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Sustainability Analysis on Economic and Ecological Aspects of Dry Land Management in Jerowaru District Using Multi Dimensional Scaling (MDS)

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Abstract

This study aims to determine the factors from the ecological and economic aspects that have the most sensitive attributes in influencing the sustainability of dry land management in Jerowaru District. This study uses the Multi Dimensional Scaling (MDS) analysis of Rapfish. The population in this study were all dry land farmers in Jerowaru District, East Lombok. The number of farmer respondents surveyed was 90 farmers spread over three villages with varied agricultural cropping patterns and topography. The sample unit in this study were individuals, namely dry land farmers. The sample in this research is some farmers who do dry land management. The analysis used is descriptive and MDS Rapfish is supported by qualitative analysis from field observations and in-depth interviews as outlined in a descriptive analysis to determine the characteristics of each respondent while MDS Rapfish is used to determine the most sensitive factors on ecological and economic aspects. The results of the feasibility study were tested with the r2 value which is close to one and the stress value <20% and the results of the Monte Carlo analysis which have a difference of <5% with the MDS results. The results of the MDS analysis show that the sustainability status on the economic aspect is 46.3 and on the ecological aspect it is 39.08. On the economic and ecological aspects in the less sustainable category. Leveraging factors from leveraging analysis to improve the status of sustainability in the economic aspect are the availability of inputs, especially fertilizers, access to marketing and availability of water for farming. While the lever factors in the ecological aspect are the use of biochar, the occurrence of floods / landslides, and vegetation cover. These levers must be a priority for sustainable dryland agricultural management in Jerowaru District, East Lombok.

Keywords: Sustainability, Dry Land, MDS, Economics, Ecology

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INTRODUCTION

Dry land or often referred to as dryland or upland or rainfed is defined by several aspects (Walker, 2016). From the aspect of irrigation availability, dry land is defined as a stretch of land that is utilized without waterlogging, either permanently or seasonally with water sources in the form of rain or general irrigation (Utomo, 2014). Dry land is a stretch of land that is never flooded or flooded during a large period of time in a year. From a geographical point of view, dry land is usually in the form of hilly soil with a wavy morphology, also has soil types that are poor in nutrients (Mauget, et al., 2020). In terms of rain availability, dry land also has a relatively low level of rainfall with short wet months. The average rain falls in 3-4 months and the dry season 7-8 months (Rollenbeck, et al., 2011). Annual rainfall ranges from less than 1000 mm in certain areas to 1200 mm. At higher elevations, rainfall can reach more than 1500 to 2000 mm/year with a rainy season of six months. Evapotranspiration is much greater than precipitation (Siarudin, et al., 2014).

West Nusa Tenggara Province has land which is defined as dry land, which is more than 70% of the total area of West Nusa Tenggara Province, which has great potential to be developed. However, dry land has a high level of vulnerability due to its natural nature which has limitations in terms of rainfall levels, wavy shape, with high soil acidity level with relatively low fertility. With its naturally vulnerable nature, dry land management requires special and specific attention, where its management must be carried out by not only prioritizing economic aspects, but also conservation and sustainability aspects. According to Suwardji (2018), biophysical factors and socio-cultural factors of the community are the main causes of the slow management of marginal land or dry land, especially in the southern area of Lombok.

Efforts to pay attention to dry land development are due to regional problems that threaten sustainability (Rogosch, et al., 2019). This is indicated by the increasing number of critical lands in the West Nusa Tenggara region. Based on data from the Forestry Service of West Nusa Tenggara Province, the level of land damage that triggers an increase in critical land occurs in forest areas and also outside forest areas. This can affect the level of water availability, and affect the local climate in addition to being influenced by the phenomenon of climate change. Dry land agricultural land, both in the forest area, or outside the forest area, must be managed carefully because if it is not managed carefully it will affect other aspects, namely social and economic aspects (Kim, et al., 2020). These three aspects will affect each other where one weak factor can make other factors change (Ayeb-Karlsson, et al., 2016).

Regarding the problem of critical land in the Province of West Nusa Tenggara, and on the island of Lombok in particular, the efforts of the West Nusa Tenggara Provincial government to ensure that development is generally carried out in a sustainable manner are embedded in the regional Vision and Mission, namely NTB Gemilang in the Asri and Sustainable Mission which means as a development effort in all fields that is carried out in a sustainable manner and pays attention to environmental sustainability. Asri and Lestari's mission is to improve sustainable environmental management. Asri concerns the availability of land cover, and the availability of land planted with shady trees which at the same time can generate economic benefits for the community. Sustainable means that the use of natural resources must be carried out in a sustainable manner by paying attention to ecosystems, not only economic problems but sustainability in natural cycles which are actually better for the environment (Tschopp, et al., 2018). Sustainable in terms of conservation of the natural environment around, concerning improvement of soil nutrients, improvement of water quality, soil quality and also air quality. Several aspects of sustainable development or also called sustainable development, are also mandated in the MDGs agenda, as well as in the SDGs agenda. One indicator of the development of a region and even a country is sustainability.

Assessing agricultural sustainability must be carried out with a multidisciplinary, integrated and comprehensive approach. Efendi (2016) said that land conservation and the sustainability of production and ecosystem services now and in the future is a Sustainable Land Management approach with an integrated approach between biophysical, socio-economic and institutional aspects. This is because there are several systems involved. Effective and comprehensive assessment methods can bring together the complex concepts involved, interpret and apply agricultural sustainability at different scales from local to global by encouraging increased attention to social, ecological and economic resilience and good governance in agricultural systems. Sustainability assessment is based on concerns for human well-being, ecological conditions, and the forms of anticipation needed to maintain sustainability, as well as to increase attention towards better integrated sustainability in the future. It is therefore necessary to evaluate existing or proposed policies, plans, programs, projects and regulations, as well as current practices and activities. Sustainable agriculture practices in dry land must have a target of at least producing several variants of commodities in an integrated manner, namely producing food (food), feed (animal feed) and fuel (fuel).

Therefore, dry land management efforts must be carried out in an integrated and sustainable manner. In an effort to implement the government's mission to realize sustainable development, it must be an important factor to find solutions for its implementation starting from the smallest spatial scale. The researcher intends to assess the level of sustainability of dry land agricultural management practices in Jerowaru District with a holistic and comprehensive approach. The first impact that can arise from unsustainable dry land management is land degradation which in the long term can lead to desertification. This research is based on the results of research conducted by Ayu et al. (2020) which states that through extension it can increase farmers' knowledge about plant cultivation using organic fertilizers, timing of planting according to the availability of soil moisture, soil and water conservation practices on sloped dry land, and simple accounting books for farming. Efforts to rehabilitate land not only with a physical approach, but of course must be done with a social and economic approach. The first step in land improvement is to identify and find the main causes of land degradation, which is the key basis for realizing sustainability (according to Yierdwa E, et. al. 2016). Factors that cause land degradation and unsustainability can be done by conducting a study of the sustainability status of several sustainable indicators that must be identified. From some of these indicators, it can be seen the level of contribution of several factors taken from field conditions and also expert opinion. From the status and condition of sustainability, it can be seen recommendations for improving dryland agricultural management. The purpose of this study is to identify the levers of sustainability in every aspect of sustainable dryland management. In addition, the results of this research will later be used to formulate policies regarding priorities that need to be recommended for improvement in order to obtain sustainable management of dry land.

METHOD

The unit of analysis in this study is farmers on dry land in Jerowaru District, namely farmers in two locations suspected of having different conditions and planting pota. Based on field observations and with a quick analysis of the target, it is determined which locations are the targets of the survey and study. This research was conducted in Jerowaru District, East Lombok Regency, consisting of 3 (three) villages, namely Pemongkong Village, Sekaroh Village and Ekas Buana Village. The determination of the three villages was purposive sampling, with the consideration that the three villages implemented different land management systems and represented the characteristics of dry land in the Jerowaru sub-district.

The respondents in this study were farmers who managed dry land in the three villages. From the three villages, there were 90 respondents consisting of dry land farmers in each village of 30 people who were spread out on each condition, the characteristics of the farmers were also added with information from the extension workers, and expert opinions who knew the conditions and causes of sustainability in the study location. The selection of respondents at the research location was carried out by Simple Random Sampling based on a list of names of farmers in the farmer groups in each village.

This study uses quantitative data types, namely the data obtained in the form of a database or general description of respondents, descriptions of regional conditions such as natural physical conditions, geographical conditions, rainfall conditions, soil types, land cover, land use. While the detailed data are funds and information regarding economic conditions, social conditions and environmental conditions. This data and information helps in determining the numerical qualitative figures that will be assigned to each formulated sustainability indicator. These conditions are based on field facts and respondents' perceptions which are determined at what interval class from the conditions sought.

The study used two data sources, namely: The types of data obtained in this study were primary data and secondary data. Primary data is data obtained directly from respondents, through interviews that are guided by a list of questions that have been prepared in advance.

While secondary data is data collected from various sources of research results, journals, scientific articles, papers and textbooks as well as reports from relevant agencies that support the data sources for this study, including publications via the internet.

In carrying out the operationalization of research, variables and indicators that are measured at the farmer level are needed to be used as inputs for sustainability analysis. These variables are obtained from literature and journal studies as in the previous chapter. It is described in more detail as follows:

In the economic aspect, the indicators used in formulating the sustainability status are the average on-farm income per hectare per season, the fulfillment of needs (perception of adequacy) from the managed farm, the area of agricultural land, production costs, ease of access to marketing and post-harvest processing. . From the social aspect, the indicators used are social justice, social harmony/occurrence of conflict, disaster events, culture/local wisdom, distance of land from home, and intensification of land management. From the environmental aspect, the indicators are environmental knowledge, environmental conservation counseling, the use of organic fertilizers, the use of mulch in agricultural land processing, tree land preparation and post-planting waste management. From the technological aspect, the indicators are cropping patterns, types and spacing, cropping patterns used, water conservation and water availability, rain harvesting, processing capability, water sources, tree planting. From the institutional aspect, the indicators used are the existence of farmer groups, the existence of an organizational structure, the existence of organizational functions, assistance from the government, finance (financing), and the existence of agricultural extension activities.

One alternative simple approach that can be used to evaluate the sustainability status of an area is Rapfish (Rapid Appraisal for Fisheries). Rapfish is a new multi-disciplinary rapid appraisal technique to evaluate comparative sustainability based on a large number of attributes that are easy to score.

Rapfish is a new technique developed by the University of British Columbia Canada, which is an analysis to evaluate the sustainability of fisheries in a multidisciplinary manner. Rapfish is based on the technique of ordination (putting something in the order of a measured attribute) using MDS. MDS itself is basically a statistical technique that tries to transform multi-aspects into lower aspects. Aspects in Rapfish involve aspects of sustainability from ecology, economy, technology, social and ethics. Each aspect has attributes or indicators related to sustainability as required in the FAO Code of Conduct.

In general, Rapfish analysis begins by reviewing the attributes and defining the fishery to be analyzed (eg vessel-base, area-base, or based on time period), then proceeds to scoring, which is based on the provisions set by Rapfish. After that, the MDS was carried out to determine the relative position of the fishery to the good and bad ordinances. Furthermore, Monte Carlo and Leverage analysis was carried out to determine the aspects of uncertainty and anomalies of the analyzed attributes.

The selection of MDS in Rapfish analysis was carried out considering that other multivariate analysis methods such as factor analysis and Multi-Attribute Utility Theory (MAUT), proved not to produce stable results (Pitcher and Preikshot, 2001). In MDS, the observed object or point is mapped into a space of two or three aspects, so that the object or point is attempted to be as close as possible to the origin. In other words, two points or the same object are mapped in a point that is close to each other. Conversely, objects or points that are not the same are depicted with points that are far apart. The ordination technique (distance determination) in MDS is based on Euclidian Distance which is in n-aspected space. By using Rapfish, a clear and comprehensive picture of the condition of the transmigration area is obtained, so that in the end it can be used as material to determine the right policy to achieve sustainable transmigration area development.

The MDS analysis procedure is carried out through several stages, namely:

1. Analysis of dry land area data through statistical data, literature studies, and field observations.
2. Scoring by referring to the literature and respondents.
3. Perform MDS analysis with SPSS software to determine the ordinance and stress value through the ALSCAL Algorithm.
   The ordination technique (distance determination) in MDS is based on the Euclidian distance which in n-aspected space can be written as follows:

   $$d = \sqrt{(|x_1 - x_2|^2 + |y_1 - y_2|^2 + |z_1 - z_2|^2 + \ldots)}$$

   The configuration or ordinance of an object or point in the MDS is then approximated by regressing the Euclidian distance (dij) from point i to point j with the origin (δij) as follows:

   The ALSCAL method optimizes the squared distance (squared distance=dijk) to the square (origin point=0ijk), which in three aspects (i, j, k) is written in a formula called S-Stress as follows:

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

   The squared distance is the Euclidian distance weighted or written:

   $$d_{ijk}^2 = \sum_{a=1}^{r} w_{ka}\left(x_{ia} - x_{ja}\right)^2$$

4. Perform a "rotation" to determine the position of the area in the "bad" and "good" ordinances.

Goodness of fit in the MDS is reflected in the magnitude of the S-stress value which is calculated based on the S value. A low stress value indicates good fit, while a high S value indicates bad fit. In MDS, a good model is shown if the stress value is less than 0.25 (S < 0.25).

Fauzi, Akhmad, (2019) explained the process and interpretation of the results of the analysis using MDS RAPFISH. After performing input analysis, anchor analysis, also after running it using the Rapfish application, you can find a rapfish graph or diagram. This diagram illustrates the position of each attribute in each aspect analyzed. This position in two images describes the distance and position shown. The analysis of the RAP-FISH ordinance with the MDS method was carried out through several stages, namely (1) attributes, (2) attribute assessment on a scale (scoring) based on the causal factors, (3) RAPFISH ordinance analysis with the MDS method using the SPSS program to determine ordination and stress values, (4) assessing the index and status of capacity building capacity building for extension workers in utilizing climate information both in multiaspect and in every aspect, (5) Leverage analysis to determine the influencing variables, (6) Monte Carlo analysis to estimate aspects of uncertainty (Kavanagh and Pitcher, 2004). Determine the assessed status with MDS results by looking at the range on each aspect and the overall range of values. The categories are unsustainable, less sustainable, moderately sustainable and very sustainable. determination indicators are described in the following Table 1.

Table 1. Sustainability Level Category

Index Value	**Category**
0 ± 25,00	Bad (unsustainable)

Index Value	Category
25,00 ± 50,00	Less (less sustainable)
50,00 ± 75,00	Sufficient (sufficiently sustainable)
75,00 ± 100,00	Good (very sustainable)

More fully, the MDS analysis procedure starting from input, feasibility, analysis results and recommendations is described in the following diagram:

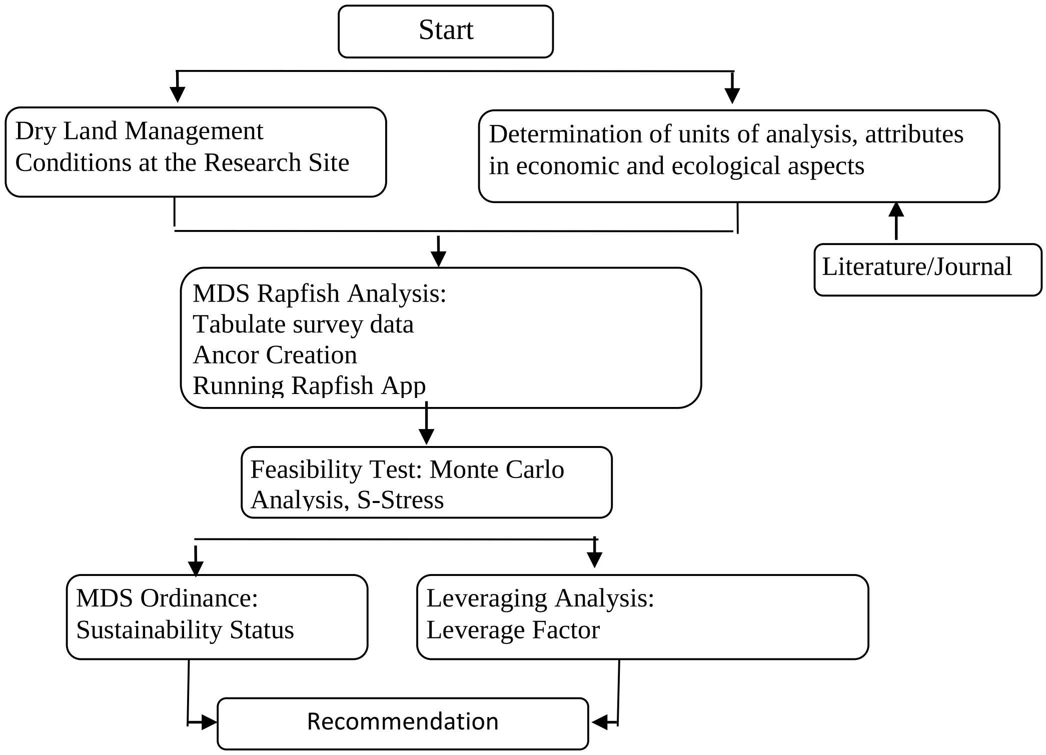

Figure 1. MDS Analysis Procedure Diagram

RESULTS AND DISCUSSION

Ecological Aspect

Based on the results of the Rapfish analysis which was strengthened by the Monte Carlo analysis, the value of the ecological aspect of sustainability status for sustainable use of dry land management in Jerowaru District is 40 (Figures 1 and 2). This shows that the use of dry land is less sustainable with the index value on a scale of 25.00-50.00. According to Erwina et al. (2015), this category reflects unfavorable conditions for sustainable processing.

The results of the analysis of the leverage/sensitivity of the ecological aspect show that the most sensitive attribute is the use of biochar/soil improvement, which is 3.365 (Figure 3). A slight change in this attribute will affect the status of efforts to use sustainability in dry land management in Jerowaru District. Attributes of the use of biochar / soil improvement need to be managed properly so that the ecological aspects can be improved properly. In addition to the attributes of using biochar / soil improvement, other attributes that have high sensitivity or high leverage are disaster events such as landslides, erosion, and drought which show a sensitivity or leverage rating of 1.373. Although the leverage value shown by the disaster event is quite different from the use of biochar, this attribute needs to be considered in order to improve the sustainability of dry land management in Jerowaru District. Sustainability indicators from aspects of flood and landslide events are of concern because they affect economic aspects and farming financing. According to farmers' information, there were floods after planting corn and other crops when it started to rain. However, when the rain discharge increased, erosion and flooding occurred which inundated the lower area of agricultural land which caused the farmers' crops to be submerged. Of course, this is detrimental to farmers who have already incurred costs for land preparation, purchase of seeds, labor and other costs. This means that the ecological aspect greatly affects the economic aspect, and vice versa. While the least sensitive attribute is the use of organic fertilizer/compost fertilizer, which is 0.095. This means that changes to this attribute will not significantly affect the sustainability status. This is in line with the data in the field which shows that there are farmers who use compost in the management of dry land for agriculture, namely Sekaroh Village, while in Pemongkong Village only a few use compost in their agricultural business.

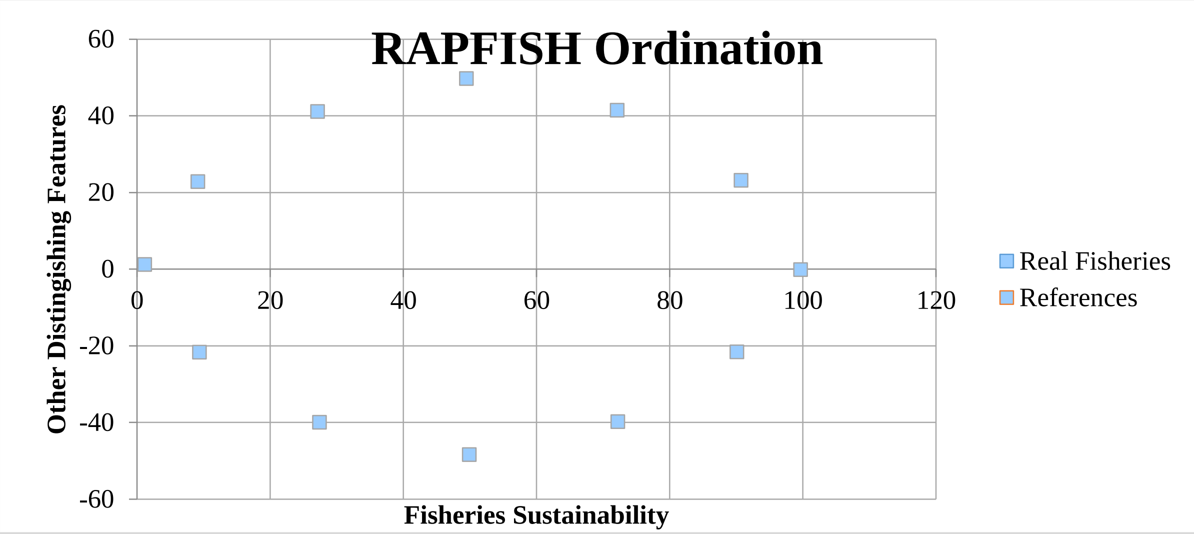

Figure 2. The position of the sustainability status of the ecological aspect of sustainable use of dry land management in Jerowaru District using RAPFISH MDS Analysis.

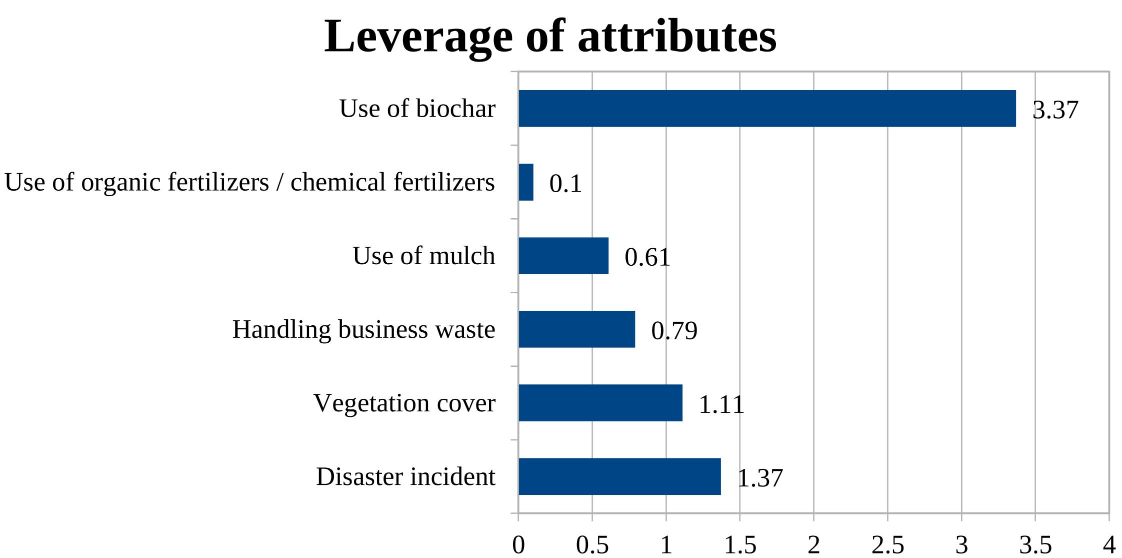

Figure 3. Leverage analysis results on ecological aspects

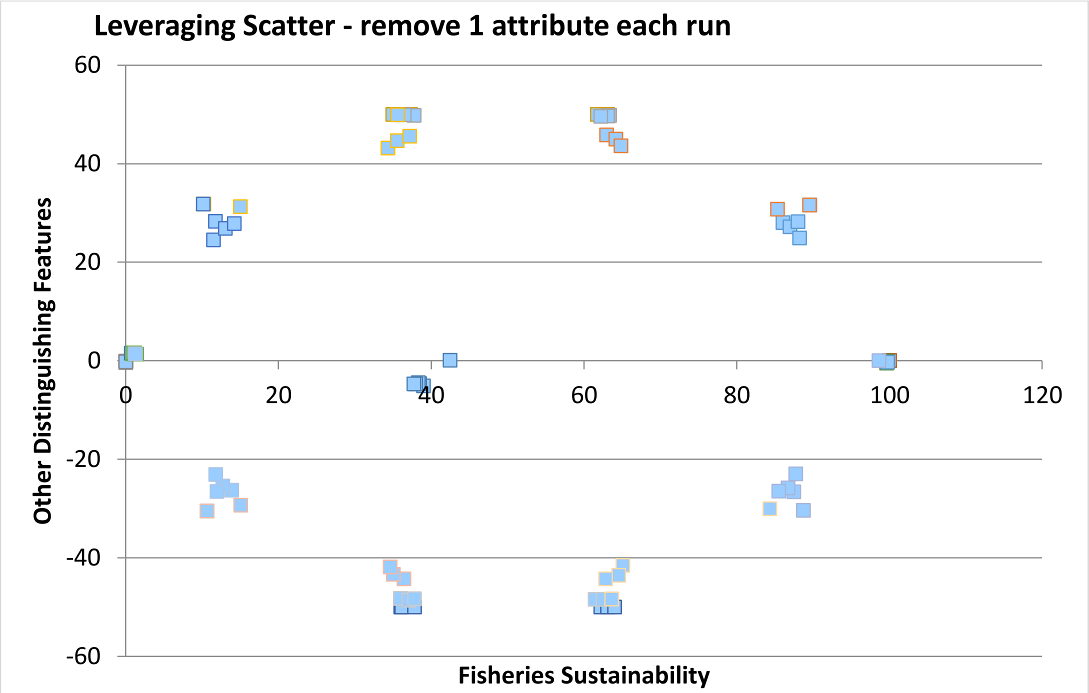

Figure 4. The position of the sustainability status of the ecological aspect of sustainable use of dry land management in Jerowaru sub-district using MDS based on the Monte Carlo analysis test.

Economic Aspect

Based on the results of the Rapfish analysis which was strengthened by the Monte Carlo analysis, the value of the status of the economic aspect of sustainability in the effort to use sustainability in dry land management in Jerowaru sub-district is 46.30 (Figures 4 and 5). This shows that the use of dry land is less sustainable with the index value on a scale of 25.00-50.00. According to Erwina et al. (2015), this category reflects unfavorable conditions for sustainable processing.

The results of the economic aspect of leverage/sensitivity analysis show that the most sensitive attribute is the availability of inputs (fertilizer) which is 3.849 (Figure 6). A slight change in this attribute will affect the status of efforts to use sustainability in dry land management in the Jerowaru sub-district on the economic aspect. The availability of inputs (fertilizer) attributes need to be managed properly so that the economic aspects can be improved properly. In addition to the availability of inputs (fertilizer) attributes, another attribute that has high sensitivity or high leverage is marketing access which shows a sensitivity or leverage number of 2,666. Although the leverage value shown by marketing access is quite different from the availability of inputs (fertilizer), this attribute needs to be considered in order to improve the sustainability of dry land management in Jerowaru District. Meanwhile, the least sensitive attribute is on-farm income, which is 0.607. This means that changes to this attribute will not significantly affect the sustainability status. This is in line with the data in the field which shows that there are farmers who have quite high agricultural yields, for example in Sekaroh Village. In addition, farmers also not only use the land for agriculture, but also combine it with livestock. Some parts of the agricultural land are used as land for planting turi. The results of this turi planting are then used as animal feed, such as cows and goats. For farmers, this method of combining agriculture and animal husbandry is quite helpful in terms of farmers' finances.

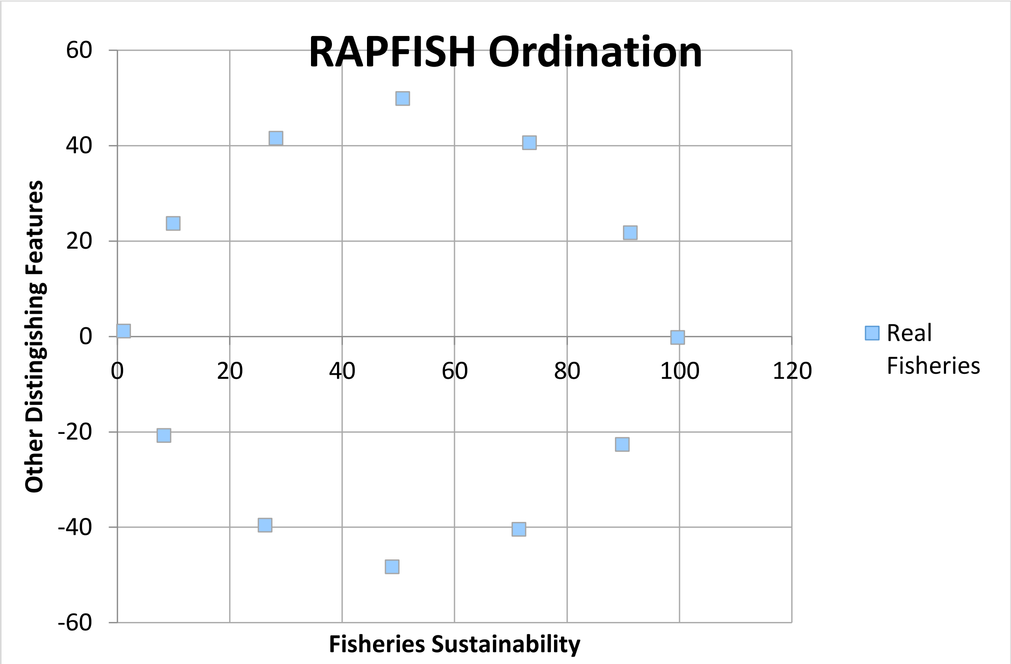

Figure 5. The position of the sustainability status of the economic aspect of sustainable use of dry land management in Jerowaru sub-district using MDS based on RAPFISH analysis.

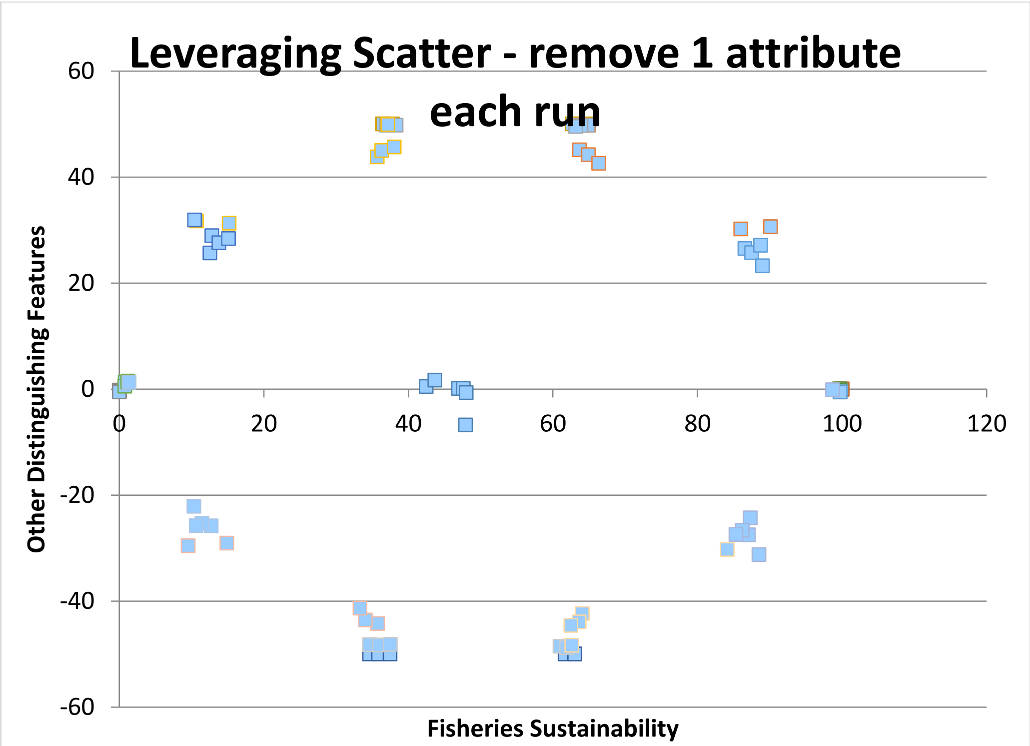

Figure 6. The position of the sustainability status of the economic aspect of sustainable use of dry land management in Jerowaru sub-district using MDS based on the MONTE CARLO analysis test.

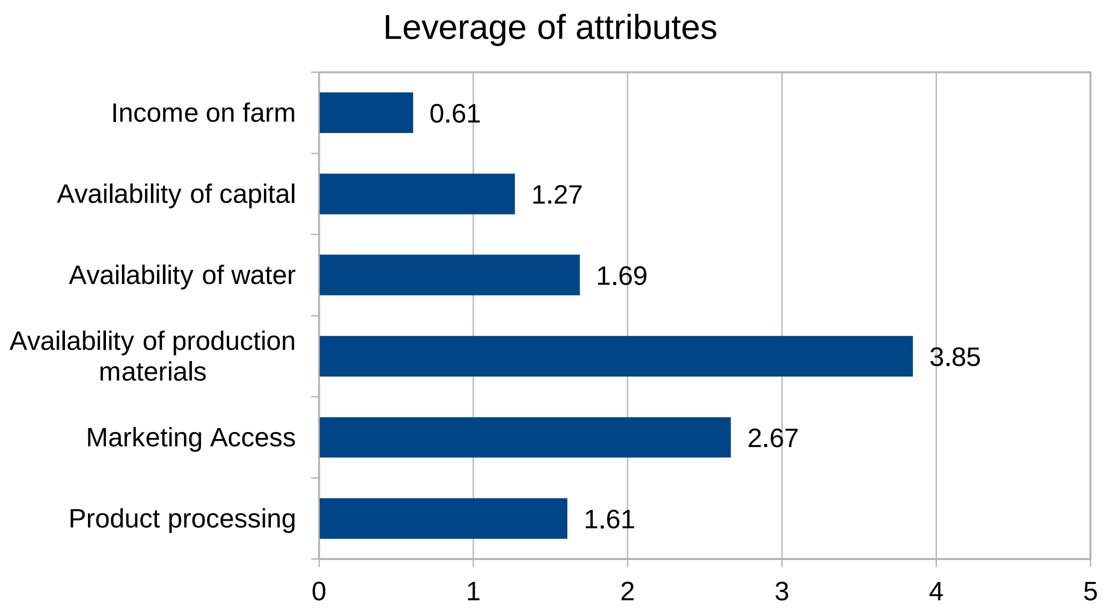

Figure 7. LEVERAGE analysis results on economic aspects

CONCLUSION

From the results of the MDS Rapfish analysis, it can be concluded that the sustainability status of the economic and ecological aspects is less sustainable. The status of sustainability in the ecological aspect is lower than in the economic aspect. The economic aspect of the sustainability status is less sustainable towards the sustainability criteria. This indicates that there are many things that must be considered in dry land farming in Jerowaru District. On the ecological aspect, the main thing that needs to be considered as a leveraging factor is the use of biochar / soil improvement and decreasing disaster events such as landslides, erosion, and drought. The use of biochar is due to the need for improving soil quality, which can be obtained naturally and technologically more complex. The following two factors need to be considered, a slight change in these two factors will determine the sustainability of dry land agriculture in Jerowaru District on the ecological aspect. In addition to the ecological aspect, another aspect that is considered in this research is the economic aspect. Leverage factors that must be considered based on the results of the analysis that have been carried out are the attributes of production inputs (fertilizer) availability and marketing access. These two factors are the most sensitive factors for realizing sustainable dryland agriculture.

RECOMMENDATION

Based on the results of this study, the government is expected to take action by promoting regulatory improvements in areas that are important to improve. In the economic aspect, the most priority to address is the provision of fertilizers and water at right time and on target as important production input to increase dryland productivity. In the ecological aspect, the most critical thing is the use of biochar to increase soil quality. Another factor is the importance of paying attention to land vegetation cover is very useful in reducing soil erosion that causes flooding, and also improves the quality of the soil. In addition, the diversification of plant species can increase sources of income for people who have needs to employment. The results of this study are expected to be used as a reference for the government to make improvements so that dry land can be utilized optimally and more sustain.

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