SUSTAINABILITY STATUS OF TECHNOLOGY APPLICATION ON RICE FARMING IN PEATLANDS (CASE STUDY AT KANAMIT JAYA VILLAGE, CENTRAL KALIMANTAN)

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ABSTRACT

Peatlands become one of the potential resources that could be developed as an area of rice farming to improve national food security. Agricultural cultivation in peatlands, if not managed well, will contribute to environmental destruction and land degradation, which will ultimately affect land productivity. As a first step in preparing the development of rice farming, research on the application of technology has conducted. This research included water management, which consists of: without water management or control (A0), macak-macak water management (A1) and intermittent water management (A2). Moreover, research on pesticide application was also conducted which consist of: without pesticide application or control (P0), Paraquat herbicide application at the time of tillage (P1), Fenobucarb insecticide applications every week (P2), Fenobucarb insecticide applications every two weeks (P3), Difenoconazole fungicide applications every week (P4), Difenoconazole fungicide applications every two week (P5).

This study aims to determine the level of sustainability of rice farming in peatlands, and the dominant factors that influence by considering economic, social and environmental through a Multi Dimensional Scaling (MDS) approach. The analysis shows a quite sustainable level, with score for each dimension is 53.13 for the economic dimension, 69.49 for the ecological dimension and 61.79 for the social dimension. The dominant factors to be considered for the sustainability of rice farming in peatlands are changes in the level of decomposition of organic matter, farming purpose and outreach intensity.

Keywords: sustainability status, rice farming, rice, peatlands

INTRODUCTION

National food availability is a major problem in Indonesia. It is because of increasing population, conversion of rice fields in Java, rice productivity that not increasing, and failed in diversification. In such conditions, develop rice farming in peatlands become important efforts in maintaining national food security.

Exploitation of peatlands produce a very broad debate. On the one hand, either the C stored in peatlands or the ability of peatlands to hoard C (C sink) is very high. Therefore, any change in the use of peatlands (land use change) produce greenhouse gas emissions (GHG).

On the other hand, the objective conditions in the past decade shows quite alot of peatlands has been cleared, both for agriculture and as a result of deforestation. At the farm level, peatlands management still faces many problems. In addition to chemical and physical aspects of the land, social and economic issues including weak institutional system, and application of low technology is also a problem faced in farming in peatlands (Haryono, 2013).

Agricultural cultivation contributes to environmental destruction and degradation of land. The decline in the quality of land will lead to decreased productivity, food security, and loss of biodiversity through changes to habitats at both species and genetic levels. In addition, the decline in the quality of land will have an impact to the socio-economic life of
people who depend on the land as a source of life and ultimately affect the increasing in poverty (Atmojo, 2006). Indonesia concerns and is fully aware that the economic value of conserving resources of peatlands is very high and may not be lower than the value of its economic exploitation. But the answer to long-term problems could not be achieved if short and medium term issues are also addressed, especially the need of land for food. Therefore, how to ensure that the utilization of peatlands should be based on the principles of sustainable agricultural development where GHG emissions are minimized and as much as possible contribute to the sequestration of C. In addition, at the same time, target related to the interests in financial, economic, employment, and poverty reduction is also achieved. In this research, a case study of rice farming in peatlands carried out, by considering the economic, social and environmental aspects, as a basis for developing sustainable farming in peatlands.

Farming in peatlands will be sustained if beneficial from the farming aspects (economic aspect), can maintain a good condition of peatlands or no decline in quality (environmental aspects) and farming technology can be accepted or adopted by farmers (social aspect). Kerf (2002) reported that the management would be sustained if in the implementation gave equal weight and integrating the economic, environmental and social aspects. The development process should not be stopped but this nature must still be passed down from generation to generation in a state that is still good, worthy to support the life of future generations to prosper. Such a development is a sustainable development. Moreover, it is also explained that sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland Report, 1987). Thus, the social, economic and environment should be mutually supportive and involved in the development process (Munasinghe, 1993). Therefore, that agricultural development can improve the welfare of farmers, maintaining the quality of the environment, and avoid land degradation (Laba, 2009). This study aimed to evaluate the sustainability of rice farming technology applications in peatlands by considering economic, social and environmental aspects.

MATERIALS AND METHODS

Study site

This study is a further stage of a series of research activities. The field research was on tidal peatlands area at Kanamit Jaya village, on dry season (MK). The further data collection on socioeconomic and sustainability status of farming was carried out in the same village through direct interviews with farmers using the questionnaire. The determination of respondents was done by using purposive sampling method, which is a deliberate method of sampling that are considered representing rice farmers in peatlands. The criteria of the respondents were rice farmers in peatlands that have farming experience of more than 10 years and a member of a group of farmers in the research location.

Field research

The main plot factor was water management (A), consisted of three treatments, namely; without management (control) (A0), macak-macak (A1), and intermittent (A2). While the subplot factor was six pesticide treatments (P) comprising; without application of pesticides (P0), application of herbicide paraquat when tillage (P1), the application of insecticides fenobucarb every week (P2), the application of insecticides fenobucarb every two weeks (P3), the application of fungicide difenoconazole every week (P4), and application of fungicides difenoconazole every two weeks (P5). The observations were made against emissions of CO2 and CH4, phenolic acids, soil and water quality. The field data was used as a source of information for the analysis of ecological dimensions on the sustainability status analysis.
Analysis of rice farming sustainability

In order to obtain information on the sustainability potential of farming in peatlands, the research was conducted through analysis of three sustainability dimensions, which are the social dimension, the economic dimension and the environmental dimension. The analysis index and sustainability status were conducted with Multi Dimensional Scaling (MDS) approach by using ordination techniques of Rapfish modifications to the model farming studied. The analysis was made through six stages, namely:

1. Determination of the attributes of each dimension;
2. Assessment of the attributes in an ordinal scale;
3. Analysis of ordination;
4. Preparation of the index and sustainability status;
5. The sensitivity analysis to see most influential (sensitive) attribute;
6. Evaluation on the effect of random error with Monte Carlo analysis can be used to determine: (a). effect of error in making scores of attributes, (b). the effect of variation scoring, (c). stability on repeated analysis process, (d). entry errors or loss of data, and (e). stress value.

The attribute selected from each dimension describes the condition of rice farming in peatlands and the status of sustainability in every dimension. The attributes were taken from several sources, among others: Nazam (2011), Ruslan et al. (2012) and Mamat et al. (2014), which was later modified to adjust with the conditions in peatlands, and the opinions of experts and stakeholders. The attributes were grouped into three dimensions of social, economic, and environmental. The social dimension was composed of 10 economic dimension attributes, social dimension attributes, and 10 ecological dimension attributes (Table 2).

The score of each attribute was estimated, i.e. a score of 4 for good condition (good), 1 means bad and between 1-4 for circumstances between good and bad. Definitive value was the average value of a questionnaire that is used to determine the position of the sustainability toward the good and bad points.

The attributes data or social and economic parameters were obtained through a descriptive survey against 25 farmers respondents, while most of the ecological data were obtained from biophysical aspect from the research result. The index value and sustainability category refer to Table 1.

Table 1. Index value and sustainability category.

| Index Value     | Sustainability Category       |
|-----------------|-------------------------------|
| 0 – 25          | Bad: not sustainable          |
| 25.01 – 50.00   | Less: less sustainable        |
| 50.01 – 75.00   | Fair: fairly sustainable      |
| 75.01 – 100     | Good: very sustainable        |

The sustainability score was declared from the worst scale (0%) to the best score (100%). Sustainability index value >50 indicated that the analyzed system has been sustainable while sustainability index value <50 indicated that the analyzed system yet or not sustainable. Goodness of fit in the MDS could be seen from the S-stress (S) and coefficient of determination (R²). Low S value showed a good goodness of fit. The model can be said to be good if the value of S <0.25 and RSQ score >80 or close to 1 (Pitcher and Preiskot, 2001). Sustainability comparison between dimensions expressed in kite diagram. The attributes and scores for each sustainability dimension are described in Table 2.
RESULT AND DISCUSSION

3.1. Farming System

The pattern of farming developed by farmers in the Kanamit Jaya generally uniform, which only grow rice once a year. Rice varieties used were local varieties of mountain rice, local farmers named varieties Briti Mountain. This variety is quite adaptable and long-lived (eight months), with an average yield of 1 to 2.5 t ha\(^{-1}\), with an average of 1.5 t ha\(^{-1}\). Planting is done during the rainy season begins around August (tillage and seedling) and planting around September depending on the availability of water in the soil and harvest around March. Some farmers plant upland rice during the dry season starts around April and the harvest in July. However, only a few farmers who planted in dry season.

Farming begins with land preparation and tillage. Preparation of planting begins by spraying the field with herbicide. Herbicide which is commonly used is contact herbicide, from a variety of trademarks such as Round Up, Rambo, and Gramoxone with an average

Table 2. Attributes and scores for each sustainability dimension

| No. | Attributes                                                                 | Scores | Very Good | Bad |
|-----|---------------------------------------------------------------------------|--------|-----------|-----|
|     | **Economy dimension:**                                                    |        |           |     |
| 1.  | The potential of family labor (TKK) in farming                            | 1,2,3,4| 4         | 1   |
| 2.  | The adequacy of family labor (TKK) for farming                            | 1,2,3,4| 4         | 1   |
| 3.  | Land tenure and Management intensity                                      | 1,2,3,4| 4         | 1   |
| 4.  | Interest for farming                                                      | 1,2,3,4| 4         | 1   |
| 5.  | Farming purpose                                                           | 1,2,3,4| 4         | 1   |
| 6.  | Price stability of the farmers production during the harvest period       | 1,2,3,4| 4         | 1   |
| 7.  | Ease on the marketing of farm production                                  | 1,2,3,4| 4         | 1   |
| 8.  | The availability of farming input in the village                          | 1,2,3,4| 4         | 1   |
| 9.  | The contribution of farming to the total income of farmers                | 1,2,3,4| 4         | 1   |
| 10. | Land productivity / financial gain (RC ratio) of farming on research plots | 1,2,3,4| 4         | 1   |
|     | **Social dimension:**                                                     |        |           |     |
| 1.  | Public perception on the management of peatlands                          | 1,2,3,4| 4         | 1   |
| 2.  | Knowledge and experience on climate change                                | 1,2,3,4| 4         | 1   |
| 3.  | Knowledge and experience regarding the control of plant pests (OPT)       | 1,2,3,4| 4         | 1   |
| 4.  | The intensity and effectiveness of outreach to the community regarding sustainable peatland management | 1,2,3,4| 4         | 1   |
| 5.  | The existence and togetherness of farmers groups                          | 1,2,3,4| 4         | 1   |
| 6.  | Farmers action which indicate preservation of farming in peatlands        | 1,2,3,4| 4         | 1   |
| 7.  | How to clear the land and cultivate the land                              | 1,2,3,4| 4         | 1   |
| 8.  | The response of farmers in applying technology to preserve peatlands      | 1,2,3,4| 4         | 1   |
| 9.  | Local knowledge related to sustainable agriculture                        | 1,2,3,4| 4         | 1   |
| 10. | The participation of women workers in farming management                  | 1,2,3,4| 4         | 1   |
|     | **Ecology dimension:**                                                    |        |           |     |
| 1.  | The development of demplot GHG emissions level before and after treatment | 1,2,3,4| 4         | 1   |
| 2.  | The concentration of organic material at the observation land in the beginning and end of the observation | 1,2,3,4| 4         | 1   |
| 3.  | Changes in the level of decomposition of organic matter                  | 1,2,3,4| 4         | 1   |
| 4.  | Ground water level in the beginning and end of the observation           | 1,2,3,4| 4         | 1   |
| 5.  | Fluctuations in water flow at the observation land in the beginning and end of the observation | 1,2,3,4| 4         | 1   |
| 6.  | Soil pH at the observation land in the beginning and end of the observation | 1,2,3,4| 4         | 1   |
| 7.  | Water pH at the observation land in the beginning and end of the observation | 1,2,3,4| 4         | 1   |
| 8.  | Fires at the time of the research was conducted                           | 1,2,3,4| 4         | 1   |
| 9.  | Pesticide residues in soil and water in the beginning and end of the observation | 1,2,3,4| 4         | 1   |
| 10. | The type and number of insects in the beginning and end of the observation | 1,2,3,4| 4         | 1   |
dose of 6.5 L ha$^{-1}$. These herbicides used to kill weeds in the rice field, and then left it to dry. Once the weed dried, slashing will be carried out. It is for reducing the thickness and height of the weeds in the field. Then farmers will clear the land from weeds by burning. Burning the land was done under supervision, so that the rate of fire can be controlled. A few days later, light tillage with a hoe will be carried out if necessary. Application of agricultural lime to improve soil acidity is only done by some farmers due to lack of funds. Land preparation was done by the land-owning farmer assisted by a member of his family like his wife or son. Land preparation and tillage can take up to two weeks.

Farmers generally do not protect the seed from the previous crop season. Seed is sown on land until the age of 25 days. Once the seed and land are ready then the process of planting will be done. The prevailing traditions in the farmers are doing mutual aid (gotong-royong) during the implementation of the planting. Farmers will gather in the morning and together doing planting. This activity is conducted alternately in other farmers’ fields until the planting is completed. Furthermore, at 30 days of the plant age, farmers will fertilize their plantations with as much as 50 kg ha$^{-1}$ of urea and 50 kg again applied to the age of two months after planting. Fertilizer was applied by direct stocked and carried out by the land-owning farmer assisted by family members, almost no farmers used P and K fertilizer. The limited funds for agricultural inputs become main reasons for the minimum use. On some occasions the farmers get donations of agricultural inputs such as seeds, lime, and fertilizer P and K or NPK compound fertilizer. In such conditions, farmers will be enthusiastically applying the input to their paddy plantation.

After planting and fertilization are completed, then the next activities are the responsibility of other family members such as his wife and son to keep and maintain the rice. At that time the majority of male farmers would do a side job. Generally, male farmers will go out of town to work as laborers planting or construction worker. Others went into the forest to work as workers at gold mine. Further activities, family members of farmers perform maintenance such as replacing dead rice due to mole crickets pest, weeding the weeds and observations of insect or disease. Weeding is generally done by using herbicides. Weeds on dikes will be brushed with herbicides (like painting), while the weeds on the rice field will be sprayed with herbicides carefully. There will be effect to the rice crop, but in general, the effect can be tolerated quickly by the rice crop. Labor shortages are the reason to use herbicides for weeding activities.

Furthermore, if the plant pest attacks appear, such as caterpillars and leafhoppers, then the farmers will apply insecticide. The insecticides that commonly used by farmers are from the class of lambda cyhalothrin, with a trademarked name Matador, and from the class of fipronil, with a trademarked name Reagent. Matador is an insecticide commonly used to control armyworms, pod borer for crops planting and palm oil, but is not intended for rice pests. While the regent is to control the mole crickets, rice bug and rice stem borer. Based on observations and interviews with farmers, the choice of insecticide and the dose is based on experience. So, the insecticide used sometimes does not match with the type of pests’ attack. The dose used was also adjusted to the financial capacity of farmers. Often, farmers mix the different types of insecticides to achieve the desired results.

Another interesting thing, most farmers do not take seriously the attack of diseases caused by fungi or bacteria. They regard it as a physiological disorder. Most farmers let this disease disorder, and when they try to control it, the pesticide used was not appropriate. Serious treatment made against rodents and birds. Installation of fish net around the rice field is to prevent birds. Activity to keep birds away is done every day throughout the generative period until harvest. Entering the generative period until before harvest, male farmers who go abroad will return to the village and take care again their rice crop.
Harvesting is done by using a sickle to cut rice plants. Then rice stacked on land to carry out threshing manually. Grain yield further cleaned by sorting seeds machine, to dispose of empty grain. Grains were then packed in a plastic sacks and brought back home for further dried in the sun until completely dry. Grain yield would be stored for family consumption and to be set aside as a seed for the next planting season. If there is an excess of harvesting results, the grain will be sold to mills at the local village. The selling price of grain fluctuated with the price range of Rp 4,000-4,500 kg\(^{-1}\) of dry milled grain.

**Sustainability Status of Rice Farming in peatlands**

**Ecology Dimension**

The ecological dimension had the highest sustainability index value compared with other dimensions which was 69.49 (Figure 1). This shows that the ecological dimensions had a better sustainability status compared with other dimensions.

![ Ecology Dimension](image)

**Figure 1. Status and sustainability index value of ecological dimension**

Figure 1 shows index and sustainability status of rice farming in peatlands based on MDS ordination analysis results in a two-dimensional plot. The sustainability status is on the X-axis between 0-100. The analysis showed the sustainability status for ecological dimension was 69.49.

Based on the leverage analysis results (Figure 2), there were no attributes that have a value of more than 10. Thus, it can be concluded that no dominant attribute. The attribute value of over 10 indicates that these attributes are very dominant compared with other attributes. The most dominating values of the attributes based on leverage analysis ranged from 0.19 to 5.36.

One of the specific characteristics of the peatlands is the high content of organic material. The organic fraction of Indonesia's peatlands is more than 95% (Soil Survey Staff, 2003). High content of organic material on peatlands lead to a very high CO\(_2\) emission potency. In the natural state, C stored in peat soil is relatively stable (Parish *et al.*, 2007), but in disturbed conditions the C deposit will decomposed quickly and emitted in the form of CO\(_2\).

Peat soil is generally very sour and acidic. The acidity level of peat soil is ranging from 3.0 to 4.0 (Hartatik *et al.*, 2011). Peat soil acidity is also closely related to the level of the peat depth and content of organic acids. The thicker the layer of peat, the pH level will be higher as well. To overcome the problem of soil acidity, in the system of rice cultivation, the addition of ameliorant needed in peatlands. Agricultural lime, mineral soil, manure and ash are a few examples of materials that can be used as ameliorant material to raise the pH of peat soil (Subiksa *et al.*, 2011).

The research location is a tidal swamp land with overflow type B which still strongly influenced by the ebb and flow of the tide. Therefore, water management in rice farming systems is very important. The drainage channels equipped with sluice gates to control the ground water level needed in the development of peatlands for agriculture (Subiksa *et al.*, 2011). The existence of the drainage channel is also closely related to the subsidence level of peatlands. The subsidence process of peatlands occurs because of the compaction, decomposition and erosion of dried peatlands surface. The deeper the drainage channel, the greater the rate of subsidence (Subiksa *et al.*, 2011).
To improve the status and value of ecological dimension sustainability index on rice farming in peatlands, there should be an effort to improve the pH of the soil, water flow regulation to reduce the decomposition, and the subsidence level of peat soil. Farmers' awareness of the importance of conserving peatlands should be improved, by giving an understanding not to burn the land at the time of preparation and tillage. Cheap and easy alternative ways to prepare the land need to be used to replace the habit of burning the land before planting. The herbicide application with appropriate type and dose methods, as well as minimum tillage system with light mechanization can be presented as a replacement technology for burning the land before planting. Therefore, the support of local governments to provide a necessary mechanization for farmers is required. Through a group of farmers, mechanization can be empowered independently to improve the quality of agricultural products while maintaining environmental sustainability.

Economy Dimension

The index value and economy dimension sustainability status is 53.15 (Figure 3).

Although lower than the value of the ecological dimension but still in the category of fairly sustainable (score >50).

Based on the leverage analysis results, farming purpose is the most influential attribute with a leverage score of 3.75, then followed by land tenure and management intensity with a score of 2.87 and price stability of the farmers’ production during the harvest period with a score of 2.10 (Figure 4).
In general, the farmer’s purpose in rice farming is only to meet basic food needs alone, and is still very dependent on outside work to improve the standard of living and welfare. This will affect the level of the agricultural land management. Agribusiness system has not been fully implemented in the farming management system. Thus, the results are not yet sufficient to meet the needs of farmers in general.

Farmers usually sell harvested grain alone to a collector in their neighborhood. This causes farmers are in a weak position because the price will be determined by the collectors and farmers receive a harvested price at a fairly low level. The farmers do not have accurate information about grain market price and it makes farmers receive directly price that offered by the collectors. Therefore, the government should disseminate updated agricultural commodity prices to the farmer's groups.

The improvement in commerce or marketing chain is one strategy to address the problem of agricultural product marketing. The efficiency of the commerce chain is a quite important to the stability of the price of agricultural products. Strengthening the farmers’ institution is also one of the strategies to strengthen the bargaining position of farmers in marketing the product. With collective system, sale of their products through farmer groups are expected to increase the grain price received by farmers. Through a group of farmers, alliance of farmers' groups, and coop, farmers can be assisted to conduct business, seek of means of production, and marketing the farming product, as well as addressing the issue together (Herman, 2011). Low price of grain that received by farmers will affect the level of profit that received by farmers. It is proved by high score of farmer's profit attributes on the leverage analysis.

Besides the increase in the selling price of harvest product, farming efficiency also plays an important role in increasing farmers' income. Other influential factors are land tenure and farm management level that can be used as an attempt to increase the income of farmers. Agricultural land strived not to be more narrowed and rice planting intensity increased from one planting to double planting. Planting intensity can also be enhanced by planting crops or vegetables as a second crop. With the increase in land tenure and efficient management, the benefit of farming systems is expected to increase.

Figure 4. Leverage analysis results (Root Mean Square /RMS) of economy dimension

| Attribute                                                                 | Leverage of Attributes |
|--------------------------------------------------------------------------|------------------------|
| Land productivity / financial gain (RC ratio) of farming on research plots | 0.71                   |
| The contribution of farming to the total income of farmers                | 0.88                   |
| The availability of farming input in the village                         | 0.95                   |
| Ease on the marketing of farm production                                 | 0.96                   |
| Price stability of the farmers’ production during the harvest period      | 2.10                   |
| Farming purpose                                                          | 3.75                   |
| Interest for farming                                                     | 0.34                   |
| Land tenure and Management intensity                                     | 2.87                   |
| The adequacy of family labor (TKK) for farming                           | 1.16                   |
| The potential of family labor (TKK) in farming                           | 0.89                   |
| Root Mean Square Change % in Ordination when Selected Attribute Removed  | (on Status scale 0 to 100) |

| Attribute                                                                 | Leverage of Attributes |
|--------------------------------------------------------------------------|------------------------|
| Land productivity / financial gain (RC ratio) of farming on research plots | 0.71                   |
| The contribution of farming to the total income of farmers                | 0.88                   |
| The availability of farming input in the village                         | 0.95                   |
| Ease on the marketing of farm production                                 | 0.96                   |
| Price stability of the farmers’ production during the harvest period      | 2.10                   |
| Farming purpose                                                          | 3.75                   |
| Interest for farming                                                     | 0.34                   |
| Land tenure and Management intensity                                     | 2.87                   |
| The adequacy of family labor (TKK) for farming                           | 1.16                   |
| The potential of family labor (TKK) in farming                           | 0.89                   |
| Root Mean Square Change % in Ordination when Selected Attribute Removed  | (on Status scale 0 to 100) |
Strengthening the financial institutions of farmer groups has also become a very important thing to be implemented. The government support through financial institutions is expected to help to strengthen the financial institutions of farmers groups. So that farmers are able to provide agricultural inputs optimally, such as lime, fertilizer, and pesticides on their rice field. Farmers are not refused to provide a complete fertilizer on their rice field. The capital constraint is the main reason for the lack of agricultural inputs used by farmers. The application of pesticide accordance with the principles of integrated pest management is also constrained by high price of pesticide.

### Social Dimension

The analysis results show that the status and sustainability index value of the social dimension is the smallest among all, which is 61.79 (Figure 5). However, based on these results, the economic dimension is still in the category of fairly sustainable (score >50).

![Social Dimension](http://ijwem.unlam.ac.id/index.php/ijwem)

**Figure 5.** Status and sustainability index value of social dimension.

Furthermore, the leverage analysis results show that the intensity and effectiveness of outreach to the community regarding sustainable peatland management having the highest score with score 4.54, followed by farmers action which indicate preservation of farming with score 4.42 (Fig. 6).

![Leverage Attributes](http://ijwem.unlam.ac.id/index.php/ijwem)

**Figure 6.** Leverage analysis results (Root Mean Square /RMS) of social dimension.
Rice farming in peatlands had been going very long, extensive use of peatlands in South Kalimantan starting from 1920, along with the opening of a road through the peat bog along the 14 km from Banjarmasin to Banjarbaru. With the opening of the road, people try to grow rice and the result was very good so they began to develop rice farming in peatlands (Noor, 2001). It shows that actually system of rice farming in peatlands nowadays is a legacy of predecessors who steadfastly deal with the natural condition which is sometimes less friendly. This practice is called indigenous knowledge. So it can be said that the practice or activities undertaken by farmers already environmentally-friendly and sustainable. Therefore, it is necessary to revive this indigenous knowledge on rice farming management in peatlands so that practice or activities undertaken by farmers are toward sustainability. As an example, farmers should clear the land in accordance with the principles of sustainability that is not by burning the land. Farmers need to be aware of the danger of fires from burning peatlands that deliberately done by farmers which will result in a huge loss not only for the farmer, but also a huge loss for Indonesia.

The role of outreach is very important as an awareness effort to the farmers on sustainable rice farming in peatlands. The capacity of Agricultural Extension Workers (AEW), as the spearhead of agriculture in the field, need to be improved on peatlands management so that the knowledge can be spread out to the farmers under their care. This awareness is important for the sustainability of farming in peatlands so it can ongoing until the next generations.

Another effort that needs to be done to improve the sustainability status of the social dimension is to strengthen the existence of farmers groups. Peatlands agriculture cannot be done individually, but it is a development of the region with a specified extent. One example of the importance of farmers groups is that in the regulation of water flow, without the presence of the farmers’ groups that facilitates among members, the success of water management in peatlands will never be realized. The stronger the organization and institution of farmers, the more obstacles and problems that can be addressed together (Herman, 2011). Here is a kite diagram that shows the status of sustainability of rice farming system in peatlands for different dimensions (Figure 7).

![Figure 7. Kite diagram of sustainability status of rice farming](image)

Furthermore, based on the S-stress and RSQ value in the range of 1.4 and 0.95 (Table 3), it can be said that this model is pretty good, it means that the configuration of attributes used can reflect its original condition. A good model if has S-stress value less than 0.25 (Pitcher and Preiskot, 2001) and RSQ value greater than 80 (Kavanagh, 2001).

| Dimension | S-stress | RSQ |
|-----------|----------|-----|
| Ecology   | 0.135    | 0.952 |
| Economy   | 0.142    | 0.951 |
| Social    | 0.136    | 0.953 |

Based on above sustainability analysis, it could be said that in order to implement the system of rice cultivation in peatlands require meeting several conditions. The first is to increase farmers’ knowledge about rice cultivation techniques, including the knowledge about the management of pests and plant diseases. Integrated Pest Management Field School (FFS) should be raised again to improve farmers’ knowledge.
Awareness of the importance of protecting peatlands and climate change must also be submitted. In this case, the active role of agricultural extension workers is absolutely necessary. The second condition that must be met is strengthening the farmers’ institution. Roles of Farmers groups must be improved so it can be serve as forum for farmers to increase knowledge and as a financial institutions aid for farmers. The third condition that must also be met is government support through subsidies for agricultural input and marketing. Subsidies for fertilizer, lime and pesticides should be regulated and granted to improve farmers’ income. Marketing channels that in favor to the interests of farmers are very important to be provided. In addition, it should also be regulated through local regulations that regulate the peatlands management. Thus, there will be no farmers that burned the land in preparation for planting.

CONCLUSION

Rice farming in peatlands (case in Maliku, Pulang Pisau) was fairly sustainable, which was indicated by the value of each dimension above 50, *i.e.* sustainability value of the economic dimension was 53.13, ecological dimension was 69.49 and social dimension was 61.79.

As the implementation of the policy, the use of peatlands, particularly in support of national food security, some necessary strategies are needed including: strengthening of technological innovation through research and development activities; strengthening the cooperation in harmony, synergy and participation between the parties concerned; peatlands development regulations; zoning of development region and commodities region; development of supporting infrastructures; and strengthening the distribution and marketing of agricultural products.

REFERENCES

Atmojo SW. 2006. *Degradasi Lahan dan Ancaman Bagi Pertanian.* Solo Pos Edisi Selasa Pon, 7 November 2006.

Haryono. 2013. *Policy Strategy of Ministry of Agriculture on Optimization of Suboptimal Area for supporting Food Security.* Proceeding of National Seminar on Suboptimal Area” Intensification of Suboptimal Management for Supporting Self-Sufficiency, Palembang 20-21 September 2013

Herman. 2011. *Tinjauan sosial ekonomi pemanfaatan lahan gambut dalam Pengelolaan lahan gambut berkelanjutan.* Penyunting Neneng L. Nurida, Anny Mulyani, Fahmuddin Agus, Balai Penelitian Tanah. Badan Penelitian dan Pengembangan Pertanian.

Kavanagh P. 2001. *Rapid Appraisal of Fisheries (RAPFISH) Project.* University of British Columbia, Fisheries Centre.

Keraf A.S. 2002. *Etika Lingkungan.* Penerbit Buku Kompas, Jakarta.

Laba I.W. 2009. *Analisis Empiris Penggunaan Pestisida Menuju Pertanian Berkelanjutan.* Pengembangan Inovasi Pertanian 3(2), 2010: 120-137.

Mamat H.S, Irsal L, Irawan, Anny M, Wahyu AN, Rofik, M. F. 2013. *Potensi Usahatani Berkelanjutan di Lahan Gambut Terdegradasi: Studi Kasus Analisis Sosial Ekonomi dan Lingkungan di Kalimantan Tengah.* Laporan Hasil Penelitian Balai Besar Litbang Sumberdaya Lahan Pertanian. Bogor.

Munasinghe M. 1993. *Environmental economic and sustainable development.* The International Bank for Reconstruction and Development. The World Bank, Washington DC. 20433. USA
Nazam M. 2011. *Penyusunan model untuk penentuan luas lahan optimum usahatani padi sawah pada wilayah beriklim kering mendukung kemandirian pangan berkelanjutan (Studi kasus Provinsi Nusa Tenggara Barat)*.

Noor, M. 2001. *Pertanian Lahan Gambut: Potensi dan Kendala*. Penerbit Kanisius. Jakarta.

Parish F, Sirin A, Charman D, Joosten H, Minayeva T, Silvius M, Stringer L (Eds.). 2007. *Assessment on Peatlands, Biodiversity and Climate Change: Main Report*. Global Environment Centre, Kuala Lumpur and Wetlands International, Wageningen.

Pitcher TJ and Preikshot DB. 2001. *Rapfish: A Rapid Appraisal Technique to Evaluate the Sustainability Status of Fisheries*. Fisheries Research 49(3): 255-270

Ruslan 2013. *Model Pengelolaan Perkebunan Kelapa Sawit Berkelanjutan Pola Inti-Plasma (Studi Kasus di PT Perkebunan Nusantara VII, Kabupaten Muara Enim, Sumatera Selatan)*. Disertasi Institut Pertanian Bogor. Bogor.

Soil Survey Staff. 2003. *Key to Soil taxonomy. 9th Edition*. United States Department of Agriculture. Natural Resources Conservation Service.

Subiksa IGM, Hartatik W dan Agus F. 2011. *Pengelolaan Lahan Gambut Secara Berkelanjutan*. Badan Litbang Pertanian. Kementerian Pertanian. Bogor. 16 hlm.