan, 2017). To avoid the market failure in contract farming, parties should commit to identify a profitable market and find the potential returns. The government also needs to support the activity (FAO, 2001).

All of the respondents stated that the income earned from horticulture and livestock production can cover their daily needs such as food (largely), clothing, water, electricity, and education without receiving any subsidies. However, they face considerable financial risk and the uncertainty in the food and dairy production. To achieve economic well-being, farmers require to make the best decision on their expenditure by prioritizing the resource allocation (Achmad and Diniyati, 2018).

Social Sustainability

The sustainability index of the social dimension is 27.37%, which means the integrated farming system is less sustainable (Figure 04a). Alternative livelihood and the types of farming management (individual or group) are two attributes analyzed that have the greatest influence on the index (Figure 04b).

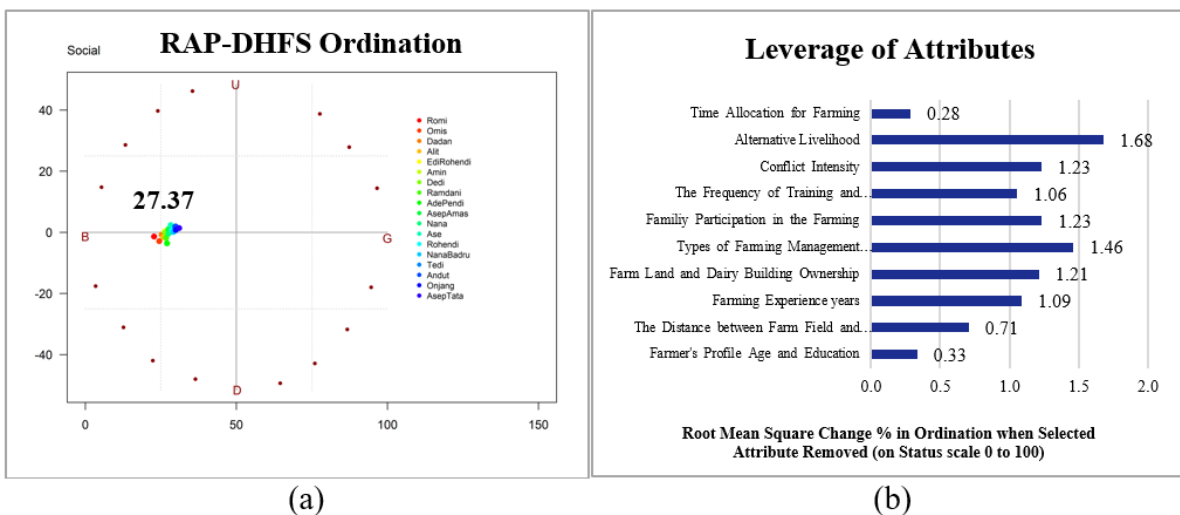


Figure 04: Sustainability index (a) and leverage analysis results (b) of the social dimension.

As many as 94% farmers only rely on their on-farm activities as their main jobs and have no other alternative livelihood in off-farm activities. However, the alternative livelihood can be an important option for farmers as it generates income diversification which can compensate a cash constraint faced by farmers. It can also contribute to the total income of family and maintain their livelihood under negative shock (FAO, 2015).

The typical integrated farming system in this area is predominantly organized by a family (100% of respondents), mostly assisted by the farmer's wife (78%). The family farming provides a model of adaptability and resilience promoting sustainable development. It has an important role in socio-economic, environment, and culture including reducing investment in labour, creating more jobs, boosting local economies, preserving traditional knowledge and agro-biodiversity (Chauhan *et al.*, 2017)

Institutional Sustainability

The result of RAP-DHFS shows that the value of the sustainability index is 21.77% (unsustainable) (Figure 05a). Based on Figure 05b, the most sensitive attributes identified are the dairy cooperatives membership and the length of membership (year).

The half of respondents stated that they had joined as a member of dairy cooperation (KPSBU) for more than 15 years, continuing the membership of their parents. They are relatively new members even though the cooperative has been established for 42 years. Also, more than half of them (89%) participate actively in the internal or external cooperation activities mostly in attending the annual meeting. This membership participation is due to the farmer's dependency on dairy cooperation which has facilitated milk marketing, providing concentrate feeds, Artificial Insemination (AI), farm credit, and counselling services that have been benefited farmers. The cooperative membership can be a suitable business institution to enhance livelihood, rural economic development and food security (Chagwiza *et al.*, 2016). It is also important for the local government to promote the membership. However, there are challenges

in this type of participation which are the high cost of concentrate feeds, the lack of counselling frequency and irregular schedule (Septianto, 2013).

Technological Sustainability

Dimensions of technology is categorized as less sustainable, with the index value of 29.15% (Figure 06a). The dominant attributes that affected the index are dairy cattle building and equipment and reproductive technology for dairy cattle (Figure 06b).

In typical dairy housing facilities, 44% of farmers have separate cages for adult cattle, feed bunks, and water storage. It is rare to find the individual calf cage and feed storage system because of the lack of space. According to Ministry of Agriculture Decree No. 46/2015, calves need to be maintained in separate cages until the age of one month for physical activity needs and the prevention of disease spreading. It is also important to have a feed storage site with a good storage environment to maintain feed availability and quality and prevent feed spoilage (House, 2011).

All farmers (100%) have sufficient knowledge in raising dairy cattle including the selection of cattle breed, signs of estrus, calving interval, and milking process and they mainly use the traditional method in the practices. However, they have a lack of awareness and confidence in implementing the breeding program. Until now, the application of Artificial Insemination (AI) has been done by the farmers' cooperatives (KPSBU). The government should increase farmers' participation in breeding schemes by providing training and technical assistance, especially in heat detection problems (Gatew *et al.*, 2018).

Sustainability Index of 5 Dimensions

The index of sustainability of 5 dimensions is presented in the kite diagram (Figure 07). The figure depicts that the integrated horticulture and dairy farming in Suntenjaya village is categorized as less sustainable based on 4 dimensions (ecology, economy, social, and technology) and classified as unsustainable

based on the institutional dimension. The economic dimension has the highest index of sustainability at 29.52% while the institutional dimension has the lowest index at 21.77 %.

The results of RAP-DHFS validation are shown in Table 02. The table illustrates that the stress

value of each dimension is below 20% (except in the institutional dimension that reached 23%) and the value of R^2 is close to 1. This validation indicates that the RAP-DHFS model is sufficiently suitable for sustainability analysis.

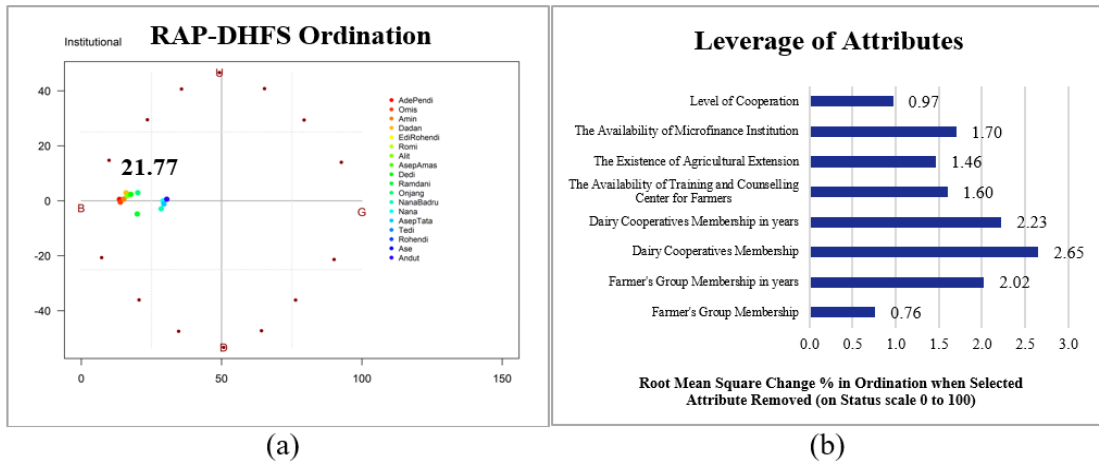


Figure 05: Sustainability index (a) and leverage analysis results (b) of the institutional dimension.

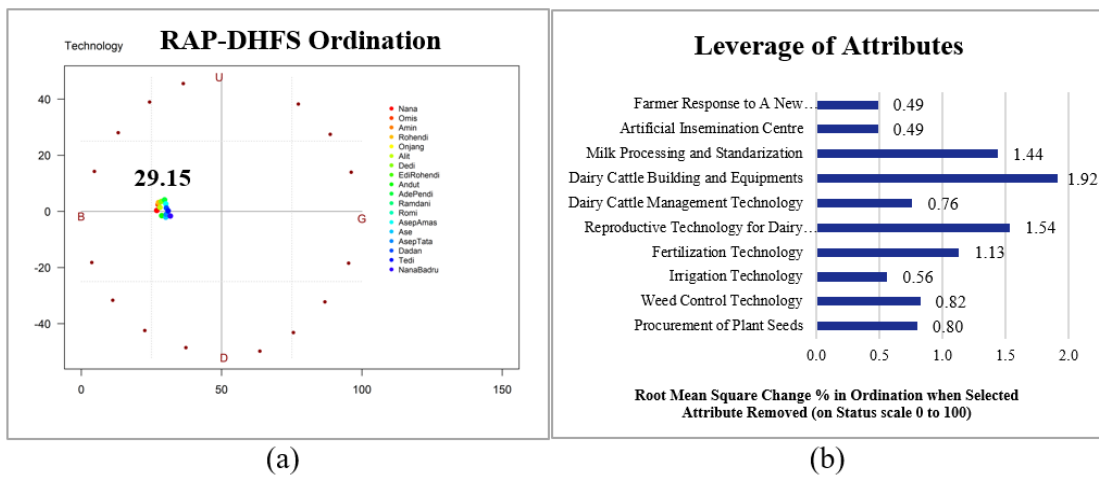


Figure 06: Sustainability index (a) and leverage analysis results (b) of the technological dimension.

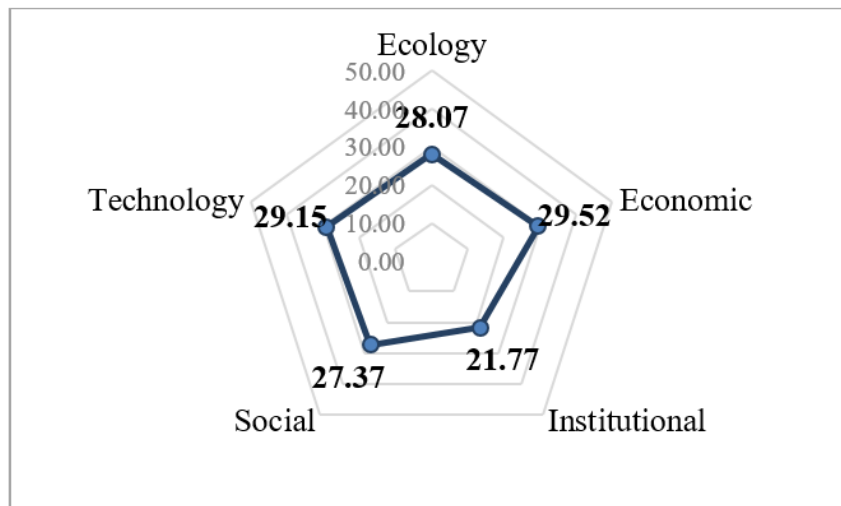


Figure 07: Kite Diagram of Sustainability Index of Five Dimensions.

Table 02: The Validation of RAP-DHFS Model.

Dimension Sustainability	Stress	R ²	MDS
Ecology	0.16	0.89	28.07
Economy	0.15	0.91	29.52
Social	0.14	0.92	27.37
Institution	0.23	0.78	21.77
Technology	0.15	0.91	29.15

CONCLUSIONS

The sustainability status of dairy-horticulture integrated farming system in four dimensions can be categorized as less sustainable, which were, for ecological dimension (28.07%), economic dimension (29.52%), social dimension (27.37%), and technological dimension (29.15%). As for the institutional dimension, the sustainability index was 21.77% (unsustainable). The number of the most sensitive attributes analyzed in this study were 10 out of 46 attributes. It is an urgency to improve all of these attributes to achieve sustainable agriculture.

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ACKNOWLEDGMENT

This research is funded by The Institute for Research and Community Services (LPPM) grants, ITB. Infinite thanks to Village Government of Suntenjaya and Yayasan Walungan Bhakti Nagari for the support in this study.

Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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