Sustainability analysis for rice and duck farming in swampy land, Hulu Sungai Utara Regency, South Kalimantan

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Abstract. In Hulu Sungai Utara Regency, the increasing of the potential of swampy land utilization through rice and duck farming needs to be developed towards the sustainable agriculture. This study aims to analyze the sustainability index of rice farming and duck poultry using the Sustainability Index approach of Lebak in Sungai Durai Hulu Village, Regency of Hulu Sungai Utara. Measurement of sustainability index includes six dimensions namely environment, economy, human resources, social, technology and institutions. The results showed that the sustainability index of rice and duck farming was about 47.54%, indicating rice and duck farming was less sustainable. The highest value of sustainability index was the social dimension, while other dimensions were included in the less sustainable category. The dimensions that has less sustainable need to be improved that could be focused on the leverage attributes which are land fertility and livestock raising system in ecological dimension, availability of livestock and product market and marketing of livestock product in economic dimension, ability to manage farming in the family and availability of family human resource in human resource dimension, agricultural waste treatment technology and feed supplement for livestock in technology dimension as well as the institution of output in institutional dimension.

1. Introduction

Availability of agricultural land is currently under pressure of competition with other sectors in line with economic and population growth. Although agricultural land is the main production factor, declining of agricultural land area has occurred in most agricultural production centers in Indonesia due to land conversion to non-agricultural use. Facing this condition, swamp land is a potential resource that can be used for agricultural production, both food plantations and livestock. Role of swamp land is becoming increasingly important in accordance with government's commitment to create Indonesia as a World Food Barn by 2045 [1].

Alihamsyah [2] explained that compared to tidal swamp land, development of low swampy land for agriculture could be priority because this land was relatively more fertile and has no problems with sulfidic materials. The main obstacles that have been faced in the development of swampy land were related to the biophysical conditions of the land, socio-economy, community culture, and supporting institutions. The biophysical constraint that occurs was the extreme availability of water in two...
seasons, i.e. drought in the dry season and flooding in the rainy season. This condition results in shorter planting times and hence the planting index was only once a year.

Potential of swampy land as a food producer in South Kalimantan has been reported from several studies. Ningsih et al. [3] stated that the productivity of rice in the lowlands of Hulu Sungai Utara Regency (HSU) ranged from 4.27 to 6.09 t ha⁻¹ of milled dry grain (MDG). The results of Pujiharti [4] explained that application of innovation at all stages of rice cultivation in swampy land had the opportunity to increase production towards sustainable rice self-sufficiency. Technological innovation for rice in Pengelolaan Tanaman Terpadu (PTT) or Integrated Planting Management in swampy land has provided a significant increase in rice production when compared to previous condition before the introduction of PTT [3]. The potential of swampy land was not only for rice, but also horticulture such as eggplant, chilies, and watermelon as well as duck farming [5].

Rohaeni and Kurniawan [6] in the research on Plant and Duck Farming Strategies in Swampy Land in Hulu Sungai Utara Regency showed that strategy that should be carried out in the swampland utilization was a business diversification since it was an opportunity to increase the contribution of swamplands to agricultural production and to increase farmers' income as well. Furthermore, they also stated that development of business diversification for plants and duck livestock in the future should refers to market needs, high productivity and quality of production by improving cultivation and intensification post-harvest activities and processing of horticulture and duck livestock products and utilization of agricultural waste for organic fertilizers as well.

Utilization of lowland swamps as a source of food with diversification of rice and duck farming should based on the concept of sustainable development and sustainable agriculture, considering that lowland swamps undergo dynamic changes in line with environmental changes. Sustainable development is a process perceived the economic, social, and environmental aspects [7].

Agricultural development according to Adnyana [8] is not only aimed at increasing or maintaining productivity or production but at the same time it must be able to protect and preserve agricultural resources and long-term economic growth. It requires appropriate technology, policies and resource management in line with comparative and competitive advantages of a region.

In accordance with previous description, this study aims to analyze the sustainability of rice and duck farming in swamp land using the Ustanlebak Rap Sustainability Index approach in Sungai Durait Hulu Village, Babirik District, Hulu Sungai Utara Regency and to formulate recommendations for the development of rice and ducks farming in the future. The benefit of sustainability analysis is that it becomes a reference for developing rice and duck farming systems in swamp land by optimizing the contribution of sensitive attributes that affect each dimensions of sustainability development.

2. Materials and methods
This research was conducted in Sungai Durait Hulu Village, Babirik District, Hulu Sungai Utara Regency, South Kalimantan. The types of data collected were primary and secondary data. Primary data was collected by survey method through in deep interviews using questionnaaire and direct observation of farming activities in the research location, the number of respondents were 36 peoples. Secondary data were obtained from various sources, namely from the results of previous research and literature review related to the research field. Sustainability concept that adopted in this research using six dimensions i.e. dimension of ecology, economy, social, human resources, technology, and institutions.

Analysis of RAP-Ustanlebak based on the Multidimensional Scaling (MDS) method was carried out through the following stages: (1) attribute determination; (2) assessment of each attribute in an ordinal scale (Rap Scores) based on multidimensional sustainability criteria; (3) ordination analysis (Rap Analysis) to determine ordination and stress values; (4) indexing and status of the multidimensional system sustainability as well as each dimension (distances); (5) sensitivity analysis (Leverage Analysis) to see the attributes or variables that are sensitive to influence. Sensitive attributes contribute to multidimensional sustainability can be seen in the form of changes in Root Mean Square (RMS). The greater the RMS change value, the greater the role of attribute or the more sensitive it is.
in the formation of the sustainability value, and (6) the evaluation of the effect of random errors using Monte Carlo analysis. Monte Carlo analysis aimed to determine (a) the effect of attribute scoring errors, (b) the effect of scoring variations, (c) the stability of the repeated MDS analysis process, (d) data entry errors or missing data, and (e) stress value. Each dimension is represented by a sustainability attribute or variable. Determination of variables or attributes of each dimension of the lowland rice production system refers to factual data and information coupled with expert opinion (judgment knowledge).

Ordination analysis of RAP Ustanlebak in the "Multidimensional Scaling" (MDS) method is complemented by the preparation of indexes and sustainability status which is assessed through the assessment stage of each attribute on an ordinal scale based on the sustainability criteria in each dimension. The process of ordination of Rap Ustanlebak used a modified Rapfish software by Pitcher et al.[9] and Alder et al. [10]. The Rapfish software is an MDS development in the SPSS software, consisting of Multi-Dimensional Scaling (MDS) analysis, Monte Carlo, and Leverage analysis.

Indicator of sustainability studied in each dimension were derived from a combination of sustainable agriculture concept obtained from various sources, including Smith and McDonald [11] as well as concept of food security from Samekto [12]. The index values and sustainability status were grouped into 4 categories as follows:

| Sustainability Index Value Category: |  |
|--------------------------------------|---|
| 00.00 to 25.00 Bad                   | Not Sustainable |
| 25.01 to 50.00 Less                  | Less Sustainable |
| 50.01 to 75.00 Sufficient            | Sufficiently Sustainable |
| 75.01 to 100.00 Good                 | Very Sustainable |

3. Results and discussion

3.1. Multidimensional sustainability

Sustainability analysis of the swamp land use for rice and duck farming in Sungai Durait Hulu Village, Babirik District, Hulu Sungai Utara Regency applied the Multidimensional Scaling (MDS) called Rap Ustanlebak. Five dimensions in sustainability status consist of ecological, economic, socio-cultural, technological, and institutional dimensions.

Based on figure 1, result of analysis showed that the sustainability index of rice and duck farming was about 47.54 % which was in the value range 25.01 to 50.00 with the criteria of being less sustainable. The sustainability index was obtained based on an assessment of 44 attributes covered in six dimensions (environmental, economic, social, human resources, technology and institutions).

![Figure 1. Sustainability index of rice and duck farming in swamp land, HSU, South Kalimantan.](image_url)
Table 1 show the sustainability status for each dimension and social dimension has the highest index in the fairly sustainable category, while other dimensions (environment, economy, human resources, technology and institutions) fall into the less sustainable category. Results of this analysis can determine factors that must be improved so that the value of sustainability for each dimension could be increased. Index and sustainability status of each dimension should be improvement in the future, especially on sensitive attributes that affect the sustainability of rice and duck farming management in lowland swamps significantly. This result also showed that value of two parameters (“stress” and R2) for all attributes used in the sustainability analysis of the Ustanlebak RAP in the Hulu Durait River were good enough in explaining the six dimensions analyzed.

| No | Dimension   | Stress | R2   | Sustainability Index | Indication        |
|----|-------------|--------|------|----------------------|-------------------|
| 1  | Ecology     | 13.70  | 94.40| 45.34                | Less Sustainable  |
| 2  | Economy     | 13.95  | 94.91| 39.94                | Less Sustainable  |
| 3  | Social      | 16.86  | 93.22| 57.23                | Moderately Sustainable |
| 4  | Human Resources | 17.37  | 93.02| 49.88                | Less Sustainable  |
| 5  | Technology  | 13.89  | 94.87| 41.26                | Less Sustainable  |
| 6  | Institution | 14.25  | 94.84| 48.05                | Less Sustainable  |

The multidimensional sustainability index of rice and duck farming is also presented in figure 2 in the kite diagram of the Rawa Lebak Rap Ustan Sustainability Index in Hulu Sungai Utara.

Since five dimensions were still less sustainable, improvement on that dimension should be focused on i.e. dimension of ecology, economy, human resources, technology and institutions. This means that holistic improvements in these five dimensions still need to be conducted and this result was in line with the development concept conveyed by Suwanda and Noor [1] that explained the swampland development requires a holistic and comprehensive approach so that it requires integration, in various fields and aspects that were mutually exclusive. The potential of swampland and diversity of its resources requires a different approach from one location to another and may also have different goals and targets from one interest to another. In order to find out which aspects were still weak and require improvement, it is necessary to carry out a RAP analysis of ustanlebak on each dimension as reported by other research using a similar method by Syarifuddin [13].

Efforts to develop swampland that can be carried out including for rice and duck farming according to Muthmainnah et al. [14] were directed at increasing the integration and peculiarities of the ecosystem. Furthermore, it was stated also that the swamp land management pattern was a long-term policy that can provide benefits to users in a sustainable manner. The utilization rate of swamps was expected to generate economic growth in line with conservation measures. Another point stated by Noor et al. [15] that efforts that can be made to support the implementation of a sustainable agricultural system includes: (1) compilation of land use zoning, (2) improving land and crop management systems, (3) increasing added value, (4) strengthening institutions, and (5) policy support.
3.2. Sustainability index of ecological dimension

In order to find out attributes that were still weak and require an improvement, a RAP analysis of ustanlebak was carried out on each dimension as reported by other research using a similar method by Syarifuddin [13]. The index analysis and sustainability status for the ecological dimension used eight attributes which were predicted had significant influence to the sustainability of the ecological dimension. Those attributes were (1) utilization of livestock waste which is used as organic fertilizer, (2) the smell of duck manure polluting the air, (3) fly pollution, (4) duck raising system, (5) land fertility, (6) land use rate, (7) availability of final disposal sites, and (8) types of animal feed. The results of the analysis of the sustainability of the environmental dimension gave 45.34% results and were included in the less sustainable category (figure 3). This is probably due to the fact that many attributes are less sensitive.

Result of the attributes leverage analysis for ecological dimension is presented in figure 4. Of eight attributes in the environmental dimension, only two attributes were sensitive to sustainability of rice and duck farming in swamp lands currently. They were land fertility and duck breeding system. Thus, management of land fertility and duck breeding system must be improved properly to realize the sustainability of farming and livestock systems in swamp land.

Land fertility was one of the leverage attribute in the sustainability of rice farming in the research location. When the land was less or not fertile, the sustainable use of swamp land will decrease and vice versa. Less fertile land cannot provide high productivity for plants. Therefore, land fertility must be conditioned by farmers who were supported by government.

Soil fertility can be improved by soil processing and using both organic and inorganic fertilizers with the right dose. The use of organic fertilizers is very possible because the study location is an agricultural area both for food crops (rice), horti, and ducks farming. The resulting agricultural waste in the form of hay and manure could be returned to the land naturally as organic fertilizer. Especially for livestock manure, processing or composting should be carried out in order to produce quality organic fertilizer. Since farmers' habit of not using chemical fertilizers too much because of limited capital, duck farming business can supply the availability of organic fertilizers supported by processing of quality compost.
Figure 3. Sustainability index of ecological dimension.

Figure 4. Leverage attribute in sustainability of ecological dimension.
Apart from land fertility, livestock raising systems had a sensitive influence on the sustainability of the ecological dimension. Livestock raising systems can be divided into three patterns depending on the age of the duck, namely extensive (released), semi-intensive (mixed) and intensive (confined in a pen). Duck that were raised extensively (released in open land) were generally carried out by farmers in ducks aged 1.5 to 5 months with the hope of reducing feed costs. However, with an extensive maintenance system for ducks, the resulting manure cannot be collected and composted. Furthermore, the ducks that were kept intensively were carried out on ducks aged 1 day to 1.5 months, after which they were released to the land. At 5 months old ducks, they will gradually be put in cages to be maintained intensively, because at this age the ducks start producing (laying eggs). According to Widyastuti et al. [16], duck dung was livestock waste that causes environmental pollution (water, land and air) and public health if disposed of directly without proper management.

3.3. Sustainability index of economic dimension

The results of sustainability ordination showed that value of the sustainability index for the economic dimension reaches 39.94\% (figure 5) and indicated that category of economic dimension was less sustainable. Analysis of index and status of sustainability for economic dimension used nine attributes as shown in figure 6. Further, the leverage analysis showed that there were six leveraging attributes in the economic dimension, namely the availability of livestock/product markets, marketing of livestock products, changes in livestock business scale, business feasibility, and the contribution of livestock business to family income.

Availability of a market for selling livestock was one attribute that sensitive to economic sustainability. In the research location, there was a market that routinely opened every week to sell livestock products. Even the livestock market in Hulu Sungai Utara Regency was the only market for poultry in South Kalimantan. Consumers who come to this market came from within the district, outside the district and even from outside the province. Market demand had a big influence on economic sustainability because it guarantees the sale of livestock products and provides income for farmers.

![RAPFISH Ordination of Economic Dimension](image)

**Figure 5.** Sustainability index of economic dimension.
The scale of duck farming greatly affected the sustainability of rice and duck farming in the swamp land since it is related to farmers’ income. When the scale of raising ducks was small, the farmer's income will decrease, and even could not give a significant effect to family income. On the other hand, if the scale was large, the farmers will get the impact on the family economy. The scale of raising ducks was strongly influenced by the capital owned by the farmers as well.

Fourth attribute that leverages economic sustainability was business feasibility. A feasible business reflected the health of the business and provides a decent profit for farmers. Profits generated from rice farming have a sensitive effect to economic sustainability as well. This result showed that the rice commodity was indeed profitable and feasible to be cultivated if the season is favorable (not flooded or drought). Profit generated from a business was one of indicator for farmers whereas if a business was profitable and provides sufficient income for their household, business will be carried out and continue. So far, duck farming was a source of family income that can provide daily income and can be carried out throughout the year, while income generated from rice was only carried out once a year.

**Figure 6.** Leverage attribute of economic dimension sustainability.

3.4. **Sustainability index of social dimension**

Rice and duck farming sustainability for social dimension was in the fairly sustainable category with a value of 57.23% (figure 7). The results of the leverage analysis showed four attributes of social dimension sustainability i.e. communication relationships with village officials, communication relationships with livestock health workers, communication relationships with other poktan and communication relationships with agencies (figure 8). This means that four attributes have a sensitive influence on the sustainability of rice and duck farming in swamps.

Communication with village officials, livestock health workers, farmer groups and government agencies were important because this attribute has a role in agricultural development, especially the implementation of agricultural programs through the coordination of agencies and implementing officers. Animal health workers have a role as a source of information and treatment of livestock if a
disease attacks farmers’ livestock. Farmers’ communication with other groups is also important in the smooth dissemination of information about the development of a profitable rice and duck business.

![Figure 7](image)

**Figure 7.** Sustainability index of social dimension.

![Figure 8](image)

**Figure 8.** Leverage attribute of sustainability of social dimension.
3.5. Sustainability index of human resource dimension

Sustainability index for dimension of human resources used six attributes i.e. availability of family human resources, availability of human resources in the village, ability to manage farms in the family, coaching officers to farmers about farming, information sources of technology and the welfare level in the village. The results of the analysis show that the value of the sustainability index for the human resource dimension reaches 49.88% (figure 9) was in the less sustainable category. Leverage attributes of the human resources sustainability were availability of family human resources, availability of human resources in the village, and sources of technological information.

![RAPFISH Ordination of Human Resource](image)

**Figure 9.** Sustainability index for human resource dimension.

The availability of family human resources has an important role because it was a quickly available resource, while the availability of human resources in the village was very important as well during planting and harvesting season with low wages. Sources of technological information were leverage attribute for sustainability since it was closely related to additional insight or knowledge for human resource both in rice and duck farming (figure 10).
3.6. **Sustainability index of technology dimension**

Analysis of index and status of sustainability for technology dimension used nine attributes that has most influence to the sustainability. Those attributes were extension and research services, the use of feed supplements for livestock, seed selection technology, livestock reproduction technology, knowledge of livestock and rice diseases, feed technology, agricultural waste processing technology, livestock and rice processing technology, and training and counseling.

RAP ordination of technology sustainability shows that sustainability index for technology dimension about 41.26% and indicated that technology was less sustainable (figure 11). This result was in accordance with existing conditions in research location whereas farmers generally used limited technology. This occurred not because of the isolated location, but because the level of demand for technology was indeed low, technology adoption and capital ability were low as well.

Leverage attribute of the sustainability of technological dimension is presented in figure 12 whereas out of nine attributes analyzed; seven attributes become leverage of technology sustainability. Technology of livestock waste management, use of feed supplements and knowledge of rice and livestock disease were three most important attributes of technological sustainability. This means that these technologies need to be introduced massively to farmers since livestock waste processing has a positive impact on the environment and land fertility. In addition, processing of livestock waste will improve the quality of tradable fertilizers.

The use of vitamins, drugs and probiotics could trigger optimal livestock growth so that it could be socialized and introduced into duck farming. Seed selection technology was very necessary, because quality seeds would produce optimal productivity if accompanied by the appropriate maintenance management. Livestock reproduction technology needs to be improved and fostered in order to build in the optimal productivity of livestock.
**Figure 11.** Sustainability index of technology dimension.

**Figure 12.** Leverage attribute of technological dimension.
Disease is one of factors causing the loss of duck and rice farming because it reduces production optimality and even causes the death. This condition proved that knowledge about livestock and rice diseases needs to be known by farmers in order to prevent and carry out treatment at the initial stage of disease attack on the cultivated commodity.

Innovation in processing technology for both livestock and rice products were needed by farmers, especially when the price of livestock was low since processing product can increase the selling value of product. Furthermore, feed technology was required to support livestock businesses so that farmers did not depend on the expensive commercial feed. Besides, when farmers master on feed technology, they could produce livestock feed using more local feed ingredients mixed with concentrate so that the price was cheaper than commercial one.

According to Adnyana [8], development of appropriate technology should consider advantages of farmer’s technology. Technology sustainability in swamps, especially in supporting increased rice production, includes seven technology components i.e. (1) water management in accordance with the needs of plants and the expected cropping patterns, (2) land preparation and soil management that are practical and safe against land and environmental degradation, (3) efficient management of nutrients and fertilizers based on nutrient status, (4) new land adaptive superior varieties swamps and high yields, (5) easy and practical planting systems and profitable cropping patterns, (6) integrated and environmentally friendly pest and plant disease control, and (7) alsintan which is in accordance with the nature and conditions of the land and its practice [1].

3.7. Sustainability index of institutional dimension
Result of the sustainability analysis of institutional dimension of 48.05% (figure 13) shows that the institutional dimension was in the unsustainable category based on nine attributes, i.e. transparency in the group, illegal farming activities, the number of families who enter poktan, agricultural institutional activities, institutional inputs, output institutions, assets owned by agricultural institutions, group of meetings, structure and division of tasks in groups.

![Figure 13. Sustainability index of institutional dimension.](image-url)
Of nine attributes, there were six attributes that leverage institutional sustainability (figure 14), namely output institutions, assets owned by agricultural institutions, transparency in groups, agricultural institutional activities, number of families joining poktan, and group meetings. According to Adnyana [8], farmer institutions have a potential to become big organizations that can accelerate or optimize the dissemination of site-specific technology. In addition, institutions as an effort to solve problems and even input or output institutions have an important role in supporting the success of agricultural enterprises [17].

![Graph showing leverage attribute of institutional sustainability.](image_url)

**Figure 14.** Leverage attribute of institutional sustainability.

Assets owned by agricultural institutions were one of the leveraging attributes that affect the sustainability of institutional dimension. Assets that supporting farming were equipment or facilities such as water pumps, spray equipment, feed processing equipment, and cash that can be borrowed by farmer for farming capital. Transparency within the group becomes other leverage attributes in the institutional dimension since transparency in group activities will build trust on farmers and further could enhance the sustainability of the institutional dimension.

Other leverage attribute of institutional dimension was number of farmer households (heads of families) in the village who were becomes members of farmer groups. It could be explained that inclusion of farmers as group members will facilitate farmer to get guidance and government assistance. Routine meeting was one of activity carried out by healthy farmer groups whereas they usually had a fixed agenda of conducting mutually agreed upon routine meetings. In that meeting, they can discuss some important things and problems faced, especially for rice and duck farming.
4. Conclusions
Sustainability analysis for rice and duck farming in swamp land using six dimensions and 44 attributes indicated that sustainability status was less sustainable. Social dimension has the highest sustainability index in the fairly sustainable category, while other dimensions, namely the environmental, economic, human resources, technology, and institutional dimensions were included in less sustainable category. Therefore, the improvement on the five dimensions is prioritized to achieve sustainable rice and duck farming in swampy land. Improvement could be focused on the leverage attributes that were sensitive to the sustainability. They were land fertility and livestock raising system in ecological dimension, availability of livestock and product market and marketing of livestock product in economic dimension, ability to manage farming in the family and availability of family human resource in human resource dimension, agricultural waste treatment technology and feed supplement for livestock in technology dimension as well as the institution of output in institutional dimension.

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