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Research Article
Index and Sustainability Status of Economic Dimension for Wetland Rice Business in Siak Regency, Riau, Indonesia

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Abstract

Background and Objective: Rice as a food-producing crop is a highly sensitive commodity in terms of political, economic and social vulnerabilities in Indonesia. This study aimed to analyze the index and the sustainability status of the economic dimensions of wetland farming. It also attempted to evaluate the role of each economic attribute that has a sensitivity to the future management of wetland rice in Siak Regency. **Materials and Methods:** Data from Siak Regency was collected through interviews, questionnaires and field observations. The index and sustainability status were analyzed using the Rap-rice method with Multidimensional scaling (MDS). **Results:** The results of the Rap-rice analysis of 9 economic attributes were analyzed, 2 attributes lended sensitivity to the Bunga Raya sub-district, 5 attributes lended sensitivity to Sungai Apit district, 4 attributes lended sensitivity to Sabak Auh and Sungai Mandau. The attribute of dependency on farming as a source of income and the price of harvested unhulled rice was only sensitive for the Sungai Apit sub-district. The attributes of economic efficiency and availability of production facilities were sensitive for the districts of Sabak Auh, Sungai Apit and Sungai Mandau, while the marketing attributes of agricultural products provided sensitivity to the districts of Sabak Auh and Sungai Mandau. **Conclusion:** Based on economic conditions, the analysis of paddy rice farming in Siak Regency provided a sustainability index value of >50%, being fairly sustainable for Sabak Auh, Sungai Apit and Sungai Mandau and greatly sustainable for Bunga Raya.

Key words: Index and sustainability status, economic, wetland rice, siak regency, Indonesia

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice is a food-producing crop and economically, it is a strategic commodity. The strategic role of rice in the national economy comes from it being a staple food for 95% of Indonesia's population. It can move the economy through its demand for and the subsequent formation of various seed companies, fertilizers, pesticides, tools and agricultural machinery[1]. Economic assessment of the function of agricultural land is essential as an input for policy setting. According to Chen[2], the assessment method used is generally an indirect calculation including Replacement Cost Method (RCM), Contingent Valuation Method (CVM) and Travel Cost Method (TCM). Nationally, the economic value of rice fields in South Korea was USD 9,751-11,458 million[3]. In Japan, the multi functional value of national agricultural land and the value of hills and mountains were measured. The results of the assessment were JP¥ 6,878.9 billion/year for paddy fields and hill areas and 3,031.9 billion yen/year[4] for mountain areas. Agus and Husen[5] considered that the two functions of agricultural land that were not counted were the prevention of landslides and air cleaning. Furthermore, it was explained that the value of the benefits lost due to 15% of the converted paddy fields was USD 39,447,130/year. Sumaryanto *et al.*[6] stated that the conversion of one ha of paddy fields would cause a loss in farming activities worth IDR 2.3 million/planting season and IDR 900,000/planting season to a farmer's income and the income of farming groups, respectively.

The rice industry has an enormous influence on economics (in terms of employment, growth and rural economic dynamics, as it is a wage good), environment (maintaining water use and air cleanliness) and socio-politics (unifying the nation, maintaining order and security). Rice is also the primary source of nutrition for Indonesian people, including carbohydrates, protein, fat and vitamins. Taking into account the importance of rice, the government always strives to improve food security and food sovereignty, particularly of those rice varieties that developed from increased domestic production[7]. These considerations are becoming increasingly crucial for Indonesia because of a large growing population which widely distributed and geographically scattered. Indonesia requires a sufficient and nation-wide coverage of food stock to meet the food needs of its population[8,9]. Increasing rice production and productivity must be sought at all times to ensure food security for the entire community. One of the government's leading programs in developing and increasing rice production was an extensification and intensification program. In Siak, the extensification program was carried out in 5 sub-districts (Pusako, Kandis, Tualang, Koto Gasip and Mempura). These sub-districts became the development sites of rice plantations (land clearing for new rice fields) covering an area of 5,041 ha. Simultaneously, an intensification program was carried out at rice production centers spread across four sub-districts: Bunga Raya, Sungai Apit, Sabak Auh and Sungai Mandau[10].

Rice production from these four sub-districts contributed to 98% of the production of dry milled rice in Siak Regency. This contribution makes the Siak district government continue to strive to increase production and productivity and to maintain the sustainability of these farming practices. Sustainable agriculture embodies current social and economic needs without reducing the ability of future generations to fulfill their own needs. The process of sustainable agricultural production leads to an increased use of environment-friendly biological products. If farmers do not pay attention to environmental aspects, agricultural development cannot be declared sustainable. Sustainable agricultural development includes activities that are economically, ecologically and socially sustainable[11,12].

Economic sustainability means that a development activity must produce growth and provide economic benefits. According to Sudrajat[13], the economic benefits of paddy fields received by humans both directly and indirectly include food production, employment opportunities in the agricultural sector, local sources of income, sources of community income and tourism facilities. These benefits can be utilized by the next generation if the current generation is able to maintain its sustainability[7,11,12,14]. The purpose of this study was to analyze the index and economic sustainability status of wetland rice farming and to analyze the role of each economic attribute that has a sensitivity to the management of wetland rice in the future development of rice farming in Siak Regency.

MATERIALS AND METHODS

Time and location: This research was carried out over 7 months from January-July, 2018, in 4 wetland rice-producing sub-districts of Siak Regency, namely Bunga Raya, Sabak Auh, Sungai Apit and Sungai Mandau.

Data types and sources: The data in this study were grouped into 2 types: Primary data and secondary data. The primary data was obtained through direct observation in the fields (field observation) and the results of in-depth interviews of 203 farmers and 20 stakeholders. Informants were selected using purposive sampling and identification of stakeholders was carried out by the snowball sampling method where

stakeholders recommended other stakeholders as respondents[15]. The number of farmer samples was calculated using the Slovin equation as mentioned in Ryan[16] with an error margin of 7%. The secondary data was obtained from documents published by the Siak Regency government, Siak Agriculture Service and the Siak Regency Central Statistics Agency in the form of sub-district profiles, monographs, agricultural census books, research results, reports and other documents related to legislation, duties and plans of strategic management owned by each relevant agency.

Method of analysis: The status of sustainability of wetland rice was expressed in the form of a sustainability index based on the Rap-rice quantification by applying the MDS (Multidimensional Scaling) technique[17,18]. The Rap-rice approach was modified from the Rapfish (Rapid Assessment Techniques for Fisheries) program developed by the Fisheries Center, University of British Columbia[19,20]. The MDS method is a statistical analysis technique that transforms every dimension of and the multidimensional facets of the sustainability of lowland rice farming[21]. According to Nurmalina[22], the MDS technique maps two points of the same object at a point that is close together, whereas different objects or different points are represented by points that are far apart.

Multidimensional Scaling is a collection of statistical techniques for analyzing similarities and dissimilarities between objects. It gives results in the form of plots of dots so that the distance between points represents a degree of similarity or dissimilarity and provides clues to identify unknown variables or factors that influence the appearance of similarities or dissimilarities[17].

Rap-rice ordination analysis was carried out in 5 stages:

- Determining attributes
- Assessing each attribute on an ordinal (scoring) scale
- Analyzing the Rap-rice ordination to determine the ordination and stress values through ALSCAL algorithm
- Rotating to determine the position of the index and the status of sustainability of rice farming management in good and bad ordination
- Conducting sensitivity analysis (leverage analysis) and Monte Carlo analysis. Sustainability indicators are tools that are used to provide information directly or indirectly about the future viability of a system from various levels of objectives. It is considered valuable because it will inform subsequent system planning and development. Stress value of <25% is an acceptable stress value

The method of determining the sustainability index of rice farming using the Rapfish technique was carried out based on predetermined systematics. According to Liu and Zhang[14], determining the index and sustainability status is based on these stages: (1) Assessing the attributes of each sustainability dimension and assessing these attributes based on actual data through field observations, expert interviews and literature studies, (2) Scoring the attributes of each dimension of sustainability and then analyzing them in Microsoft Excel[23] by using a template that has been prepared previously, so that a value known as the sustainability index is obtained, (3) Categorizing the sustainability index value based on the sustainability interval to obtain the sustainability status. The interval for the value of the sustainability score for each dimension includes: bad (0.00-25.00), less (25.01-50.00), sufficient (50.01-75.00) and good (75.01-100.00). Another result obtained in the MDS analysis is the determination of leverage factors, which are strategic factors for managing rice farming in the future[24].

RESULTS

Index and sustainability status of the economic dimension of wetland rice management in Siak Regency: The index and the sustainability status of the economic dimension of managing wetland rice farming in Siak Regency were determined based on the results of calculations and interviews with farmers in the region. The interview results were tabulated to determine the value of each attribute. Leverage analysis was carried out to determine the attributes that have a sensitivity to the sustainability of lowland rice farming management in the economic dimension. Attributes that were estimated to have an influence on the economic dimension included: farmer's income level, price of milled dry rice, availability of farmer's capital, availability of production facilities, economic efficiency, potential for agro-tourism, dependence on rice farming as a source of income, marketing facilities for agricultural products and fulfillment of production (Fig. 1, Table 1). Based on Rap-rice analysis (Fig. 1), the values of the sustainability index were higher than 50% for all sub-districts (Bunga Raya 80%, Sabak Auh 52%, Sungai Apit 55% and Sungai Mandau 52%). These values were categorized as fairly sustainable.

The Rap-rice analysis also produced an output in the form of leverage of attributes. Leverage analysis aim to determine sensitive attributes that influence the sustainability index value of all dimensions. This indicates the magnitude of the role of each attribute to sensitivity and to sustainability status.

Table 1: A score of economic dimension and attributes of sustainability for the management of wetland rice farming in four sub-districts in Siak Regency

Attributes	Status		Explanation	Score			
	Good	Bad		BR	SAu	SAp	SM
Farmers' income level (UMK, Kab. Siak, 2018)	3	0	(0) Low≤Rp 2,6 (1) Medium>2,6-3,25 jt (2) High>3,25-3,9 jt (3) Very High>3,9 jt	2	0	0	0
The price of unhulled rice (Kementan, 2017)	2	0	(0) Below HPP (<Rp 3.700) (1) Equal to HPP Rp 3.700 (2) Below HPP>3.700	2	2	2	2
Availability of farmers' capital (Rapfish, Tesfamichael dan Pitcher, 2006)	3	0	(0) No capital (1) Lack of capital (2) Sufficient capital (3) No problem with capital	1	1	1	1
Availability of production facilities (Rapfish, Tesfamichael dan Pitcher, 2006)	1	0	(0) Not available (1) Available but not sufficient (2) Available and sufficient	2	1	1	1
Economic efficiency (Rapfish, Tesfamichael dan Pitcher, 2006)	2	0	(0) BCR<1 (1) BCR=1 (2) BCR>1	2	2	2	2
Agrotourism potential (Rapfish, Tesfamichael dan Pitcher, 2006)	3	0	(0) NA (1) Exist, not managed (2) Exist, starting managed (3) Exist, well managed	2	1	1	1
Dependence on farming as source of income (Rapfish, Tesfamichael dan Pitcher, 2006)	2	0	(0) Low (<50%) (1) Medium (>50-75%) (2) High(>75%)	2	1	0	1
Marketing of farming products (Rapfish, Tesfamichael dan Pitcher, 2006)	2	0	(0) Difficult (1) Medium (2) Easy	2	2	1	2
Fulfillment of production facilities (Rapfish, Tesfamichael dan Pitcher, 2006)	2	0	(0) Not fulfilled (1) Less fulfilled (2) Fulfilled	2	1	1	1

BR: Bunga Raya, SAu: Sabak Auh, SAp: Sungai Apit, SM: Sungai Mandau

Table 2: Value of stress, coefficient of determination and effect of ecological dimension error

Kecamatan	Sustainability index (MDS)	Stress	R^2	Monte carlo analysis*	Differences (MDS-MC)
Bunga Raya	80.10	0.14	0.95	77.70	2.40
Sabak Auh	52.90	0.14	0.95	52.50	0.40
Sungai Apit	55.70	0.14	0.95	55.70	0.50
Sungai Mandau	52.90	0.14	0.95	52.90	0.50

*Error at 95% confidence level, index value of 25.01-50.00 is categorized as less sustainable, index value of 50.01-75.00 is categorized as quite sustainable, stress value <0.25 means goodness of fit, value of R2> 80% or close to 100%, contribution is very good

Therefore, the higher the RMS value, the greater the influence of these attributes on sustainability sensitivity. Leverage attributes were attributes that gave the highest percentage value in the sustainability of a management dimension (Fig. 2).

Stress value, determination coefficient and effect of economic dimension errors: The configuration accuracy of a point that reflects the original data can be measured by looking at the stress value from the analysis of Rap-rice ordinance on each dimension analyzed. The ability of each attribute to explain and contribute to the sustainability of the system was studied by looking at the coefficient value (R^2) of each dimension analyzed. The value of stress and the coefficient of determination and effect of the ecological dimension are presented in Table 2.

DISCUSSION

Index and sustainability status of the economic dimension of the wetland rice management in Siak Regency: Figure 1 illustrates that the management of lowland rice farming did not experience economic pressure and the ability of natural resources to provide environmental benefits and services was still quite high.

The sustainability of the economic dimension in Siak Regency had the support of the local government in various forms. Those included assistance with agricultural machinery and equipment, maintaining road farming and making and maintaining irrigation channels to ensure the availability of water for the plant. If the availability of water could be fulfilled

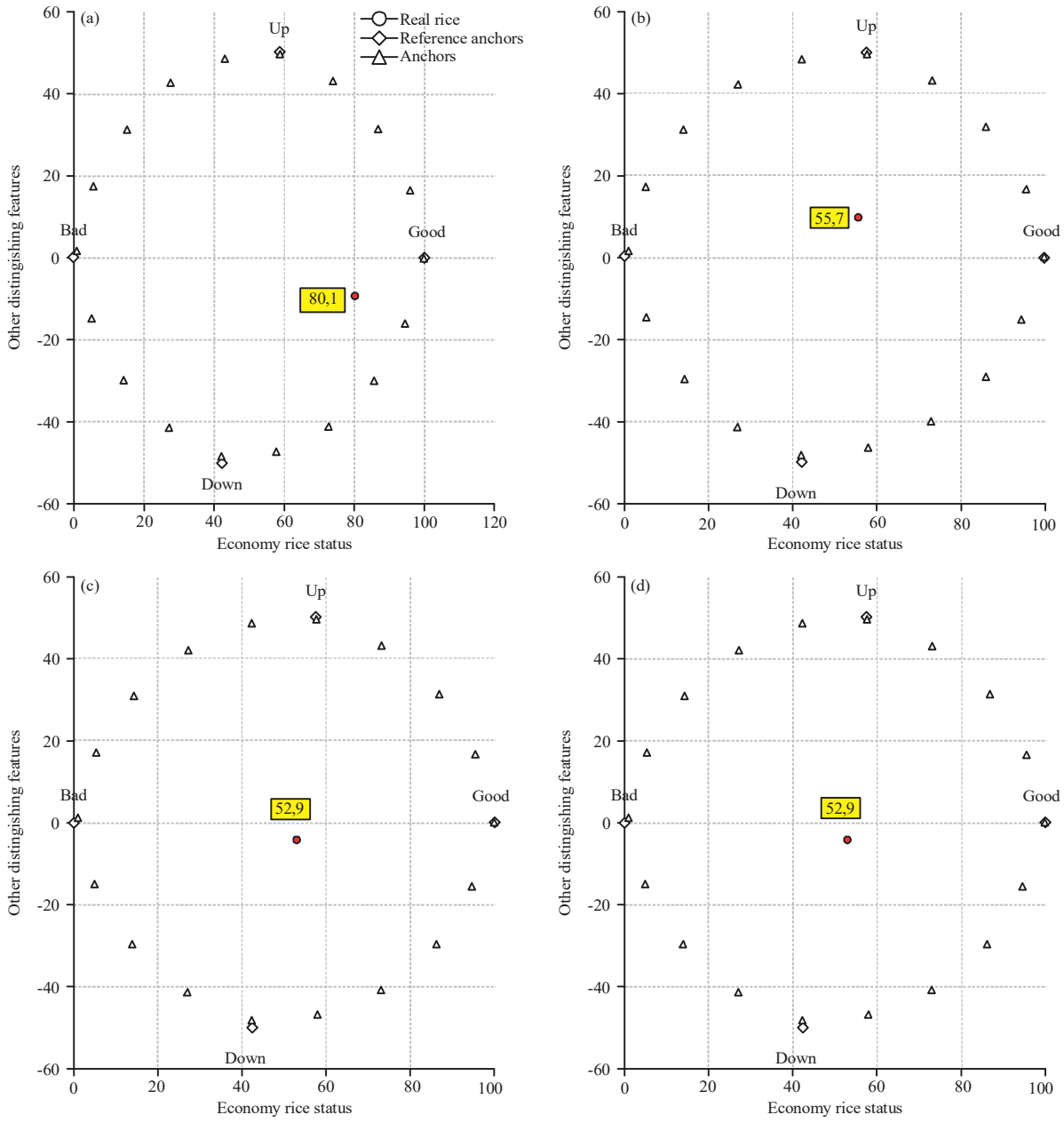

Fig. 1(a-d): Economic dimension sustainability index in 4 sub-districts in Siak Regency (a) RAP-rice ordination at Bunga Raya, (b) At Sungai Apit, (c) At Sabak Auh and (d) At Sungai Mandau

the crop index and the rice production would increase, which in turn affected the welfare and income of farmers. According to Irawan *et al.*[25], in general, rice production was still low due to low productivity and smaller harvest area. There were several causes of low productivity, such as inadequate irrigation capacity, limited adoption of technological innovations and limited capital of farmers. All of these conditions led to limited farmers' access to production inputs[26].

The potential attributes of agro-tourism lended sensitivity to the sustainability of wetland rice management from an economic dimension in all the study areas. The development of agro-tourism could be used to develop alternative economic sources in the study area. Therefore, agro-tourism infrastructure such as adequate roads, irrigation facilities, telecommunications networks, banking facilities, agricultural production processing facilities, public facilities and other social facilities needed to be prepared. Agro-tourism area

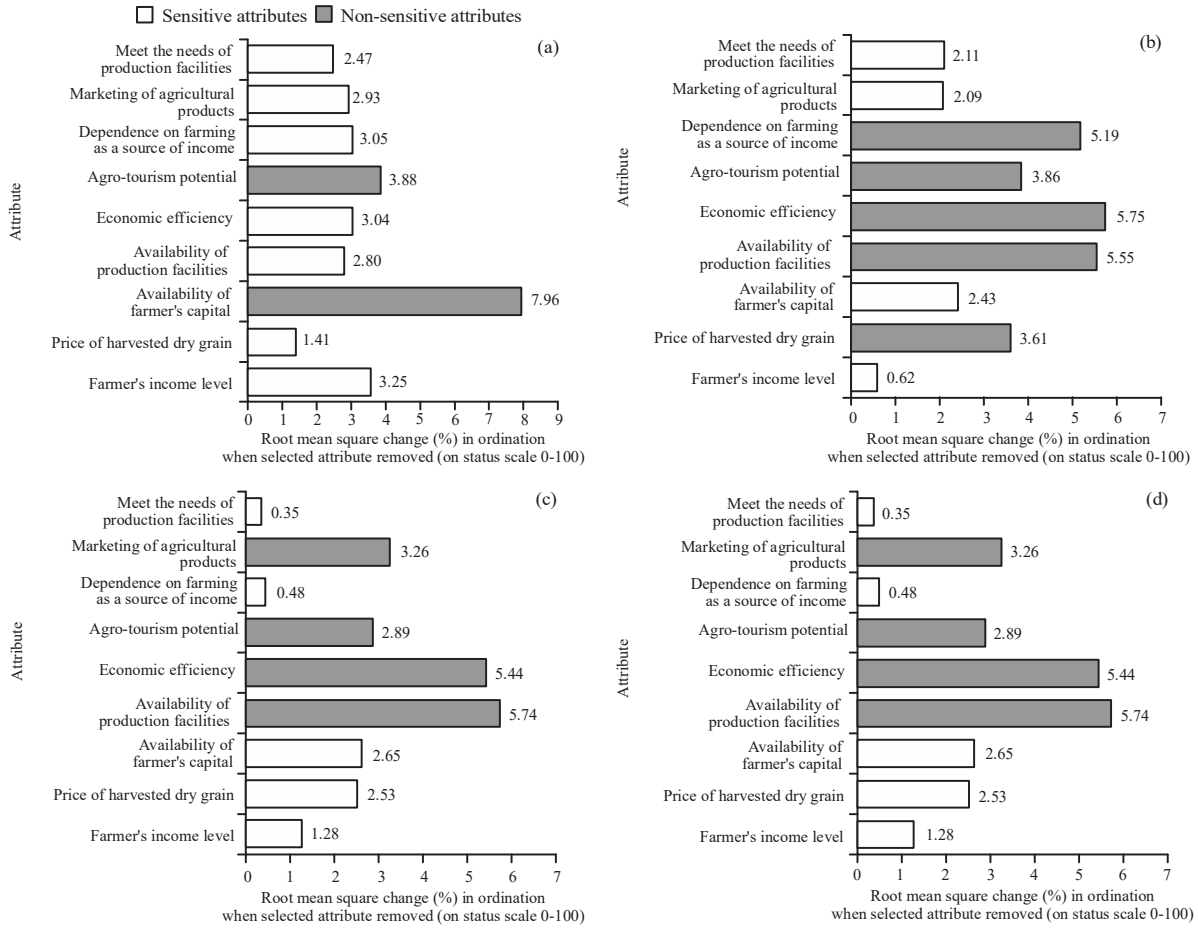

Fig. 2(a-d): Role of each attribute of the economic dimension in 4 sub-districts in Siak regency which are expressed in the form of RMS values (root means square) (a) Leverage of economy attributes at Bunga Raya, (b) At Sungai Apit, (c) At Sabak Auh and (d) At Sungai Mandau

development must be developed in an integrated manner with related sectors such as agriculture, animal husbandry, fisheries, hotels, travel agencies, industry, arts and culture within the framework of territories and integrated regional management. Agro-tourism could be developed from other sectors that are expected to be able to support sustainable economic development. This statement is consistent with Nnadi and Akwiwu[27] and Handayani[28], who stated that agricultural resources have the potential to be developed into agro-tourism and agro-tourism development could be an opportunity for local farmers to increase their income and the quality of family life. The government's limited attention to agro-tourism was one of the factors behind the small economic value obtained from agro-tourism attributes.

Economic efficiency and dependence on the availability of production facilities provided high sensitivity for 3 sub-districts, namely Sabak Auh, Sungai Apit and Sungai Mandau. The lack of availability of production facilities, such as the unavailability of quality seeds due to late arrivals, unsuitable varieties and scarcity of subsidized fertilizers, have resulted in non-optimal productivity in these 3sub-districts. If the availability of production facilities and economic efficiency did not receive serious attention, it might have reduced the farmers' interest in growing rice. It would affect the sustainability of rice farming in this area as the primary source of rice supply in Siak Regency. Therefore, it is necessary to improve the management of wetland rice to ensure better quality and efficiency.

Efficiency in these 3 sub-districts could be increased by expanding the number and use of agricultural machinery, such as using tractors to plow the land. The use of a tractor reduces the number of laborers and the time needed for tillage. This is in accordance with the study of Unadi and Suparlan[29], which stated that the use of tractors could increase

productivity, speed up tillage time and prove to be more economical. The use of labor to move seeds could also be reduced by using a transplanting machine. The use of a rice transplanter could save planting costs and planting time. Therefore, it was seen to be more effective and efficient compared to manual planting. The same thing was expressed by Effendi *et al.*[30], who stated that the transplanter machine compensates for the shortage of human labor and overcomes the increasing wage level. The same is also achieved by using the combine harvester harvesting equipment which increases farming efficiency by saving energy, time and cost of harvesting. The use of other agricultural technologies in the form of medium and large types of rice harvesting equipments (combine harvester) also greatly benefit farmers. The use of the combine harvester reduced the rate of yield loss from 25% to below 5%[10].

The use of agricultural technology that could save labor requires substantial capital. The average capital availability of farmers in Siak Regency was classified as a lack of capital. It was found that only around 45% of farmers in the Bunga Raya sub-district could be categorized as farmers with sufficient capital. Therefore, the attributes of capital availability and the level of income of farmers provided a high sensitivity to the Bunga Raya sub-district. Farmers with enough capital and a high income in Bunga Raya were usually those who had farming machinery such as tractors, mini combine harvesters and combine harvesters by themselves or in groups that could rent it to other farmers in order to meet their needs. It could be concluded that capital had a solid relationship to production and had a significant effect on income and the farm's sustainability. This is in line with the opinion of Mantiri *et al.*[31], who stated that the greater the working capital issued by farmers, the greater the amount of income received by farmers.

The marketing attributes provided sensitivity for Sabak Auh and Sungai Mandau, while the attributes of unhulled rice prices and dependence on rice farming as a source of income provided sensitivity only to Sungai Apit district. Based on the results of the study, it is known that unhulled rice prices in Sungai Apit sub-district were always lower compared to other sub-districts by about IDR 100 kg^{-1}. This was due to smaller land areas and longer distances in the region. The price of unhulled rice on the study area ranged from IDR 4,500-4,700 kg^{-1} in 2018. This price was above the government purchase price (IDR 3,700 kg^{-1}). Through the government purchase price policy, the government expects rice production to be increased to meet domestic supply needs, to stabilize the rice prices, to increase farmer income, increase rice farming and to encourage national economic growth[8,32]. The policy for determining government purchase price is based on water content and the level of hollow grain. However, the determination of this quality did not use a moisture meter but only visual observations based on trader knowledge and trading experience. Determination of the purchase price of grain from farmers was also based on the quality and market prices prevailing at that time.

Differences in quality based on the perceptions of farmers and traders lead to unequal communication transactions. The only quality language understood by farmers and traders in the transaction was the differentiation of grain quality based on the type of long-round grain and short-round grain. Long grains were understood by both parties as better grain quality and as more expensive in the market than short grains, even though the quality of long or short grains could come from different rice varieties. Sutoro *et al.*[33] stated that every variety would give varying results on a total number of tillers, a total number of panicles, filled grain weight, plant height and grain form. Based on this description, in order to maintain the sustainability of the economic dimensions of the management of wetland rice, it is essential to manage sensitive attributes in a better and integrated plan to provide an optimal impact. The attribute of dependence on rice farming as a source of family income could be capital to encourage farmers to manage their farming better and sustainably.

Stress value, determination coefficient and effect of economic dimension errors: Table 2 shows that the stress values for 4 sub-districts ranged 0.14 and R^2 values ranged 0.95. In Rapfish the stress value is said to be good if it is below 0.25. This indicates that if the value of goodness of fit in MDS is near zero then the output produced has higher similarity to the actual situation. In short, the lower the stress value the better/more suitable the model. Kavanagh[17] stated that a tolerable stress value is <20%. Thus, the model can be well-received with stress values of 14%. The results of the goodness of fit also indicated that the ecological sustainability index estimation model could be used, where the value of Squared Correlation (R^2) is 0.95 or close to 1. When the R^2 value is closer to 1 it indicates that the data is mapped perfectly. This value illustrated that 95% of the model can be explained well and the remaining 5% is explained by other factors. Kavanagh[17] stated that a squared correlation (R^2) value of more than 80% indicates that the sustainability index estimation model is good and adequate to use.

Table 2 also shows that there was no significant difference between the MDS index value and the results of the

Monte Carlo analysis, both on the distribution value and the effect of the error on the 95% level. It could be ascertained that miscalculation of scores, the effect of variations in scores, repetitive stability of the MDS analysis process as well as errors in entry or loss of data had no effect. According to Pitcher and Preikshot[24], the Monte Carlo analysis can be used as a simulation method to evaluate the impact of random errors in statistical analysis. The results of Rap-rice analysis are acceptable given that the results of the validation test obtained by the difference in the economic sustainability index with the Monte Carlo analysis produce values of 0.40-2.40 indicating a very small difference in difference (< 5). This value indicated the error or the impact of the error, yielding a relatively small score. This means that the Rap-ice model for the management of lowland rice is declared adequate as an estimator of the sustainability index value. According to Kavanagh and Pitcher[23], if the value of Rap-rice analysis minus by the value of Monte Carlo analysis is >5 then the analysis results are inadequate as an estimator of the sustainability index value and if the difference between the 2 analysis values is <5 then the analysis results are considered sufficient to estimate the sustainability index value.

CONCLUSION

The index and current status of the management of wetland rice in Siak Regency were currently economically quite sustainable (> 50%) for all sub-districts with an average sustainability value index of 60.40%. The stress value of the average economic dimension for all sub-districts is 0.14 and the value (R^2) was 0.95. The MDS and monte carlo sustainability index values at a 95% confidence interval gave a difference of 0.40-2.40, which was considered sufficient to estimate the sustainability index value.

SIGNIFICANCE STATEMENT

This study discovered the cultivation of rice on peatlands that can be beneficial for farmers in this area to try their best to increase rice production with the use of agricultural technology while still paying attention to local culture and wisdom so that environmental sustainability is maintained and the process is economically profitable. This study will help researchers to uncover the critical areas of peatlands that many researchers have not been able to explore. Thus a new theory on sustainable agriculture in the petlands may be arrived at.

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