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SUSTAINABLE RICE FARMING IN INDONESIA

Ismail AY[1], Nainggolan MF[2]*, Andayani SA[3] and AY Isyanto[4]

Agus Yadi Ismail

*Corresponding author email: andonainggolan88@gmail.com

[1]Faculty of Forestry, Kuningan University, Indonesia

[2]Department of Agribusiness, Faculty of Agriculture, Universitas St Thomas Medan, Indonesia

[3]Faculty of Agriculture, Majalengka University, Indonesia

[4]Department of Socio Economic, Faculty of Agriculture, University of Galuh, Indonesia

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ABSTRACT

Rice is the main food in Indonesia, so increase in rice production must be achieved in a sustainable manner to maintain food security. The research case study is rice farming in Pancur Batu sub-district. The research method uses mixed methods (quantitative and qualitative) with quantitative dominance. The Objective of this study was to determine the implementation of sustainable rice farming in the Pancur Batu sub-district. The research tools used to evaluate the Sustainability Model in rice farming are Multi-Dimensional Scaling Analysis (MDS) with Rapid Appraisal Technique for Fisheries (RAPFISH) program analysis. indicators and criteria for the sustainability of rice farming are divided into ecological, economic and social dimensions, then input into the Rapid Appraisal Technique for Fisheries (RAPFISH) program. The results of the research showed that the social dimension had the highest sustainability index, namely 75.13 which indicates that the social dimension in the research location is quite sustainable, the ecological dimension with a sustainability index of 54.44 indicates that the ecological dimension is quite sustainable, and the lowest dimension value was the economic dimension with a sustainability index value of 43.58. This sustainability index value indicates that economic dimension of rice farming in the research location is not sustainable. The sustainability status of rice farming in the study area is multidimensional with an index value of 72. This index value indicates that the sustainability of rice farming in the study area is quite sustainable. The conclusion from this study was that the most sensitive and influential attributes for rice farming in the study area were: first, the ecological dimensions: (a) water availability, (b) pest attack rate, (c) land conversion rate; the economic dimension: (a) The price level of production inputs (fertilizers and pesticides), (b) The level of labor wages, (c) The level of availability of production inputs and social dimension which is counseling.

Key words: Sustainability, Rice Farming, Social Dimension, Economic Dimension, Ecological Dimensions, RAPFISHS

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INTRODUCTION

Rice is the main staple food of Indonesian society. It has become a habit and a necessity for people to consume rice every day. This means that the rice commodity can be used as a reference material in assessing the social welfare conditions of society in Indonesia. Therefore, planning is needed to prepare for community needs with sustainability analysis or future predictions [1].

The development of rice agriculture must be carried out in stages and continuously in the hope of increasing agricultural production as much as possible [2]. Along with the increasing food needs of the community, the application of sustainable rice farming is needed, one example is the utilization of rice straw waste to be used as fertilizer [3]. This increases farmers' income, so that rice farmers are more prosperous. Increasing income and welfare of farmers is the direction and goal of development and sustainability [4].

Increasing demand and supply of rice is one of the concerns of the government and researchers in Indonesia, due to the unstable productivity of rice farming caused by inefficiencies in the allocation of resources, little or no access to better varieties, and production in the hands of small- scale farmers who rely heavily on traditional technology [5-7]. Therefore, it is necessary to apply sustainable rice farming from ecology, economy, politics and culture [8].

The sustainability of rice farming in Indonesia should be a concern, especially in rice-producing centers [8, 9]. North Sumatra province is the third largest rice harvesting province after South Sumatra and Lampung. The harvested area is 400300.96 ha with a productivity of 51.87 kw/ha and production reaching 2,076,280.01 tons in 2020 [10]. One of the rice farming areas in North Sumatra is in the Pancur Batu sub-district which is in a lowland area bordering the Medan City area. Based on observations, most of the people in this area work in the rice farming sector. As a result of the conversion of agricultural land into housing, the community's agricultural land is increasingly narrow, so it is necessary to develop sustainable rice farming so that farming communities in this region can increase their welfare [11].

Improving the capabilities of farmers and their families as subjects of agricultural development through a group approach to play a greater role in the development of sustainable rice farming [12,13]. Some experts argue that a business feasibility study is a study of whether or not a business project, which is usually an investment project, is feasible or not. A business feasibility study is a material consideration in making a decision, whether to accept or reject a business idea or a planned business project [14-16].

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In line with the influence of industrial development, concern for the sustainability of food agriculture in Indonesia must be the main focus for researchers. The purpose of this research was to find out how the sustainability of rice farming is implemented in the Pancur Batu sub-district.

MATERIALS AND METHODS

The sampling method (sample) used in this study was the census method. The census method is a method that examines all elements in the research area, therefore this census method is a population study [17, 18, 23]. The sample group in this study were farmers who had registered with farmer groups, totaling 152 respondents. Data collection from each respondent was carried out using in-depth interviews and providing questionnaires to be filled in by each respondent. The research method for evaluating the Sustainability Model of rice farming uses the Multi-Dimensional Scaling (MDS) Analysis developed by the Fisheries Center University of British Colombia. Multi-Dimensional Scaling (MDS) analysis aims to analyze the sustainability of rice farming in Baru Village from three dimensions. The ecological, economic and social dimensions are based on the Standard Indicator Principles and Criteria for sustainable rice farming with a modified ordination technique from the RAPFISH (Rapid Appraisal Technique for Fisheries) program. These modifications were carried out by developing or changing indicators on each dimension and dimensions that were used because they were adjusted to the system or topic and scope of research [17, 23]. Sustainability analysis with the RAPFHIS technique began with reviewing, identifying and defining the attributes used. After that, an assessment (scoring) of the attributes analysis was carried out. In this research the scale used to interpret the sample was 1-5. Scoring was based on the provisions set out in the RAPFISH technique. The assessment results are then input into MS-Excel and then processed using RAPFISH software. Based on the input of attribute score results which are arranged in the 'Rap Scores' matrix in the form of a MS-Excel software worksheet, data processing is then carried out in the RAPFISH software. The results of the analysis were then strengthened by using Leverage Analysis and Monte Carlo Analysis. The following attributes were used in each dimension in RAPFHIS [17, 23].

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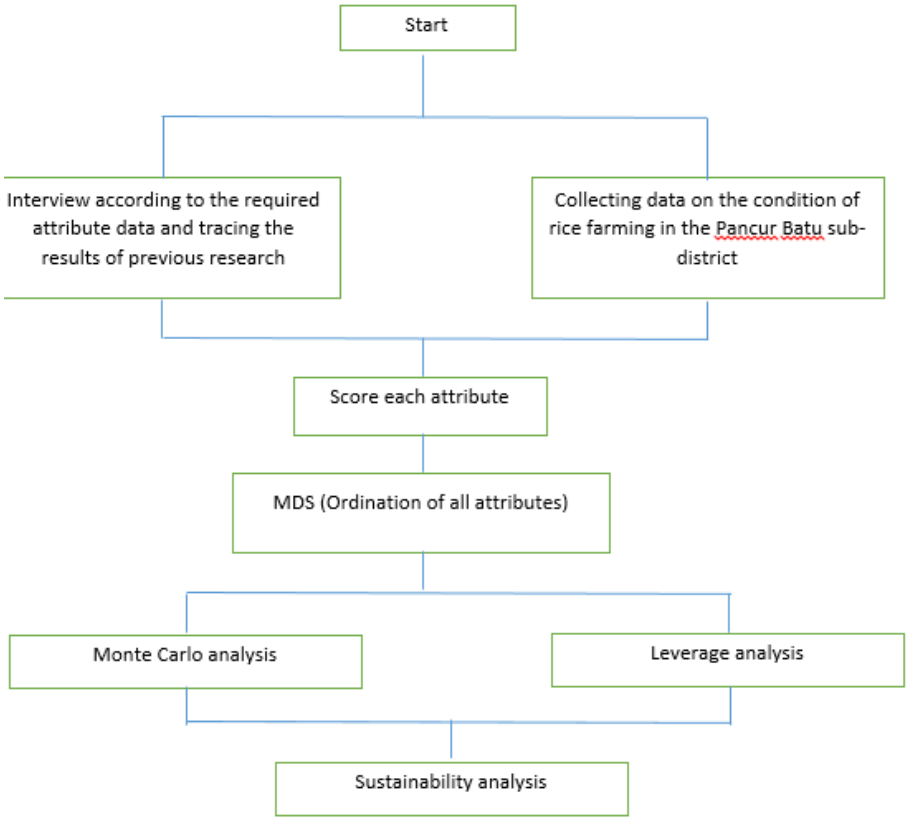

Figure 1: RAPFHIS Analysis Stages

The analysis of the sustainability of rice farming in Indonesia was carried out using the Multi Dimensional Scaling (MDS) approach called RAPFISH [23] then strengthened with the Monte Carlo test, then to find out the most influential attributes as leverage. Each attribute that has been compiled and filled in with existing data conditions is then analyzed using MDS [18]. The score of each indicator was analyzed multidimensional to determine one or several points that reflect the position of sustainability in the five dimensions studied relative to two reference points, namely the good point and the bad point. Scores were analyzed with RAPFHIS to determine sustainability status [17,18].

RESULTS AND DISCUSSION

Assessment of the sustainability status of rice farming in Pancur Batu sub-district using the RAPFHIS method in a multidimensional manner and on the 3 dimensions of sustainability, including the economic dimension, the social dimension, and the ecological dimension.

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Social dimension

The results of the RAPFHIS analysis for the Social Dimension, the index value of the sustainability index for the Social Dimension of Rice Farming in Baru Village was at a value of 75,86 entering the range of values 51 - 75, the social dimension category was "quite sustainable". The sustainability position of the Social Dimension is explained in more detail by the following Figure 2.

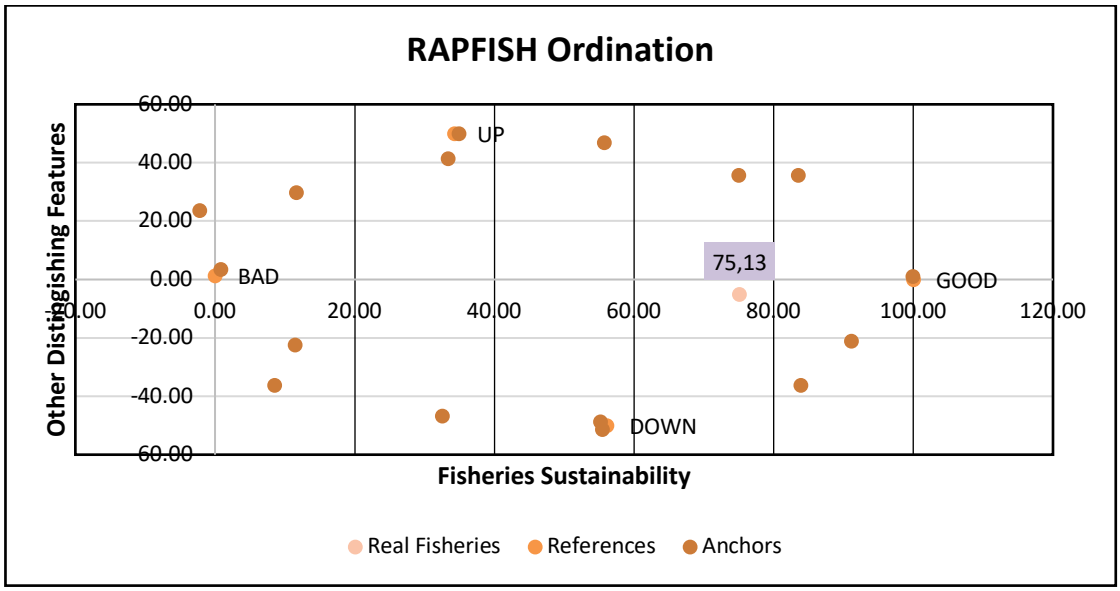

Figure 2: Social Dimensional Sustainability Position

Results of the RAPFHIS analysis show that the sustainability position of the Social Dimension of Rice Farming in Baru Village was in the range of 75.13, this value indicates that rice farming in Baru Village has a relatively good level of sustainability in the social dimension. This position is obtained by comparing the value of the sustainability index of the social dimension with the economic dimension. The results show that sustainability in the social dimension is higher than the economic dimension. The results of the analysis show that the goodness of fit or fit of the model is in the fair category with a coefficient of determination (R^2) of 0.867. A high R^2 value indicates that the MDS model is quite good at describing the relationship between objects in the dimensions being analyzed. The S-Stress value achieved in this analysis was 0.20 or 20%. The lower the S-Stress value, the better the resulting multidimensional representation. In this case, the S-Stress value of 0.20 indicates that the MDS analysis succeeded in creating a fairly accurate representation of the actual distance between the observed objects. Overall, the results of the analysis show that the social dimension of rice farming in Baru Village has a better level of sustainability than the economic dimension. The ordinate analysis with MDS also gives adequate results, with fairly good model fit and fairly accurate multidimensional representation [19]. This information provides a deeper understanding of the sustainability of the social dimension of rice farming

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in Baru Village and can be the basis for sustainable decision-making in the development of rice farming in the region.

Ecological dimension

The requirement for sustainable natural resource processing is to maintain the function of the previous natural resources, besides that it must have Eco-Efficiency criteria which means efficient both economically and ecologically. The ecological dimension is a key dimension because it can determine the balance of utilization of Natural Resources and environmental services. The measurement of the sustainability of the Ecological Dimensions in Desa Baru uses 8 measurement attributes which are analyzed using the RAPFHIS analysis. Ecological attributes were chosen to reflect how the use of natural resources and the environment has an ecological impact on sustainability [17, 23]. Based on the results of the RAPFHIS analysis, the sustainability index value of the Ecological Dimensions of rice farming in Baru Village is 54.44 and is in the "quite sustainable" category as shown in the Figure 3 below.

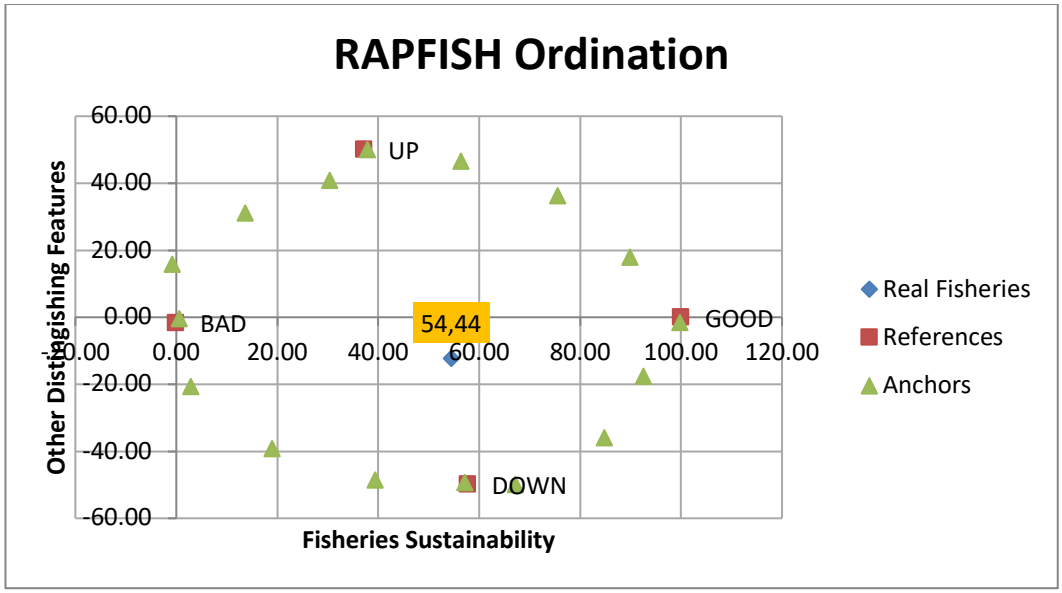

Figure 3: Ecological Dimensional Sustainability Position

Coordination analysis on the sustainability of the Ecological Dimension was carried out with 2 (two) iterations, resulting in a value of (R^2 = 0.883) and an S-Stress value of 0.18 or 18%. In this case, the R^2 value of 0.883 indicates that the model has a fairly good fit with the data used in the ordinate analysis. This indicates that the variables used in the ecological analysis of rice farming in Baru Village managed to explain about 88.3% of the variation in the data. The S-Stress value of 0.18 or 18% shows that the ecological dimension analysis in this research shows the goodness of fit condition is in the fair category. Analysis in Multidimensional Scaling (MDS) is said to be good and acceptable if the S-Stress value is <25% or

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(<0.25) and the value (R^2) is close to 1 or 100% [17, 23]. The S-Stress value is used to measure the extent to which the multidimensional scaling (MDS) model represents the spatial relationship between objects in the data being analyzed. The lower the S-Stress value, the better the model's representation of the spatial relationships of objects [17, 20, 23].

In this case, the S-Stress value of 0.18 or 18% indicates that the ordinate model successfully represents the spatial relationships between objects in the data quite well [21]. Although there is no standard criterion for evaluating the S-Stress score, generally a lower score indicates a better quality of representation [22]. Based on the s stress and R^2 values obtained, the sustainability analysis of the Ecological Dimensions of rice farming in Baru Village shows the goodness of fit condition in the fair category [21,23,22]. This shows that from an ecological perspective, the sustainability of rice farming in Baru Village is quite good.

Economic Dimension

One of the requirements in sustainable agricultural management is economic efficiency. From the analysis carried out, the results of the analysis of the Economic Dimensions for the sustainability of rice farming in Baru Village using the RAPFHIS software are shown in the Figure.4 below.

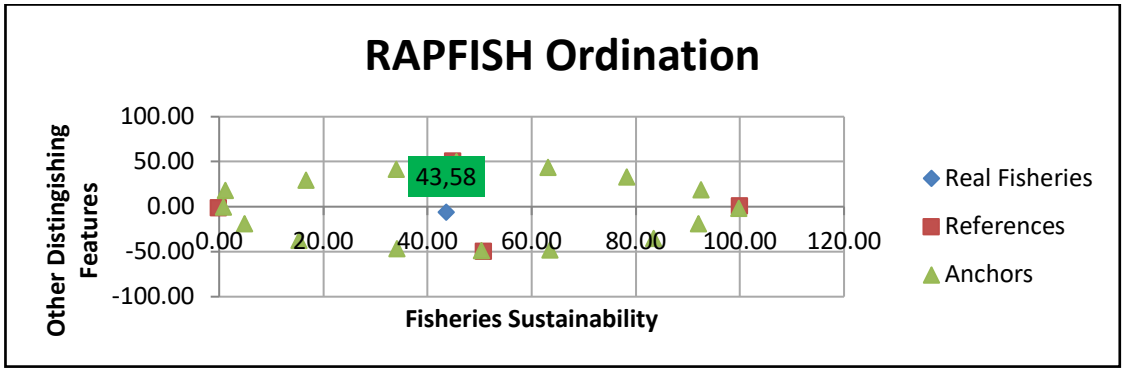

Figure 4: Economic Dimensional Sustainability Position

The results of the analysis using RAPFHIS software on the economic dimension, shows that the index value for the sustainability of the economic dimension of farming in Baru Village is 43.58. Scores indicate “less sustainable” based on the 26-50 range [17, 23]. The assessment of the sustainability index for the economic dimension of farming is based on the attributes observed in the analysis of the sustainability of rice farming in Baru Village. The "less sustainable" category shows that the economic sustainability of rice farming in Baru Village still has a number of challenges and improvements that need to be made. This may indicate problems in the economic aspect that affect rice farming in Baru Village, such as limited access to markets, low production efficiency, lack of income diversification, or other problems that may affect the sustainability of rice farming. Coordination

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analysis in the Economic Dimension with a number of iterations of 2 (two), produces R^2 = 0.8605 and an S-Stress value of 0.21 or 21% [21, 22, 23]. Thus, the analysis of the Economic Dimensions in this study shows that the goodness of fit condition is in the fair category, in the Multidimensional Scaling (MDS) analysis it is said to be good and acceptable if the S-Stress value is <25% or (<0.25) and the R^2 value is close to 1 or 100%. This shows that the attributes tested in the Economic Dimension can explain or approach the model 100% of the original model [17, 22].

The results of the analysis, of the 3 dimensions of sustainability, namely the economic dimension, social dimension, and ecological dimension are shown in Table 1.

Table 1 shows that the S-Stress value is between 0.18 – 0.22 is an indicator used in multidimensional scaling (MDS) analysis to measure the extent to which the attribute configuration reflects the original data. The low range of S-Stress values indicates that the attribute configuration in the RAPFISH analysis is quite accurate and is able to reflect the original data well. The R^2 value is between 0.88 – 0.87 and this means that the goodness of fit value in the RAPFISH analysis has been fulfilled. The coefficient of determination (R^2) value describes the attribute's ability to explain and contribute to the sustainability feasibility of the system being analysed [17]. The S-Stress value is an attribute configuration that can reflect the original data so that it can be stated that these indicators are statistically accurate [23]. The difference between the MDS and Monte Carlo analysis at the 95% confidence level or 5% error rate is between 0.01 – 2.72, so the impact of scoring errors in the analysis is relatively small. The value of the difference between the two analyses is <5%, so the results of the MDS analysis are sufficient as an estimator of the sustainable index value.

Overall, this analysis provides an understanding of the accuracy and sustainability of the RAPFISH analysis using S-Stress and R^2 values. The results of this analysis indicate that the configuration of the attributes in the RAPFISH analysis is quite accurate, the attributes analysed contribute to the sustainability of the system, and the results of the analysis can be statistically justified [23, 24]. In addition, the difference between the MDS and Monte Carlo analysis is also considered insignificant, so that the MDS analysis is sufficient as an estimator of the sustainable index value.

Rice farming Sustainability Status

The results of multidimensional RAPFHIS analysis using the multidimensional scaling (MDS) method produced a rice farming sustainability index value in Baru Village of 72.26. These results show that the sustainability analysis of rice farming is in the "quite sustainable" category. The S-Stress value is 0.16 which shows a

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good level of accuracy in representing data in two-dimensional space [23,25]. The lower the S-Stress value, the better the visual representation of the data and an R^2 value of 0.920 which indicates that the MDS model can explain about 92% of the variability in the data, as shown in the following ordination scale figure.

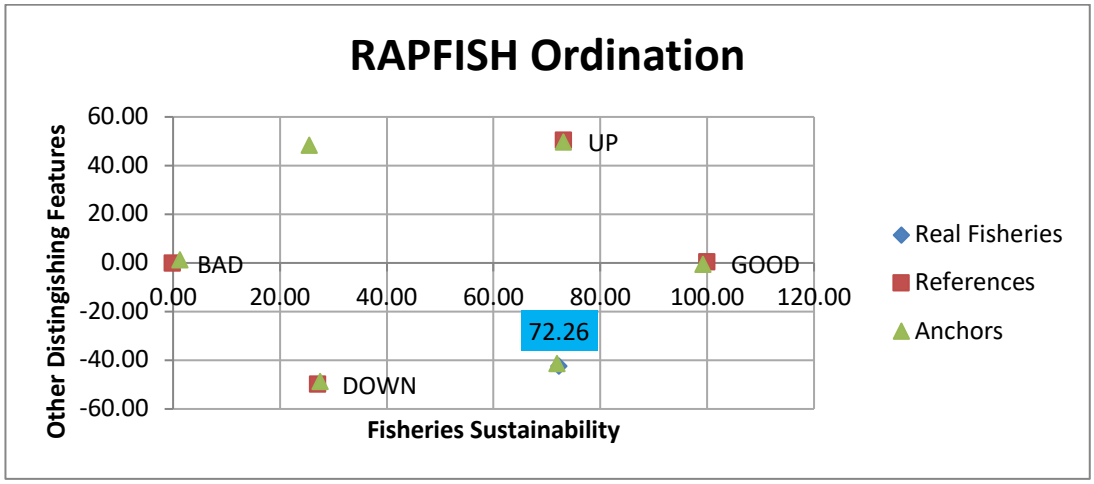

Figure 5: Agriculture Sustainability Index in Baru Village

Rapid Appraisal of Farming Systems analysis in Figure 5 shows the index value of multidimensional rice farming sustainability in Desa Baru at 72.26. This value reflects the level of sustainability of the rice farming in the village based on the calculation of a combined analysis of the three main dimensions, namely economic, social and ecological [22, 23, 24].

The economic dimension refers to aspects related to financial and economic aspects of rice farming. Productivity factor, efficient use of resources, and the balance of income and business costs are some of the indicators that may be taken into account in the economic dimension. The sustainability index value generated in this dimension can provide an overview of the extent to which rice farming in Baru Village contributes to the economic welfare of farmers and the financial sustainability of the business [26].

The social dimension includes aspects related to social interaction, justice, participation, and community involvement in rice farming. This involves consideration of the impact of rice farming on local communities, the relationship between farmers and other stakeholders, and the existence of participatory mechanisms in making decisions related to rice farming [27]. The value of the sustainability index in this dimension can provide insight into the extent to which rice farming in Baru Village promotes social welfare and community integration.

The ecological dimension is related to environmental aspects and the sustainability of the surrounding nature in rice farming. Factors such as sustainable use of natural resources, biodiversity, soil conservation and mitigation of negative impacts

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on the environment are some of the things that might be taken into account in this dimension [23, 25, 28]. The sustainability index value in this dimension can provide an overview of the extent to which the rice farming in Baru Village manages natural resources responsibly and maintains the balance of the ecosystem.

By considering all these dimensions and applying a combined analysis, the results of the RAPFHIS analysis show that the index value of rice farming sustainability in Desa Baru is 72.26. This value indicates a relatively good level of sustainability.

Each dimension has attributes that become parameters for the sustainability of rice farming in Baru Village. The farming sustainability index value is obtained based on an assessment of the 24 sustainability attributes of each dimension which is explained in more detail by the following Figure 6.

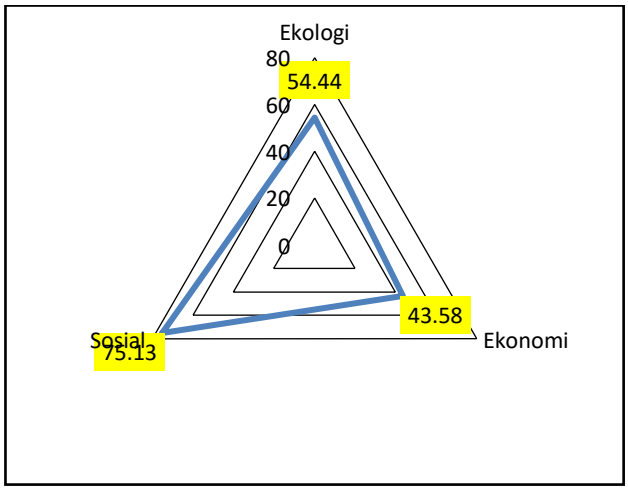

Figure 6: Flowchart of Rice Farming Sustainability Index

The sustainability index value for each dimension projected in Figure 6 means that the further the sustainability point from the number 0, the greater the sustainability value. Chart diagrams are often referred to as “radar” diagrams where the closer the analysis distance is to the zero point, the more it shows low sustainability and vice versa. Based on the fly chart, it can be seen that the sustainability index value for the economic dimension has the lowest value, followed by the ecological and social dimensions [25,26,29]. The sustainability index value of each dimension based on the fly chart is still not precise, meaning that each dimension of sustainability is still not applied evenly and in a balanced way. Chart diagrams can describe the status of sustainability of rice farming in Baru Village in an integrated manner between the various dimensions of sustainability.

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CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

Sustainability status of rice farming in the study area is multidimensional with an index value of 72.26. The social dimension has the highest sustainability index, namely 75.13 (quite sustainable), then the ecological dimension with a sustainability index of 54.44 (sustainable enough), and the lowest dimension value is the economic dimension with a sustainability index value of 43.58. The most sensitive and influential attributes of rice farming in the study area are the Ecological Dimensions: (a) Availability of water, (b) Level of pest attack, (c) Land conversion rate. The most sensitive and influential attribute on rice farming in the study area is the Economic Dimension: (a) The price level of production inputs (fertilizers and pesticides), (b) The level of labor wages, (c) The level of availability of production inputs. The most sensitive and influential attribute on rice farming in the research area, namely the Social Dimension, is agricultural counseling.

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AUTHOR CONTRIBUTION

Agus Yadi Ismail is the main researcher who conceptualized the research. She did data analysis and interpretation. Mai Fernando Nainggolan is a co-researcher that conducted the RAPFISH analysis and wrote the manuscript. All were key in development, drafting and finalizing of this manuscript.

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Table 1: Results (Goodness of fit) from the RAPFHIS analysis and the sustainability status of rice farming in Baru Village

Kriteria	MDS	Monte Carlo	Selisih	S-Stress	R^2
Multidimensional	72,26	70,93	1,33	0,16	0,920
Ekologi	54,44	44,49	0,05	0,18	0,883
Ekonomi	43,58	41,75	1,83	0,21	0,860
Sosial	75,13	72,41	2,72	0,20	0,867

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