

SUSTAINABILITY ASSESMENT OF ORGANIC AND CONVENTIONAL RICE FARMING IN THE BONDOWOSO AGRICULTURAL LANDSCAPE, EAST JAVA, INDONESIA

**Sugesti Dwi Aprilia¹, Jangkung Handoyo Mulyo²,
Lestari Rahayu Waluyati³**

^{1,2,3} Social-Economic Departement , Faculty of Agriculture, Gadjah Mada University
Jl. Agro No.1 Bulaksumur, Yogyakarta, Indonesia 55281
e-mail : ¹sugestidwiaprilias2000@mail.ugm.ac.id

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ABSTRACT

The dependency level of Indonesian rice farmers on chemical fertilizers and chemical pesticides for pest and disease control is considerably high, accounting for over 75% of the total chemical inputs used. Excessive use of these chemical substances has led to various environmental crises and ecosystem degradation, ultimately reducing rice productivity. One strategy to mitigate this dependency is through the adoption of organic rice farming practices. Therefore, it is essential to conduct an in-depth analysis to evaluate and compare the performance of organic and conventional rice farming systems, particularly in terms of sustainability. This study aims to compare the sustainability of organic and conventional rice farming systems in Bondowoso Regency, East Java Province. A total of 158 respondents were selected using a Proportionate Non Probabilistic Sampling method, comprising 64 organic and 94 conventional rice farmers. The sustainability of these farming systems, the study employed a Multidimensional Scaling (MDS) approach, focusing on five key dimensions: economic, social, environmental, institutional, and technological aspects. The results of the analysis revealed that the sustainability index for organic rice farming was 84.623, categorized as good sustainable. In contrast, the sustainability index for conventional rice farming was 46.401, indicating a less sustainability. These findings suggest that organic rice farming systems exhibit a higher degree of sustainability compared to conventional systems in the study area. The findings of this study provide important implications of agricultural development policies, particularly in promoting environmentally friendly and sustainable rice farming practices that can enhance farmer welfare while reducing environmental degradation.

Keywords: multidimensional scaling, organic rice, rapfish, sustainability

ABSTRAK

Tingkat ketergantungan petani padi Indonesia terhadap pupuk anorganik dan pestisida kimia untuk pengendalian OPT sangat tinggi mencapai lebih dari 75% dari total penggunaan bahan kimia. Penggunaan bahan kimia yang berlebih menyebabkan berbagai krisis lingkungan dan kerusakan ekosistem sehingga menurunkan produksi padi. Salah satu cara untuk mengatasi ketergantungan petani padi terhadap penggunaan bahan kimia dilakukan dengan melakukan budidaya padi secara organik. Oleh itu penting dilakukan analisis untuk mengetahui kinerja kedua usahatani tersebut di Kabupaten Bondowoso dengan melihat tingkat keberlanjutannya. Penelitian ini bertujuan untuk membandingkan keberlanjutan usahatani padi organik dan non organik di Kabupaten Bondowoso, Provinsi Jawa Timur. Responden sebanyak 158, terdiri atas 64 petani padi organik dan 94 petani padi non organik, dipilih secara *Proportionate Non Probabilistic Sampling*. Keberlanjutan usahatani padi tersebut, maka diukur menggunakan metode Multidimensional Scaling (MDS) yang berfokus pada aspek ekonomi, sosial, lingkungan, kelembagaan dan teknologi. Hasil analisis menunjukkan bahwa nilai indeks keberlanjutan usahatani padi organik sebesar 84.623 dengan status sangat berkelanjutan. Sedangkan, indeks keberlanjutan usahatani padi non organik sebesar 46.401 dengan status kurang berkelanjutan. Hasil ini menunjukkan bahwa usahatani padi organik lebih berkelanjutan dibandingkan dengan usahatani padi non organik. Temuan penelitian ini memberikan implikasi penting bagi kebijakan pengembangan pertanian, khususnya dalam mendorong praktik budidaya padi yang ramah

lingkungan dan berkelanjutan, yang dapat meningkatkan kesejahteraan petani sekaligus mengurangi degradasi lingkungan.

Kata kunci: keberlanjutan, padi organik, multidimensional scaling

INTRODUCTION

The challenges in achieving sustainable food security can be categorized into two distinct aspects: demand or consumption and the utilization of food, and supply or food provisioning. The demand side includes factors such as high population growth and demographic dynamics. Indonesia's population growth is relatively high, at 1.11 percent in 2024, with a population reaching 282,477,584 people (BPS, 2024). Secondly, economic growth is projected to reach 3.79 percent in the second quarter of 2024 (BPS, 2024). High economic growth impacts per capita income levels and the purchasing power of the population.

On the supply side, the application of conventional agriculture is often accompanied by environmental challenges such as land conversion, soil degradation, water pollution, and the loss of biodiversity (Decaens et al., 2018; Warren-Thomas et al., 2023). In addition, the impacts of climate change, including extreme weather events and changes in rainfall patterns, exacerbate these challenges, threatening food security (Okoko et al., 2022; Giam, 2017).

The findings of SOUT2017-SPD (2017) highlight Indonesian farmers' heavy reliance on chemical fertilizers and chemical applications for pest and disease management, with a dependency ratio exceeding 75%. This shows that serious efforts from the government to encourage the use of organic fertilizers and the utilization of biological pesticides by households in rice farming are urgently needed. The use of organic materials can enhance biodiversity and promote the maintenance and improvement of ecosystem quality (Dal Ferro et al., 2017; Schrama et al., 2018).

One way to address dependence on chemical materials in agriculture is by implementing a sustainable agricultural system, namely organic farming. Organic farming focuses on

minimizing synthetic inputs, conserving resources, and improving soil fertility through activities such as composting, crop rotation, and biological pest control methods (Ha Duc et al., 2023). The application of agroecology emphasizes ecological principles in farming systems, promoting biodiversity, natural pest control, and soil health through crop diversification, agroforestry, and integrated pest management (Ewert et al., 2023).

In 2019, there were 7,398 farmers across Indonesia, and by the end of 2022, the number of farmers involved in organic rice cultivation reached 12,752 (AOI, 2023). There has been fluctuation in organic rice fields in Indonesia from 2009 to 2022, due to factors such as the number of organic farmers, the number of certification bodies, and dependence on government subsidies for certification financing. According to the Organic Trade Association (OTA), Indonesia holds a 0.3% market share of the global organic product market, with an estimated compound annual growth rate (CAGR) of 6.1% for the period 2021-2026 (Global Organic Trade, 2021), indicating that the development opportunities for organic farming in Indonesia are very promising.

One of the challenges in agriculture relates to ecosystem sustainability and natural resource management (Leeuwis, 2009). Organic farming systems represent one of the sustainable agricultural innovations that can address the demands and challenges of current agricultural practices. Bondowoso Regency has been running the Botanik Program (Bondowoso Towards Organic Agriculture) from 2009 to the present and has obtained seven national organic certifications and one international organic certification. The issue faced in rice farming practices in Bondowoso Regency is a decrease in production due to soil degradation caused by the excessive use of chemicals over the years. This problem is also

observed in agricultural land in Bondowoso Regency, leading to low organic matter content in the soil, which is <2%, and a soil pH <5 or slightly acidic (Ruhimat et al., 2023).

Previous studies have highlighted various approaches to assessing the sustainability of agricultural system, particularly rice farming. For instance, Maryono (2018) examined the sustainability index of rice farming in Tasikmalaya using the Composite Indicator (CI) method. Triyono et al. (2021) analyzed the sustainability value of rice farming in relation to economic efficiency in Yogyakarta, applying the Sustainable Value Approach (SVA). Yusuf et al. (2019) assessed the economic sustainability index and status of rice farming in Riau using the Multi Dimensional Scaling (MDS) approach. The aforementioned studies analyzed the sustainability of rice farming in general. However, none has specifically examined a comparative assessment between organic and conventional rice farming, particularly in Bondowoso Regency, based on the five dimensions of sustainable development: economic, social, environmental, institutional, and technological.

The study by Yusuf et al. (2021) in Siak, Riau Province, focused on formulating a sustainability management design based on key factors and developing scenarios to improve overall sustainability performance. However, the study did not differentiate sustainability outcomes based on specific production systems, such as organic and conventional farming, and instead assessed the sustainability of a single aggregated farming system. Moreover, the approach employed was predominantly oriented toward strategic planning rather than a comparative assessment of sustainability performance across different production systems.

Most previous studies on the sustainability of rice farming in Indonesia have relied on a single analytical approach or a single sustainability dimension, without utilizing a comprehensive multidimensional evaluation that simultaneously integrates economic, social, environmental, institutional, and technological aspects. Research that specifically com-

pares the sustainability performance between organic and conventional rice farming systems remains limited, particularly in regions that have implemented organic farming development programs, such as Bondowoso Regency.

This study aims to assess and compare the level and status of sustainability between organic and conventional rice farming in Bondowoso Regency, viewed from the dimension of sustainable development (economic, social, environmental, institutional, and technological). This research is important as it highlights the significance of organic farming programs in addressing environmental degradation caused by conventional farming practices.

METHODS

The research location was determined using a purposive method, in which the selection was made deliberately in accordance with the research objectives (Purwanto, 2011). The study was conducted in Bondowoso Regency, East Java Province, with the following considerations : (1) The region is one of the certified organic rice producing areas in East Java, and (2) It has an organic rice farming development program known as Botanik (Bondowoso towards organic farming).

The research was carried in three sub-districts in Bondowoso Regency: Wonosari, Bondowoso, and Curahdami, located in East Java Province. The selection of research locations was purposively made because Wonosari Sub-district had the highest rice productivity in Bondowoso Regency, with an average productivity of 6.48 tons/ha. Bondowoso Sub-district was selected due to its relatively high rice productivity, with an average productivity of 6.34 tons/ha. Curahdami Sub-district was chosen because it had the lowest rice productivity in Bondowoso Regency, with an average productivity of 5.39 tons/ha. The study will be conducted from December 2024 to February 2025 in Bondowoso Regency.

This study used primary data obtained through structured interviews with question-

naires. A quantitative descriptive approach was employed to compare the sustainability of organic and conventional rice farming in Bondowoso Regency. Data collection was carried out through interviews using questionnaires that covered economic, social, environmental, institutional, and technological indicators, involving 158 farmers, with 64 organic farmers and 94 conventional rice farmers. The sampling method used was Proportionate non-probability sampling was employed in this study. Under this approach, the number of sample units from each sub-population (stratum) was determined proportionally to the size of the respective population; however, the selection of individual respondents was not conducted through random procedures but was based on predefined criteria, accessibility, and practical field considerations (Sugiyono, 2008). Population data were obtained from official membership lists of farmer groups. Due to field constraints, including limited access, time restrictions, and varying levels of respondent participation, fully random sampling was not feasible. Accordingly, the proportion of samples drawn from organic and non-organic farmer strata reflected their respective population proportions, while respondent selection within each stratum was based on availability and willingness to participate. The sampling frame consisted of lists of organic and non-organic farmer group members provided by farmer group leaders and local agricultural extension officers. These lists were used to identify the study population and to determine proportional sample allocation across strata. Nevertheless, respondent selection within each stratum was not entirely random due to practical field limitations, such as non-response and respondent availability.

The sample size was determined using the Slovin formula, with the population of organic farmers being 177 farmers who are members of the Al-Barokah Farmer Group (Gapoktan) and the population of conventional farmers being 1,461 farmers from the three sub-districts. The Slovin formula is commonly used to determine the sample size in social

research and other studies, where directly calculating the sample size from a very large population is not feasible (Sugiyono, 2019).

In this Study, the researcher determined the sample size a margin of error of 10, meaning that a 10% error tolerance was accepted at a 90% confidence level (Sugiyono, 2019), The sample size was calculated using Slovin's formula (Sevilla *et al.* 1993), as follows

$$n = \frac{N}{1 + Ne^2}$$

Where :

n : Sample size

N : Population size

e : critical value (margin of error)

$$n = \frac{177}{1 + 177(0.10^2)} = 64 \text{ samples}$$

Thus, the sample used in this study consisted of 64 organic farmer selected from five farmer group under the Al-Barokah farmers association. The sample size for conventional rice farmers was calculated as follows:

$$n = \frac{1461}{1 + 1461(0.10^2)} = 94 \text{ samples}$$

Accordingly, the study employed a total of 94 conventional rice farmers as respondents, selected from three sub-districts in Bondowoso Regency.

Table 1. The Sample Size of Conventional Rice Farmers

No.	Farmer Group Name	Population Size	Sample Size
1	Karya Tani II	29	$n_i = \frac{29}{177} \times 64$ = 10 sample
2	Tani Mandiri I	30	$n_i = \frac{30}{177} \times 64$ = 11 sample
3	Tani Mandiri I A	30	$n_i = \frac{30}{177} \times 64$ = 11 sample
4	Tani Mandiri I B	33	$n_i = \frac{33}{177} \times 64$ = 12 sample
5	Tani Mandiri II	55	$n_i = \frac{55}{177} \times 64$ = 20 sample
Total		177	64

Table 2. The Sample Size of Organic Rice Farmers

No.	Farmer Group Name	Population Size	Sample Size
1	Wonosari District	384	$n_i = \frac{384}{1461} \times 94$ = 25 <i>sample</i>
2	Bondowoso District	676	$n_i = \frac{676}{1461} \times 94$ = 43 <i>sample</i>
3	Curahdami District	401	$n_i = \frac{401}{1461} \times 94$ = 26 <i>sample</i>
Total		1461	94

Five indicators were used to assess the sustainability of organic and conventional rice farming in Bondowoso Regency, which consists of: 8 attributes for the economic dimension, 8 attributes for the social dimension, 9 attributes for the environmental dimension, 6 attributes for the institutional dimension, 7 attributes for organic technological dimension, and 6 attributes for conventional technological dimension.

Table 3. Attributes of the Sustainability of Organic and Conventional Rice Farming in Bondowoso Regency

Dimension	Attribute
Economic	Price of unhusked rice Farmer income level Rice productivity Market availability/access Market coverage of farm production Access to credit Capital availability for farming Land tenure status
Social	Family participation in farming activities Level of farmers' formal education Farming experience Labor absorption in rice farming Intensity of agricultural extension and training Community perception toward rice farming Collective work culture in the community Access to transportation
Ecology	Size of agricultural land Farmers' understanding of sustainable land management Waste utilization practices to reduce environmental pollution Soil condition / land suitability for rice cultivation Irrigation system Environmental pollution due to the use of chemical fertilizers and pesticides Improving soil fertility through the use of organic materials Selection of high-yield seeds adapted to the environment Climatic suitability Level of pest and disease infestation
Institutional	Access of farmer groups/ associations to financial institutions Participation in farmer groups Availability of marketing agents Role of agricultural extension officers in assisting farmers Intensity of conflict within or between farmer groups Intensity of conflict among or within farmer groups Existence and legal status of farmer groups
Conventional farming technology	Fulfillment of rice farming technology Availability of harvesting technology (combine harvester, dryer) Utilization of organic fertilizers Pest and disease management through Integrated Pest Management (IPM) Adoption of soil and water conservation technology Technology for producing organic fertilizers and pesticides
Organic farming technology	Land preparation Conversion period Seed usage Pest and disease management Integrated Pest Management (IPM) Rice processing Adoption of agricultural technology by farmers

The sustainability status of rice farming can be analyzed using a non-parametric variable method called Multi-Dimensional Scaling (MDS) with the Rap-Rice analysis tool. Each dimension uses a measurement scale, with a score range from 0 (zero) to 2 (two), where a score of 2 indicates good criteria, 1 indicates adequate criteria, and 0 indicates poor criteria.

Table 4. Percentage of Sustainability Index Value

Index Value	Category
0,00 – 25,00	Bad
25,01 – 50,00	Less
50,01 – 75,00	Enough
75,01 – 100,00	Good

Source : Kavanagh & Pitcher (2004)

In the MDS method, the sustainability points are visualized with the extreme "bad" point given a score of 0%, and the extreme "good" point given a score of 100%. The technical procedure in MDS is based on Euclidean distance, which in dimensional space can be written as (Pitcher and Preikshot, 2001):

$$d = \sqrt{(|X1 - X2|^2 + |Y1 - Y2|^2 + |Z1 - Z2|^2 + \dots)}$$

The configuration or ordination of an object or point in MDS is then approximated by regressing the Euclidean distance (d_{ij}) from point i to the origin (δ_{ij}) using the following equation:

$$d_{ij} = \alpha + \beta \delta_{ij} + \epsilon$$

Where:

d_{ij} = squared distance between object i and object j

α = Alpha

β = Beta

δ_{ij} = Starting point

ϵ = Error

The technique used for the regression equation is the ALSCAL algorithm (Alder et al., 2000). The ASCAL method optimizes the squared distance (d_{ijk}) to the squared data (o_{ijk}) which in three dimensions (i, j, k) is written in the following S-Stress formula:

$$s = \sqrt{\left(\frac{1}{m} \sum_{\alpha=1}^r \left[\frac{\sum_i \sum_i (d_{ijk}^2 - o_{ijk}^2)^2}{\sum_i \sum_i o_{ijk}^4} \right] \right)}$$

The squared distance is then weighted by the Euclidean distance (Alder et al., 2000):

$$d_k^2 = \sum_{a=1}^r W_{ka} (X_{ia} - X_{ja})^2$$

RESULT AND DISCUSSION

COMPARISON OF MULTIDIMENSIONAL SUSTAINABILITY OF ORGANIC AND CONVENTIONAL RICE FARMING IN BONDOWOSO REGENCY

Sustainability of Organic Rice Farming in Bondowoso Regency

The results of the multidimensional analysis of the sustainability of organic rice farming in Bondowoso Regency (Table 5) indicate that the S-Stress value is between 0.135 and 0.143 (<0.25), and the R² value is between 0.94 and 0.95 (closer to 1), which means that the goodness of fit for this analysis has been satisfied. The table also shows that the difference between the MDS and Monte Carlo values is between 0.347 and 3.908, indicating a very small difference (< 5). This value suggests that the influence of error or the impact of scoring mistakes is relatively small. According to

Table 5. Organic Rice Farming Sustainability Index

Dimensions of Sustainability	MDS		Monte Carlo		S-Stress		R ²		Sustainability Status	
	O	C	O	C	O	C	O	C	O	C
Multidimensional	84.623	46.401	82.989	46.750	0.139	0.145	0.947	0.943	Good	Less
Economy	92.624	52.349	88.716	52.272	0.137	0.137	0.950	0.948	Good	Enough
Social	55.701	47.049	55.327	47.189	0.138	0.137	0.949	0.945	Enough	Enough
Ecology	95.103	47.917	93.877	48.147	0.135	0.144	0.950	0.947	Good	Enough
Institutional	87.472	33.821	85.157	35.148	0.143	0.144	0.939	0.940	Good	Enough
Technology	92.216	50.867	91.869	50.996	0.140	0.162	0.947	0.935	Good	Less

Source : Primary Data Analysis, 2025

Kavanagh and Pitcher (2004), if the difference between the Rap Analysis value and the Monte Carlo Analysis value is > 5 , the analysis results are inadequate for predicting the sustainability index value. However, if the difference between the two analyses is < 5 , the results are considered adequate for predicting the sustainability index value.

The results of the Rap-Rice analysis show that organic rice farming in Bondowoso Regency has a multidimensional sustainability index of 84.623. Based on the sustainability analysis, organic rice farming in Bondowoso Regency is included in the good sustainability category. Organic farming is more efficient in using non-renewable energy and improving soil and water quality, thus supporting long-term sustainability. Although organic farming yields lower per unit compared to conventional farming, total greenhouse gas emissions are often lower due to practices that minimize the use of synthetic chemicals (Lin and Fukushima, 2016; Clark, 2020). Additionally, the selling price of organic rice is higher compared to conventional rice, as organic products often command a premium price in the market due to assurances of health benefits and environmental concerns (Wiranti et al., 2022; Lin and Fukushima, 2016).

Sustainability of Conventional Rice Farming in Bondowoso Regency

The results of the multidimensional analysis of the sustainability of conventional rice

farming in Bondowoso Regency show that the S-Stress value is between 0.137 and 0.162 (< 0.25), and the R^2 value is between 0.935 and 0.948 (closer to 1), indicating that the goodness of fit for this analysis has been met. The table also shows that the difference between the MDS and Monte Carlo values is between 0.077 and 1.327, indicating a very small difference (< 5). This value suggests that the influence of error or the impact of scoring mistakes is relatively small.

The multidimensional sustainability index of conventional rice farming in Bondowoso Regency is 46.401 percent on a sustainability scale of 0–100 percent. Based on the sustainability analysis, conventional rice farming in Bondowoso Regency falls into the category of "less sustainable." The analysis results of the sustainability of conventional rice farming in Bondowoso Regency show that the sustainability index for each dimension falls within the categories of less sustainable or moderately sustainable. From the spider diagram, it is evident which dimensions should be prioritized for management in order to raise their sustainability index above 50% or even higher than 75%, which would indicate a "very sustainable" status (Iswandi, 2014). The dimension with the lowest sustainability index is the institutional dimension, which only reaches 33.821 (less sustainable). To improve the sustainability status from "less" to "enough" or "good" sustainability, efforts are needed to manage the sensitive attributes or key indica-

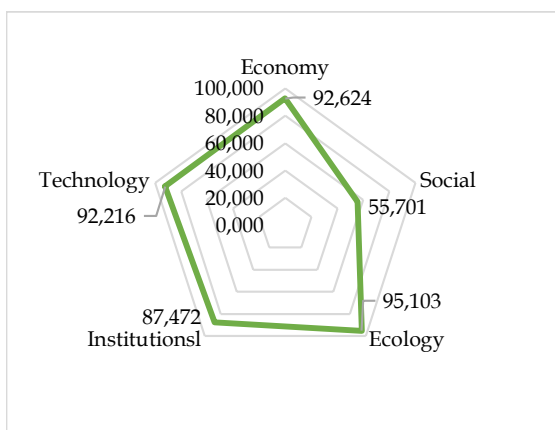


Figure 1. Sustainability of Organic Rice Farming

Source : Primary Data Analysis, 2025.

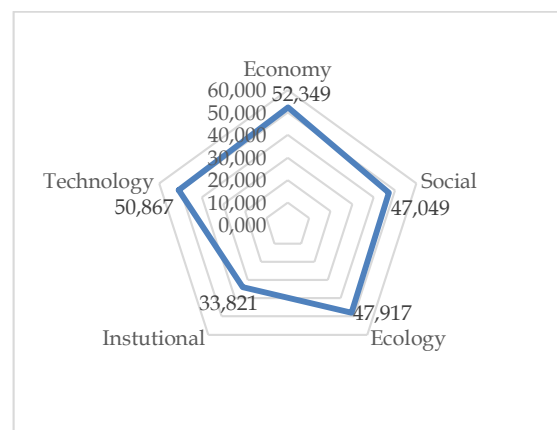


Figure 2. Sustainability of Conventional Rice Farming

Source : Primary Data Analysis, 2025.

tors that influence sustainability in each dimension.

The sustainability index projected by the spider diagram shows that as the dimension index values move outward from the center point, the sustainability value increases. Figure 2 shows that the shape of the spider diagram is still imprecise, indicating that the sustainability dimensions of rice farming in Bondowoso Regency have not yet been applied in a balanced manner. The Rap-rice analysis results indicate that the sustainability of organic rice farming is higher compared to conventional rice farming in Bondowoso Regency.

The findings from the Bondowoso study reveal a significant difference between organic and conventional rice farming systems. The organic system achieved a sustainability index of 84.62%, which is categorized as highly sustainable, whereas the conventional system reached only 46.40%, placing it in the less sustainable category. This disparity is primarily attributed to the superior performance of the organic system in the ecological, economic, and technological dimensions, while the institutional dimension in the conventional system remains relatively weak.

In contrast, the study by Yusuf et al. (2021) in Siak Regency demonstrated that the sustainability of wetland rice farming falls within the moderately sustainable category, with an index ranging from 50% to 75%. The Siak study did not distinguish between organic and conventional systems; rather, it assessed sustainability conditions in aggregate and

formulated three improvement scenarios based on key factors and stakeholder needs. Scenario 1 was recommended, as it could enhance sustainability at low cost and within a relatively short implementation period.

Therefore, compared with the findings from Siak, the Bondowoso study not only evaluates sustainability but also clearly demonstrates that the organic system exhibits much higher sustainability performance than the conventional system. Whereas the Siak research emphasizes strategic management planning for improvement, the Bondowoso study highlights the tangible superiority of the organic system and underscores the importance of institutional support to further expand its adoption.

COMPARISON OF SUSTAINABILITY OF ORGANIC AND CONVENTIONAL RICE FARMING IN BONDOWOSO REGENCY BASED ON DIMENSIONS

Sustainability Based on Economic Dimension

The sustainability of rice farming in Bondowoso Regency, in the economic dimension, includes 8 factors estimated to influence economic sustainability: (1) Rice paddy price, (2) Farmer income level, (3) Rice productivity, (4) Market availability, (5) Market coverage of production, (6) Credit access, (7) Capital for farming, (8) Land ownership. Based on the sustainability analysis of conventional rice farming in Bondowoso Regency, the economic dimension shown in Figure 3 resulted in an index of 52.349, which falls within the index

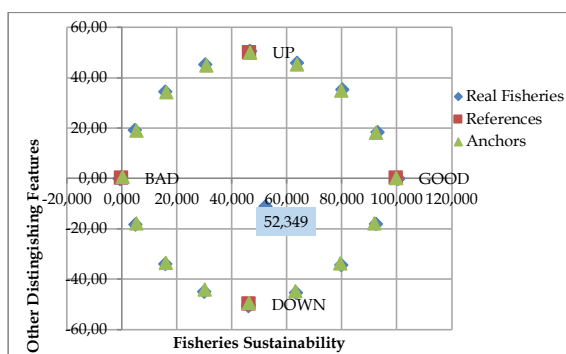


Figure 3. RAPPFISH Ordination of Conventional Economic Dimension
Source : Primary Data Analysis, 2025.

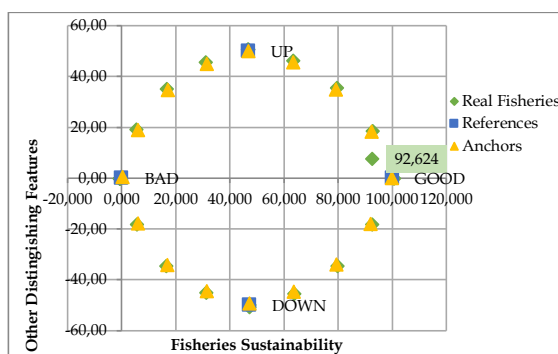


Figure 4. RAPPFISH Ordination of Organic Economic Dimension
Source : Primary Data Analysis, 2025.

scale of 50.01 – 75.00, with a "enough sustainability" status. The sustainability analysis of organic rice farming in Bondowoso Regency, based on the economic dimension, resulted in an index of 88.718 percent, which falls within the index scale of 50.01 – 75.00, with a "good sustainability" status.

Conventional rice farmers often rely on chemical fertilizers and pesticides, which are more expensive compared to organic fertilizers. Farmers who depend on chemical fertilizers and pesticides with high prices find that their income from production cannot cover production costs. High production costs, such as for seeds, fertilizers, pesticides, and labor, can reduce the profits of rice farmers. With high production costs and disproportionate selling prices, the economic sustainability of rice farming will be low (Zhang, W., et al., 2019). The economic benefits of implementing an organic farming system can be seen from indicators such as reduced farming costs, increased rice yields, higher rice prices compared to conventional rice, and higher income from organic rice farming (Gunawan et al, 2018).

Sustainability Based on Social Dimension

The sustainability of farming in the social dimension includes farmer welfare, relationships among farmers, and interactions between farmers and other institutions. Farmers who live in better conditions with adequate access to existing facilities are more likely to manage their farms sustainably (Rosset, P. M., & Ramírez, R. 2019). The presence of social

networks among farmers can play a role in building resilience against economic instability and social welfare, which will eventually influence agricultural system decisions in the long term (Sweeney, S. A., & Mulvey, R., 2021).

The sustainability of rice farming in Bondowoso Regency, in the social dimension, includes 8 factors used to analyze sustainability, which are expected to influence the social dimension: (1) Family participation in farming activities, (2) Existence of farmer groups, (3) Level of formal education of farmers, (4) Farming experience, (5) Absorption of labor in rice farming, (6) Frequency of agricultural extension and training, (7) Public perception of rice farming, and (8) Mutual cooperation in rice farming communities. The sustainability analysis of rice farming in Bondowoso Regency based on the social dimension showed a score of 47.049 percent, categorized as less sustainable. The MDS analysis with Rap-Rice showed that the sustainability index for organic rice farming in the social dimension was 55.701, indicating that from a social perspective, organic rice farming in Bondowoso Regency has a enough sustainable status.

The low sustainability index of conventional rice farming in the social dimension is caused by the disparity in access to resources among the sample farmers. Limited access to resources can hinder the achievement of social sustainability for conventional rice farmers. One of the attributes in the social dimension is the existence of farmer groups; however, the role of farmer groups still has limited impact

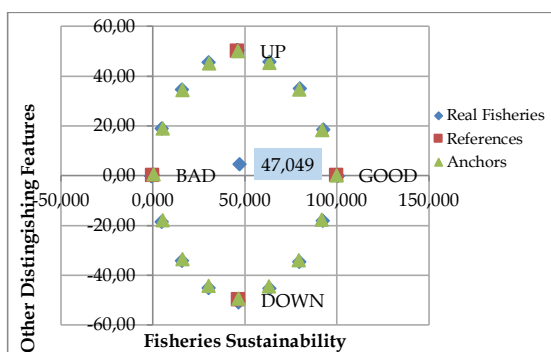


Figure 5. RAPFISH Ordination of Conventional Social Dimension

Source : Primary Data Analysis, 2025.

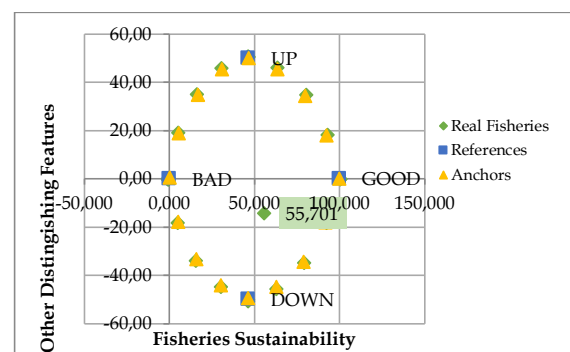


Figure 6. RAPFISH Ordination of Organic Social Dimension

Source : Primary Data Analysis, 2025.

on farmers. The insufficient and uneven intensity of extension and training leads to a lack of information and knowledge regarding agricultural technologies and practices, and socially, farmers are less connected with one another. The challenges faced in achieving sustainability in organic rice farming in the social dimension are related to the presence of farmer groups, where some groups within the Farmer Group Association are still underdeveloped compared to others. This can be seen in the assessment of administrative records related to organic rice cultivation, which are still lacking, and the low frequency of group meetings. This becomes a barrier as the distances between the members' residences are far apart, even across different regions.

Strengthening social networks and farmer organization participation can improve sustainable farming practices (Zheng et al., 2020). Social networks play a crucial role in the exchange of information and knowledge regarding agricultural technologies and practices. Farmers who are more connected to social networks tend to adopt sustainability-supporting practices more quickly (Müller, A. & M. A. G., 2020).

Sustainability Based on Ecology Dimension

The environmental dimension is crucial for the sustainability of rice farming, especially in the face of challenges such as climate change, land degradation, and resource scarcity. Sustainable natural resource management through the implementation of ecosystem-based agricultural practices, including

land, water, and biodiversity management, is essential. These practices help maintain soil health and reduce erosion, thus supporting long-term productivity and ecosystem stability (O'Donoghue et al., 2022).

Sustainability of rice farming in Bondowoso Regency in the environmental dimension includes 9 dimensions to analyze sustainability, which are estimated to influence the environmental dimension: (1) Land area, (2) Farmers' understanding of land management, (3) Utilization and management of waste, (4) Soil condition/suitability of land for rice, (5) Irrigation systems, (6) Use of fertilizers and chemicals, (7) Use of organic materials, (8) Use of rice seeds, and (9) Climate suitability.

The sustainability analysis of conventional rice farming in Bondowoso Regency based on the environmental dimension shows a score of 47.917 percent, categorized as less sustainable. Conventional rice farmers heavily rely on the use of chemical fertilizers and pesticides, believing that their use will optimize rice farming results. Agricultural systems that rely on chemical fertilizers and pesticides have negative externalities, such as soil degradation, intensified pollution, and reduced biodiversity (Li et al., 2021).

The MDS analysis with Rap-Rice shows that the sustainability index of organic rice farming in Bondowoso Regency is 95.103, indicating a "good" sustainable status. The sustainability index for the environmental dimension is very high, suggesting that most farmers believe that the implementation of organic rice farming systems can significantly

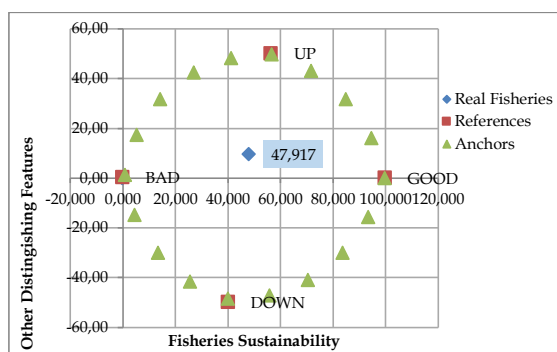


Figure 7. RAPPFISH Ordination of Conventional Ecology Dimension
Source : Primary Data Analysis, 2025.

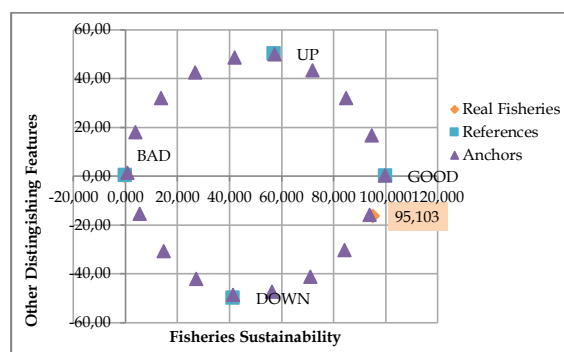


Figure 8. RAPPFISH Ordination of Organic Ecology Dimension
Source : Primary Data Analysis, 2025.

improve environmental quality. Agroecological management prioritizes effective control while promoting a healthy and sustainable ecosystem, conserving biodiversity, and ensuring long-term food security (Boutagayout et al., 2023).

Sustainability Based on Institutional Dimension

Farmer institutions are one of the key instruments in empowering farmers to develop their agricultural enterprises. The sustainability of rice farming in Bondowoso Regency in the institutional dimension includes 6 factors for analyzing sustainability, which are considered to influence the institutional dimension: (1) Access of farmer groups/ Farmer Group Association to financial institutions, (2) Participation in farmer groups, (3) Presence of marketing agents, (4) Presence of farmer group meetings, (5) Role of agricultural extension agents, and (6) Intensity of conflicts between groups or among members of farmer groups.

The analysis of the sustainability of conventional rice farming in Bondowoso Regency, based on the institutional dimension, shows a value of 33.821%, indicating that it is less sustainable. The lack of sustainability in conventional rice farming in the institutional dimension is due to the poor functioning of agricultural institutions, particularly farmer groups. This is because the frequency of meetings within the farmer groups is very low or even nonexistent in several areas. Well-functioning agricultural institutions, such as

farmer groups and cooperatives, can empower farmers to share knowledge, technology, and resources (Sihombing, 2016). The role of agricultural extension workers is also crucial in assisting farmers in addressing technical issues, production inputs, production processes, technology, and marketing in agribusiness processing (Ikhsan et al., 2024).

The sustainability index of the institutional dimension of organic rice farming is 87.472%, indicating that the institutional dimension falls under the category of good sustainability. The organic farmers in Bondowoso Regency are members of the "Al-Barokah" Farmer Group Association, which consists of five farmer groups. The role of the Farmer Group Association is to provide a platform for organic farmers to exchange information on organic rice cultivation. One of its programs is the organic farmer field school, where training on organic rice cultivation improves the knowledge of farmers in this field. The "Al-Barokah" Farmer Group Association also owns a production facility for organic rice, with the process starting from milling the paddy, packaging, labeling, and marketing. Additionally, the association serves as a supplier of production inputs for organic rice farming, such as certified organic seeds, liquid fertilizers, and biological pesticides. Farmer institutions can accelerate the socio-economic growth of farmers, improve their access to agricultural financing, provide facilities for the adoption of sustainable farming systems, and encourage farmers to adopt agricultural innovations (Mapanje et al., 2023).

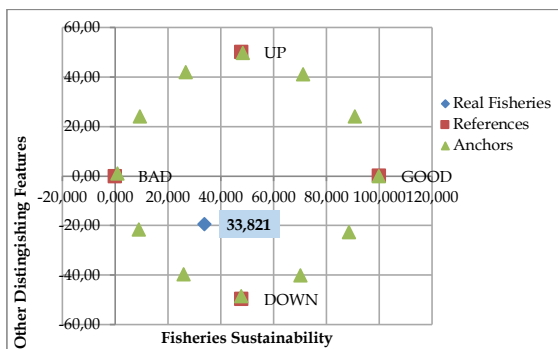


Figure 9. RAPPFISH Ordination of Conventional Institutional Dimension
Source : Primary Data Analysis, 2025.

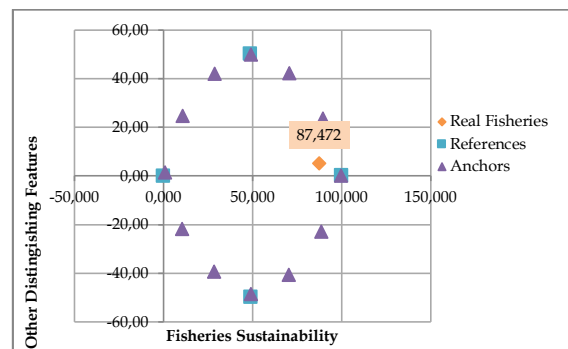


Figure 10. RAPPFISH Ordination of Organic Institutional Dimension
Source : Primary Data Analysis, 2025.

Sustainability Based on Technology Dimension

The role of agricultural technology in farming is crucial because it can enhance efficiency, productivity, and the sustainability of agriculture. Agricultural technology encompasses a variety of innovations, including agricultural tools and machinery, more efficient cultivation techniques, the use of superior seeds, improved irrigation systems, and the application of information technology for monitoring and managing farming operations (Rachman et al., 2020; Sartini et al., 2019).

The sustainability of conventional rice farming in Bondowoso Regency in the technological dimension includes six aspects that are believed to influence technological sustainability: (1) Fulfillment of rice farming technology, (2) Fulfillment of harvest technology, (3) Use of organic fertilizers, (4) Pest and disease management through integrated pest management, (5) Fulfillment of soil and water conservation technologies, and (6) Adoption of agriculture by farmers.

The analysis of sustainability in conventional rice farming in Bondowoso Regency based on the technological dimension showed a sustainability index of 50.867 percent, categorized as moderately sustainable. The low sustainability index of conventional rice farming in Bondowoso Regency is due to limited access to agricultural technology, which is primarily caused by economic factors, such as the high costs of purchasing modern agricultural tools and machinery.

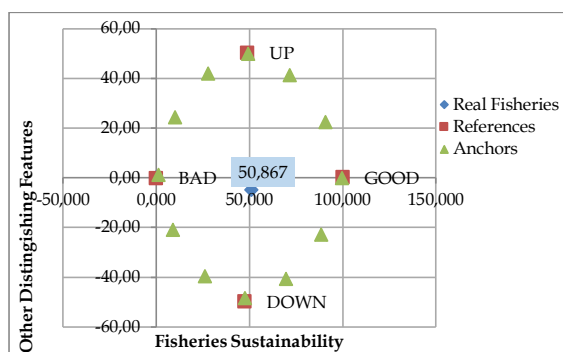


Figure 11. RAPFISH Ordination of Conventional Technology Dimension
Source : Primary Data Analysis, 2025.

Most rice farmers access agricultural technology by renting machinery from other farmers or farmer groups. The use of more advanced agricultural machinery can reduce reliance on manual labor and increase operational efficiency (Zhang et al., 2017).

The sustainability of organic rice farming in Bondowoso Regency in the technological dimension includes seven aspects that are believed to influence technological sustainability: (1) Land management, (2) Conversion period, (3) Use of seeds, (4) Management of pests and diseases, (5) Integrated pest management, (6) Rice processing, and (7) Adoption of agricultural technology by farmers. The technological dimension shows a value of 92.216%, placing the sustainability status in the "very sustainable" category. This indicates that the quality and procedures of organic farming in Bondowoso Regency are in accordance with SNI 6729:2016. Agriculture plays an important role in economic development, and the use of agricultural technology in rural areas will provide benefits to the agricultural sector (Goel et al., 2021). In addition, organic farmers need to undergo certification as it can provide positive impacts, such as market assurance and the ability to obtain higher prices, as well as the impact of certification on improving both the quantity and quality of production (Fajar et al., 2023).

Based on the comparative sustainability assessment between organic and conventional rice farming systems in Bondowoso, several important policy implications must be considered. First, since organic rice farming de-

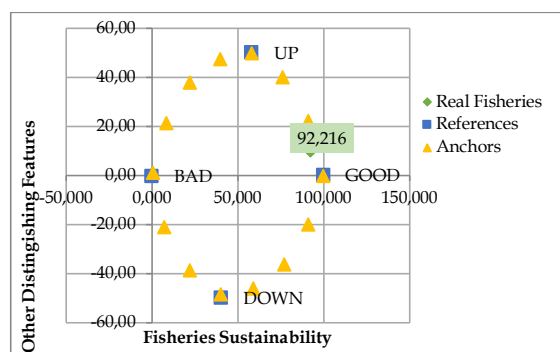


Figure 12. RAPFISH Ordination of Organic Technology Dimension
Source : Primary Data Analysis, 2025.

monstrates a substantially higher level of sustainability, local governments should strengthen organic agriculture acceleration programs through the provision of input incentives, market support, and more accessible financing facilities. This policy direction becomes even more relevant given that the study in Siak also emphasizes the importance of reducing chemical input use and protecting agricultural land from conversion pressures.

Second, farmer institutions need to be systematically strengthened, considering that the institutional dimension represents the weakest aspect of the conventional system and has been identified as a key factor for improving sustainability in the Siak study. Strengthening institutions can be achieved through the development of agribusiness-based farmer cooperatives, enhanced roles for agricultural extension officers, and the establishment of marketing networks for organic rice products.

Third, capacity building for farmers—through training, technical education, and intensive extension support—should be prioritized, particularly to encourage the adoption of organic cultivation technologies and sustainable agricultural practices. Well-structured training programs will accelerate the transition toward environmentally friendly production systems.

Fourth, sustainable paddy field protection policies are required through stricter control over land conversion and the integration of organic farming programs into regional development planning. Land protection serves as a crucial foundation for maintaining long-term sustainability and preventing declines in production capacity.

CONCLUSION AND RECOMMENDATION

CONCLUSION

The sustainability index of organic rice farming in Bondowoso Regency is higher than that of conventional rice farming in Bondowoso Regency. The sustainability status of

organic rice farming in Bondowoso Regency is classified as good sustainability, while the sustainability status of conventional rice farming in Bondowoso Regency is classified as less sustainable.

This study provides empirical evidence that organic rice farming demonstrates superior performance compared to conventional system across multiple dimensions of sustainability. In the economic dimension, organic farmers achieved relatively higher net income due to lower input cost and price premiums. In the social dimension organic farmer benefited from stronger farmer group participation and greater labor absorption. In the environmental dimension, organic farming performed better by minimizing chemical inputs, maintaining soil fertility, and promoting biodiversity conservation. In terms of the institutional dimension, organic farming was supported by more active farmer organizations and certification schemes that enhanced collective bargaining power. Finally, in the technological dimension, while conventional farmers had greater access to modern inputs, organic farmer adopted environmentally friendly practices that supported long term sustainability.

Overall, the findings highlight that the two farming system differ not only in outcomes but also in their underlying practices and institutional support. Organic rice farming offers a more balanced and sustainable pathway for agricultural development in Bondowoso Regency, whereas conventional farming still provides short term yield advantages. The result suggest the importance of strengthening market access, institutional support, and technological innovation to enhance the economic viability of organic farming while ensuring long term sustainability of rice production.

RECOMMENDATION

The sustainability status of organic rice farming is categorized as good sustainable; however, in the social dimension, it remains in the moderately sustainable category. There-

fore, efforts are needed to improve the existence of farmer groups, family participation in farming activities, and public perceptions of organic rice farming, in order to elevate the sustainability status in the social dimension to highly sustainable. The sustainability status of conventional rice farming is categorized as less sustainable; therefore, improvements are required across all dimensions, especially in the social, environmental, and institutional dimensions, which are currently categorized as less sustainable. In the social dimension, improvements are needed in the existence of farmer groups; in the environmental dimension, there is a need to enhance soil conditions for rice cultivation; and in the institutional dimension, efforts should be made to increase farmer participation in farmer groups.

Future studies could expand the scope of analysis by including a larger number of regions or agroecological zone to capture spatial variations in the sustainability of rice farming system. Longitudinal or panel data would be particularly valuable to observe change in sustainability performance overtime, rather than relying on cross-sectional data. Moreover, integrating qualitative approach such a farmer perception, consumer preferences, and institutional dynamics would provide deeper insights into the drivers and constraints both organic and conventional system.

Researchers should also consider examining additional sustainability dimensions, such as food safety, health impacts, and climate resilience, which are increasingly relevant in global agricultural debates. A more detailed economic assessment that accounts for hidden cost (e.g., environmental externalities) and long term benefits would further strengthen to evidence base.

REFERENCES

- Alder J, T. J. Pitcher, Preikshot, Kaschner, Ferrias. 2000. How Good is good?: A Rapid Appraisal Technique For Evaluation of The Sustainability Status of Fisheries of The North Atlantic. Fisheries Centre Research Reports. 8(2).
- Aliansi Organik Indonesia (AOI). (2023). Statistik Pertanian Organik Indonesia 2019. Aliansi Organik Indonesia (AOI). Bogor.
- Badan Pusat Statistik Jakarta Pusat , 2024. Luas Panen dan Produksi Padi di Indonesia 2023. Jakarta Pusat : Badan Pusat Statistik.
- Boutagayout, A., Bouiamrine, E.H., Synowiec A., L. Nassiri, and S. Belmalha. 2023. Agroecological practices for sustainable weed management in Mediterranean farming landscapes. *Environment, Development and Sustainability*. doi : 10.1007/s10668-023-04286-7.
- Clark, Sean. 2020. Organic Farming and Climate Change: The Need for Innovation. *Sustainability*, 12(17), 7012; <https://doi.org/10.3390/su12177012>.
- Dal Ferro, N., Zanin, G., Borin, M., 2017. Crop yield and energy use in organik and conventional farming: a case study in north-east Italy. *Eur. J. Agron.* 86, 37-47. <https://doi.org/10.1016/j.eja.2017.03.002>.
- Ewert, F., R. Baatz, and R. Finger, "Agroecology for a sustainable agriculture and food system: from local solutions to large-scale adoption," *Annu Rev Resour Economics*, vol. 15, pp. 351-381.
- Fajar, A., Fariyanti A., & Priatna W. B. (2023). Status Keberlanjutan Perkebunan Kopi Bersertifikasi C.A.F.E. Practices . *Jurnal Agribisnis Indonesia (Journal of Indonesian Agribusiness)*, 11(1), 1-16. <https://doi.org/10.29244/jai.2023.11.1.1-16>.
- Giam, Xingli. 2017. Global biodiversity loss from tropical deforestation," *Proceedings of the National Academy of Sciences*, vol. 114, no. 23, pp. 5775-5777.
- Global Organic. 2021. Indonesia Organic Market Overview. Retrieved from <https://globalorganictrade.com/country/indonesia>

- Goel, R. K., Yadav, C. S., Vishnoi, S., & Rastogi, R. (2021). Smart agriculture – Urgent need of the day in developing countries. *Sustainable Computing: Informatics and Systems*, 30, 100512. <https://doi.org/10.1016/j.suscom.2021.100512>.
- Gunawan. Hubeis, Aida V., Fatchiya A., Susanto D. 2018. Effectiveness of farmers learning an adaption of innovation in organik rice farming of East Java. *International Journal of Progressive Sciences dan Technologies*. Vol.2 No. 2.
- Ha Duc C., P. T. Minh, T. Van Tien, P. P. Thu, and P. M. Trien, "IoT solutions for smart farming: A comprehensive review on the current trends, challenges and future prospects for sustainable agriculture," *Journal of Forestry Science and Technology*, vol. 8, no. 2, pp. 28–35.
- Ikhsan, M., Andriyono K. Adhi, dan Harianto. 2024. Keberlanjutan Perkebunan Karet Rakyat Di Provinsi Riau. *Jurnal Agribisnis Indonesia (Journal of Indonesian Agribusiness)*. Vol 12 No 2, Desember 2024; halaman 259-273. <https://doi.org/10.29244/jai.2024.12.2.259-273>.
- Iswandi. 2014. Kebijakan dan Strategi Pembangunan Pertanian Di Sekitar Kawasan Pertambangan Emas Menuju Pembangunan Wilayah Tangguh dan Berkelanjutan. Prosiding Seminar Nasional ASPI 2014 Sustainable and Resilient Cities and Region. ISBN : 978-979-3793-65-8
- Kavanagh P, dan T.J. Pitcher. 2004. Implementing Microsoft Excel Software For Rapfish: A Technique For The Rapid Appraisal of Fisheries Status. *Fisheries Centre Research Reports* 12 (2). University of British Columbia. Canada.
- Li, X.P., Q.J. Wang, X.W. Wang. (2021). Heterogeneous public preferences for controlling agricultural non-point source pollution based on a choice experiment, *J. Environ.Manage.* 305, 114413.
- Lin, Hung-Chun and Yasuhiro Fukushima. 2016. Rice Cultivation Methods and Their Sustainability Aspects: Organic and Conventional Rice Production in Industrialized Tropical Monsoon Asia with a Dual Cropping System. *Sustainability*, 8(6), 529; <https://doi.org/10.3390/su8060529>.
- Leeuwis C. 2009. Communication for Rural Innovation, Rethinking Agricultural Extension. Yogyakarta (ID): Kanisius.
- Mapanje, Olga, Selma Karuaihe, Charles Machehe and Mao Amis. 2023. Financing Sustainable Agriculture in Sub-Saharan Africa: A Review of the Role of Financial Technologies. *Sustainability*, 15(5), 4587; <https://doi.org/10.3390/su15054587>.
- Maryono. 2018. Indeks Keberlanjutan Usahatani Padi di Tasikmalaya. *Jurnal Agribisnis Indonesia*, 6(1), 15-28. <https://doi.org/10.29244/jai.2018.6.1.15-28>.
- Müller, A., & M. A. G. (2020). The role of social networks in sustainable agriculture. *Sustainability*, 12(6), 1234. <https://doi.org/10.3390/su12061234>.
- O'Donoghue, T., Budiman M., and Alex M. 2022. Regenerative Agriculture and Its Potential to Improve Farmscape Function. *Sustainability*, 14(10), 5815; <https://doi.org/10.3390/su14105815>.
- Oko, P.E., Odey, D.U and Anake, C.B. 2022. Impact of population growth on biodiversity loss in Boki agro-ecological rainforests, CrossRiver State, Nigeria," *Global Journal of Pure and Applied Sciences*, vol. 28, no. 1, pp. 99–105.
- Rachman, A., & Faisal, M. (2020). Farmer Participation in Agricultural Groups and Its Impact on Sustainable Farming Practices in Indonesia. *Agricultural Systems*, 182, 102835.
- Ruhimat, R., Gunawan D., dan Sarjiya A., 2023. Pengaruh Pemberian Kompos Pada Pertumbuhan dan Produktivitas Tanaman Bawang Merah (*Allium cepa* L.). *Jurnal Ilmu Pertanian Indonesia (JIPI)*. Vol. 28 (4): 534–545. DOI: 10.18343/jipi.28.4.534.

- Sartini, P., Sari, D., & Wijaya, A. (2019). Farmer Groups and Collective Problem Solving for Sustainable Rice Production. *Agricultural Economics*, 50(6), 1082-1093.
- Schrama, M., de Haan, J.J., Kroonen, M., Versteegen, H., Van der Putten, W.H., 2018. Crop yield gap and stability in organik and conventional farming systems. *Agric. Ecosyst. Environ.* 256, 123-130.
<https://doi.org/10.1016/j.agee.2017.12.023>.
- Sevilla, C. G., Ochave, J.A. Pusalán, T. G., Regala, B. P., & Uriarte, G. G. (1993). *Research Methods*. Quezon City: Rex Printing Company.
- Sihombing, L. (2016). "Pemberdayaan Petani melalui Kelembagaan Koperasi dalam Meningkatkan Kesejahteraan Petani di Indonesia." *Jurnal Sosial Ekonomi Pertanian*, 12(3), 45-53.
- SOUT. 2017. Hasil Survei Struktur Ongkos Usaha Tanaman Padi. Badan Pusat Statistik Indonesia.
- Sugiyono. 2008. *Metode Penelitian Kualitatif Kuantitatif dan R&D*. Bandung: Alfabeta.
- Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.
- Sweeney, S. A., & Mulvey, R. (2021). Social Sustainability and Farmer Well-being: Investigating the Impact of Social Networks on the Resilience of Farmers to Economic Shocks. *Agricultural Economics*, 52(3), 345-358.
- Triyono, Kurniawati K., 2022. Farmers' Interest in Continuing Organik Rice Farming in Yogyakarta.
- Yusuf, Rahmawati. Fuadi, I., Nurhayati. Swastika, S., Sinaga, H. S. 2020. The Study of Economic Factors Affecting Sustainability of Rice Farming. *Advance in Biological Science Research*. Vol. 13
- Zhang, W., & Li, X. (2017). Economic and Social Impacts of Sustainable Rice Farming in Developing Countries: Evidence from China and Vietnam. *Environmental Management*, 60(5), 1046-1058.
- Zhang, W., et al. (2019). "Economic and environmental sustainability of rice production in the context of high input usage." *Agricultural Systems*, 174, 11-21.
- Zheng, X., Wang, Y., & Li, J. (2020). The Role of Social Capital in Sustainable Agriculture: A Case Study of Smallholder Farmers in China. *Agricultural Systems*, 178, 102734.
<https://doi.org/10.1016/j.agry.2019.102734>.