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A Multi-Dimensional Approach to the Sustainable Development of Moa Buffaloes in Maluku Province, Indonesia

Jomima Martha Tatipikalawan[1,4], Fransiskus Trisakti Haryadi[2]*, Endang Sulastri[2], and Tri Satya Mastuti Widi[3]

[1]Department of Animal Science, Faculty of Agriculture, Universitas Pattimura, Ambon, 97233, Indonesia
[2]Department of Livestock Socio-Economics, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, 55281**,** Indonesia
[3]Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, 55281**,** Indonesia
[4]Doctoral Student, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, 55281**,** Indonesia

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* Corresponding author:
Telp. +62 815 7950 789
E-mail: trisakti-h@ugm.ac.id

ABSTRACT

The purpose of the study was to determine the level of sensitivity of the indicator for the sustainability of the Moa Buffalo development based on the results of the identification and measurement of the index with a multidimensional approach on ecological, socio-cultural, and economic dimensions. The unit of analysis in this study, which was conducted on Moa Island, Maluku Province, was 261 farmer households and 16 experts who were selected using purposive sampling technique. Data collection method: literature study, Focus Group Discussion, in-depth interview, survey, measurement. The research variable is the development potential of the Moa Buffalo from 3 dimensions of sustainable Moa Buffalo development (ecology, socio-culture, economy), including 40 indicators. Data analysis using ordination technique Rap-BANGKER through the Multi-Dimensional Scaling (MDS) method to measure the index and status of sustainability and Leverage Analysis, to determine the key factors, Monte Carlo Analysis to assess the effect of errors on the estimated value of ordination for the development of the Moa Buffalo. The results showed that the average value of the Moa buffalo development index was 52.72% (sustainable). The ecological dimension is 41.15% (less sustainable) with 7 sensitive indicators, socio-cultural dimension is 60.28% (sustainable) with 5 sensitive indicators, economic dimension is 56.73% (sustainable) with 3 sensitive indicators. The Monte Carlo analysis of the three dimensions shows the value of the sustainability index at the confidence level of 95%, the difference in value is <1, the coefficient of determination (R2) for the third dimension is 95.00%. The MDS Rap-BANGKER analysis model is adequate to estimate the sustainability of the development of Moa Buffalo, has a high level of confidence, can be used as an evaluation tool to rapid appraisal sustainability analysis of buffalo development in an area.

Keywords**:** Ecology, Economy dimensions, Moa Buffalo, Sensitive indicators, Socio-cultural, Sustainability status

Introduction

Maluku Province is an archipelago province in Indonesia that consists of 812 islands varying from small to large islands. The Southern Islands have great livestock potential and are endemic to Moa Buffalo. Moa buffalo germplasm of local beef cattle in Indonesia and only lives in the Lemola archipelago, Maluku Province. The population of Moa buffalo in 2020 was 10,531 or 66.10% of the buffalo population in Maluku. Is a type of mud buffalo, resistant to dry agro-ecosystem environments. Moa Island also has 22,978 Ha of view area for grazing.

Buffalo farming is the main business of most of the inhabitants of Moa Island, but in its development, many obstacles cause a decline in the population of 4.55% per year. Traditional maintenance without a touch of technology, limited water resources, low quality of forage, especially during the dry season. Several factors that are thought to reduce the livestock population are the mutation of cattle out of Moa Island by 3.14% of the population per year, mortality due to limited water resources, low quality of forage, especially during the dry season. Data for the last 5 years there has been climate change from semi-arid to arid with an average annual rainfall of 155.5 mm and a relatively long dry season (± 8-9 months). FAO (2004) stated that rainfall for arid

(dry) climates is 50-250 mm. There are factors inherent in the buffalo it self that hinder its development, such as hidden lust that is difficult to detect, inbreeding, habitat disturbance due to the narrowing of the grazing area, and an extensive maintenance system that makes it difficult to apply technology, especially reproductive technology.

Another obstacle is that the utilization of natural resources has not been optimal because the potential and utilization have not been measured at the farmer level. The low quality of human resources raises several problems, are the management of maintenance businesses that are still traditional and not agribusiness oriented, limited information. Farmers amongst themselves shared information on buffalo (Kumar *et al.*, 2020). Limitations in marketing development. Marketing development strategies for products derived from buffalo (Marques *et al.*, 2016) and additional market opportunities from meat technology need to be carried out (Kumar *et al.*, 2020). Institutions at the farmer level are not well organized and farmers are limited in implementing development programs. Strong organizations/institutions make farmers have a strong bargaining position, able to build high-value commodities because they have quality human resources that can maintain competitiveness and business sustainability (Komariah *et al.*, 2020).

This effort needs to be sustainable so that it can benefit the community and the next generation. Moa buffalo development needs to meet the criteria for sustainable development (sustainable development) that combines and harmonizes economic interests, socio-culture, ecological sustainability (Saragih and Sipayung, 2002). Sustainability assessment is viewed from three dimensions: ecological, socio-cultural, and economic. The attribute for each dimension is at the farmer level so that this level is the starting point for the continuation measurement. Fauzi (2013) sustainability is a long-term concept and involves various socio-cultural, economic, environmental dimensions.

The *Multidimensional Scaling* (MDS) model can be used to measure the sustainability of buffalo development in an area because MDS is a statistical technique that tries to transform multidimensional into lower dimensions (Fauzy and Anna, 2005). The appraisal method measures the sustainability status quickly through analysis from various perspectives or multi-dimensions by including ecological, socio-cultural, and economic attributes and is more stable than other multivariate analysis methods (Pitcher and Preikshot, 2001). The study was to determine the level of sensitivity of the indicator for the sustainability of the Moa Buffalo development based on the results of the identification and measurement of the index with a multidimensional approach on ecological, socio-cultural, and economic dimensions.

Materials and Methods

Materials

This research was conducted on Moa Island, Maluku Province, Indonesia. The unit of analysis in this study, was 261 farmer households contributed to providing information about the existing conditions of the farmer's business at the research location and 16 experts contributed to assessing the sustainability indicators. Data were collected using a questionnaire and measuring the availability of feed.

Methods

The stages of the research are: (1) compiling indicators for each dimension using a literature review method taken from several concepts of sustainable agriculture and animal husbandry development from previous studies and adjusted to the potential exiting conditions of each dimension; (2) Determination of indicators which include the number of indicators and scores, provisions for the assessment of indicators for each dimension are determined through Focus Group Discussions (FGD) with Experts; (3) At this stage, interviews were conducted with farmers regarding the existing conditions and assessment of each indicator of each dimension by the expert using the depth interview method; (4) a survey is conducted to compare the existing conditions in the field with the information provided by the respondents; (5) Measuring the availability of forage buffalo forage and identification; (6) data analysis.

Data analysis

Using the Rapid Appraisal Ordination Technique for the Development of Buffalo Moa (Rap-BANGKER) to assess the index and status of sustainability. The Rap-BANGKER Ordination technique is a modification of the Rapid Appraisal for Fisheries (RAPFISH) method developed by the University of British Columbia, Canada to assess the sustainability of a system consisting of Multi-dimensional Analysis (MSD), Monte Carlo Analysis, Leverage Analysis (Pitcher, 1999; Rahayu *et al*., 2013).

Rap-BANGKER Ordination Analysis Stage: (1) Determination of indicators for each dimension, (2) Assessment of each indicators on an ordinal scale based on the sustainability criteria of each dimension, (3) Rap-BANGKER ordination analysis using the MDS method to determine the ordination and stress value, (4) Assessment of index and status of the sustainability of the Moa buffalo development, (5) Leverage Analysis to determine indicators that are sensitive to sustainability, (6) Monte Carlo analysis to account for uncertainty.

The definitive score for each indicator is the mode value, which is then analyzed to determine the point that reflects the position of the sustainability trainer against the "Good" and "Bad" points using multidimensional statistical ordination techniques. Estimated scores for each dimension are expressed on a scale of 0% (bad) and 100% (good) and grouped into 4 categories: 0 - 25% (unsustainable), 25.01-50% (less sustainable), 50.01-75% (sustainable), 75.01-100% (very sustainable) (Osak and Hartono, 2016).

Monte Carlo analysis is used to examine the effect of calculation errors and judgment errors on indicators by respondents or to evaluate the effect of errors on the estimated value of buffalo development ordination. If the difference between the Monte Carlo sustainability index and the MDS sustainability index is less than 1 (<1), this indicates that the effect of errors in the analysis is small (Kavanagh, 2001). The goodness of fit in MDS is reflected in the values of S-Stress and R2. A good model is indicated by an S-Stress value that is smaller than 0.25 (S <0.25) and R2 is 80% or close to 100% (Saida *et al.,* 2012).

Results and Discussion

Indicators of Moa buffalo development sustainability

The indicators were derived from various references of similar studies, the results of field observations, and potential studies of each dimension in the research area. Before being determined as research material, the indicators had gone through the Focus Group Discussion process. Indicators in each dimension were classified based on the criteria into "bad" and "good" (score 0 – 4) and adjusted to the definition range for each indicator. There were 40 indicators used to assess the sustainability level of Moa Buffalo development in Maluku Province, with details 16 indicators describing the ecological dimension, 14 indicators describing the socio-cultural dimension, and 10 indicators describing the economic dimension (Table 1).

Index and status of Moa buffalo development sustainability

Based on the Multidimensional Scaling Analysis (MDS) results, which in this study was called Rap-BANGKER, it showed that the average value of the sustainability index of the Moa buffalo development area was 52.72%, so that the sustainability status category was sustainable (Table 2). The sustainability index of each dimension was the ecological dimension of 41.15% (less sustainable), the socio-cultural dimension of 60.28% (sustainable), and the economic dimension of 56.73% (sustainable) (Figure 1). These results indicate that the socio-cultural dimension has the highest sustainability index because Moa buffalo are used as traditional livestock in traditional ceremonies, rituals, customary sanctions, marriage dowries. Communal maintenance system with a group pattern based on kinship. This condition causes Moa Buffalo to be maintained for its sustainability.

The ecological dimension

The ecological dimension sustainability status value was 41.15 (less sustainable). The sustainability status value on this dimension was lower than the socio-cultural and economic dimensions. The Leverage analysis results found seven indicators sensitively affecting the Moa Buffalo development sustainability, namely (1) Availability of water for buffalo, (2) The quantity of forage during the dry season, (3) Type of animal feed given, (4) Feed carrying capacity, (5) Quantity of waste, (6) Utilization of buffalo waste

Table 1. Indicators used to assess the level of sustainability of Moa buffalo development on Moa Island

Dimensions/Indicators		
Ecology	Socio-cultural	Economy
1. Rainfall	1. Number of farmers households	1. The profit of buffalo Moa farming
2. Drought	2. Work is done individually or in groups	2. The contribution of buffalo business revenue to the total household farm income
3. The condition of buffalo puddles during the dry season	3. Participation of family members in buffalo farming	3. Availability of production facilities
4. Cleaning the buffalo shead	4. Buffalo rearing system	4. Number of buffalo
5. Quantity of waste (feces and urine left in the buffalo shead)	5. Formal education	5. Availability of family labor in managing buffalo business
6. Availability of biogas plants	6. The role of the community in buffalo management	6. Capital independence
7. Utilization of buffalo waste for organic fertilizer	8. Buffalo farm empowerment program (last 5 years)	7. Market access
9. Carrying Capacity	10. There is a culture in regulating the pastoral system	8. Buffalo prices per 5 (five) years
11. Type of animal feed given	12. The role of buffalo as socio-cultural	9. Types of products
13. Utilization of agricultural waste for animal feed	14. farmer households who have attended extention and training related to buffalo farming	10. Business alternatives other than buffalo farming
15. The quantity of forage during the dry season	16. frequency of conflict	
17. Integration	12. Access to media and information	
13. Availability of water for buffalo	13. The goal of managing buffalo	
14. Land use rate (holding capacity)	14. Farmer groups	
15. Availability of superior forage land for animal feed (elephant grass, king grass, etc)		
16. Occurrence of transfer of function of pastoral land		

Table 2. Index and status of sustainability of the Moa buffalo development area

Dimension	Index Dimension	Status
Ecology	41.15	Less sustainable
Socio-cultural	60.28	Sustainable
Economy	56.73	Sustainable
Average status of sustainability	52.72	Sustainable

for organic fertilizer, and (7) Availability of biogas plants (Figure 2).

Indicators 1 to 4 had a strong relationship, namely climatic factors that affect water availability and the feed quantity for buffalo and subsequently affect the holding capacity. The long dry season impacts the drying up of almost all the wallows and forages in natural pastures. As a result, the natural grass availability fluctuated in terms of quality, quantity, and continuity. It was suspected that there was a decrease in the bodyweight of buffalo because the nutritional needs were not fulfilled. It could be seen from the selling price of buffalo in the dry season, which was 9.44% lower than the selling price of buffalo in the rainy season so that farmers tend to sell buffalo in the rainy season. The number of buffalo marketed in the rainy season was 37.14% higher than in the dry season. In the dry season, there was also an increase in buffalo mortality. In Ethiopia, a prolonged dry season causes drought and decreases the quantity and quality of feed and water. As the impact, the productivity of livestock decreases, the mortality of livestock increases, and the entire herd can be destroyed (Tolera and Abebe, 2007).

Some efforts were needed to improve the status of these indicators. First, build water reservoirs (dams) in grazing areas that can hold water throughout the rainy season to irrigate artificial puddles. Second, utilize vacant land in each village to plant superior forage. Third, utilize forage tree legumes such as *Gliricidia sepium*, *Leucaena leucocephala*, *Schleichera oleosa*, and *Ficus benjamina,* which are around the pasture location as additional feed. In Ethiopia, herders overcome food and water shortages during the dry season by cutting leaves and tree branches and using them as animal feed (Tolera and Abebe, 2007). Fourth, farmers also need access to information on good pasture management practices to improve pasture and fodder production, suitable species, management, and technology.

Indicators 5 to 7 had a strong relationship. The utilization of buffalo dung was highly dependent on the quantity of waste and the availability of biogas installations. The utilization of

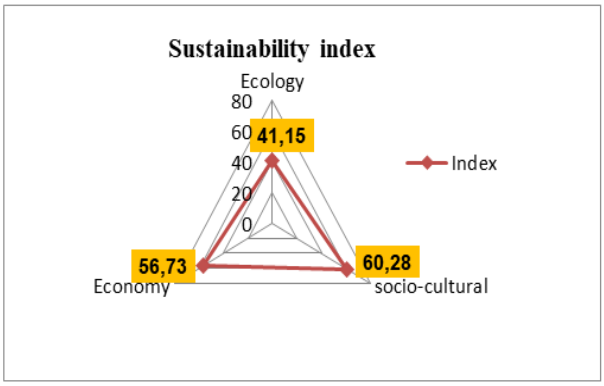

Figure 1. Development continuity index kite diagram Moa buffalo.

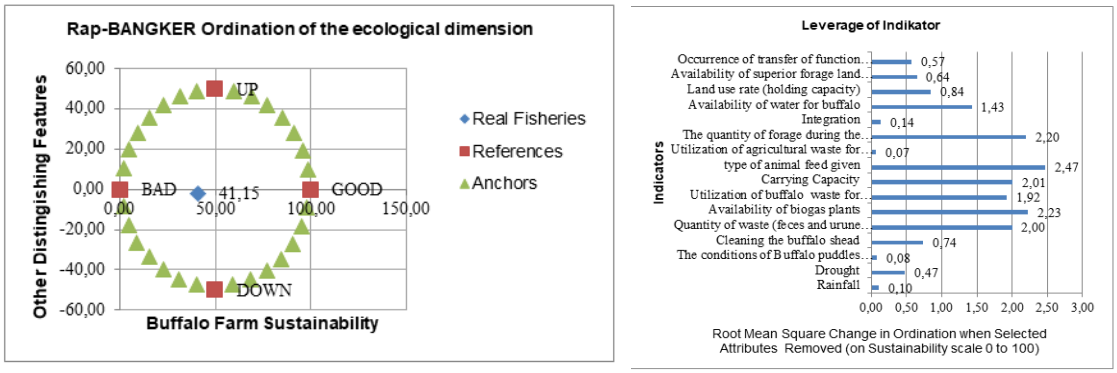

Figure 2. The value of the ecological dimension sustainability index and sensitive factors that affect ecological sustainability.

buffalo dung as an alternative energy source (biogas) was not found because it was not yet a common method. Survey data showed that only 35.95% of farmers used buffalo dung as fertilizer for food crops with a 3-6 months utilization time. Livestock waste is generally used as compost (Budiyanto, 2011), and only a tiny amount of it is used as biogas (Farahdiba *et al*., 2014). Socialization needs to be done related to the impact of buffalo dung and urine for both health and globally environmental damage. The knowledge enhancement about biogas and capital assistance for supporting installation production also can be an effort to overcome the limitations of electrical energy on Moa Island.

The socio-cultural dimension

The MDS analysis result for the socio-cultural dimension sustainability status of the Moa Buffalo breeding area was 60.28 (sustainable category). The Leverage analysis results showed that five indicators were sensitive to the value of the sustainability index in the socio-cultural dimension, namely: (1) The role of buffalo as socio-culture, (2) There is a culture in regulating the pastoral system, (3) Access to media and information, (4) Buffalo raising systems, and (5) Formal education (Figure 3).

The influence of status indicators on the role of buffalo as socio-cultural livestock is more influence. The results of the analysis, this indicator is sensitive to maintaining the sustainability of the Moa Buffalo maintenance. The function of the Moa buffalo as a means of payment of customary sanctions. Buffaloes are also used as a means of transactions or certain payments, such as the process of buying and selling land and measuring social status, although this has begun to disappear in the lives of the people of Moa Island. Its function as traditional livestock causes the Moa Buffalo to be maintained for its sustainability.

Indicator 2 (There is a culture in regulating the pastoral system) was the most sensitive indicator of the socio-cultural dimension sustainability. Communal maintenance system was performed from generation to generation by grouping breeders based on kinship (blood relations) or in local customary institutions known as Soa (Soa is a small collection of houses that have a certain "marga" or "fam" living in one area). This system had a positive impact, namely (1) utilize resources together, (2) avoid internal conflicts between farmers, (3) ease the burden of grazing, (4) help farmers who do not have cage (lutur), and (5) as information exchange media between farmers. The positive value of this system for the environment is pollution reduction. According to Asriany (2016), local wisdom in housing culture has positive consequences in preserving nature and the environment and is in line with the sustainable farming concept, which positively impacts suppressing the consumption of natural resources, saving energy, and minimizing pollution to the environment. The research results found that the 100% maintenance system was still traditional. Utilization of Lutur or buffalo cage in the form of a fence made of limestone or wood is used during the rainy season. During the dry season, Buffalo is released freely in the grazing fields. This system is still being maintained.

Another indicator that influenced the socio-cultural dimension sustainability was formal education. The level of formal education of the breeder played a vital role in the success of the buffalo business performed. Farmers with primary school education were on average 52.30±7.78 years old, in contrast to younger breeders who had better formal education. A good level of formal education is an essential factor in the success of farmers in performing buffalo business, especially in the self-opening to receive information on new technologies related to technical issues, production processes, and marketing. The low access to information causes the slow change of farmers' behavior in buffalo maintenance management (Fuady et al., 2012). It is necessary to move and increase the role of the younger generation who have a better formal education than their parents in continuing the business to improve the status of the socio-cultural dimension sustainability.

The economic dimension

The MDS analysis result for the economic dimension sustainability status was 56.73 (sustainable category). The Leverage analysis

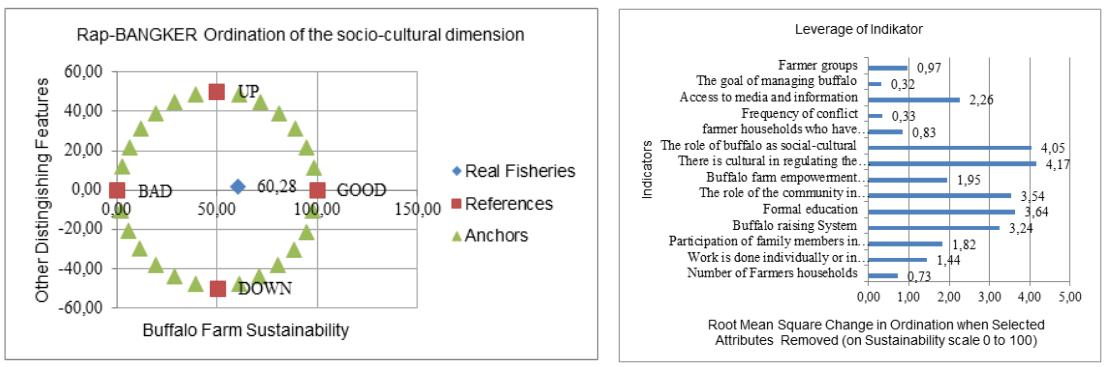

Figure 3. The value of the socio-cultural dimension sustainability index and sensitive factors that affect socio-cultural sustainability.

results showed that three indicators were sensitive to the value of the sustainability index in the economic dimension, namely: (1) Capital independence, (2) Availability of family labor in managing buffalo business, and (3) Availability of production facilities (Figure 4).

Capital independence was the most sensitive indicator in the economic dimension sustainability. All capital used came from the breeder himself. In traditional maintenance conditions, capital independence is relatively substantial because it does not require high production costs. However, if this business will be business-oriented, then the capital requirement is an essential factor. Currently, the main obstacle is the limited sources and types of capital. Farmers in rural areas still find it difficult to easily access capital (Widiati, 2012). Efforts that needed to be made to improve the economic dimension sustainability status are increasing the government's role to provide capital and its distribution to be right on target and an intermediary media between farmers and financial institutions.

The availability of family labor in managing the buffalo business was the second most sensitive indicator affecting the economic dimension sustainability. The family members involvement in the buffalo business management was low because 60.15% of farmers performed their livestock business individually and only 39.85% involved family members. The younger generation of their children tends to work outside the island after completing their education at university. Cassidy and Mcgrath (2015) found that in Ireland, the children of farmers who had migrated to cities to pursue higher education tend to dislike working in the agricultural sector. Efforts were needed to increase the value of this dimensional index by making this livestock business more attractive to perform. The efforts are improving the image of working on farms, increasing government attention for livestock producers, and increasing the accessibility of successors to livestock land. The last effort is essential because this village, located adjacent to the district capital, currently has experienced land conversion and ownership transfer. Legal protection or regulation is also needed to regulate the restrictions on the transfer of the grazing land.

Another sensitive indicator was the availability of production facilities. The production facilities need was fulfilled by utilizing the limited local materials. One effort to increase the sustainability index in the economic dimension is to manage and intervene in this indicator by establishing an inputs or production facilities market which is specific and widely open.

Monte Carlo analysis and goodness of fit

The results of the Monte Carlo analysis of the three dimensions show that the index value of the sustainability of the Moa Buffalo development on Moa Island at the 95% confidence level (Table 3) shows a very small difference in value or not more than 5%. The small difference in value indicates that the effect of the error on 1) the scoring variable because the difference in opinion is relatively small; 2) the process of analyzing data which is carried out repeatedly is stable; 3) the variation in scoring due to differences in opinion is relatively small; 4) data input errors and missing data can be avoided (Pitcher *et al*., 2013). These results also show that the MDS RAP-BANGKER analysis model produced is adequate to predict the sustainability of the development of Moa Buffalo livestock on Moa Island, has a high level of confidence and the RAP-BANGKER analysis method can be used as an evaluation tool to assess quickly (rapid appraisal). sustainability analysis of buffalo development in an area.

The results of the stress value analysis only ranged from 13% -14% and the coefficient of determination (R2) for the three dimensions was 0.95 (95%) (Table 4). Kavanagh (2001) and Pitcher *et al.* (2013) state that the results of the

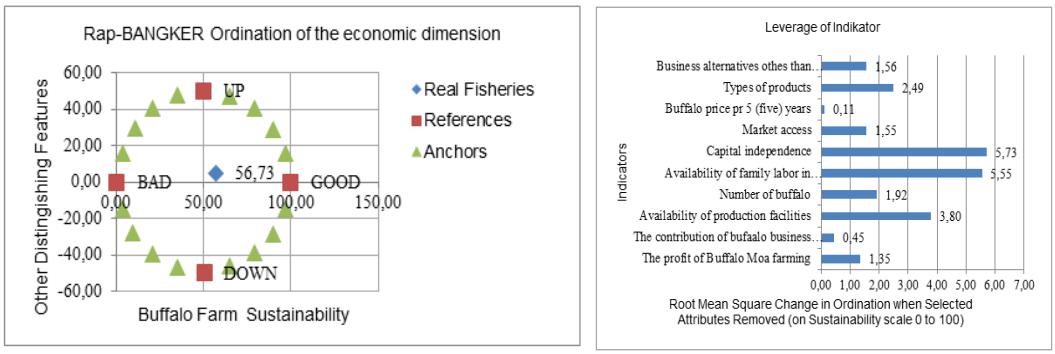

Figure 4. The value of the economic dimension sustainability index and sensitive factors that affect economic sustainability.

Table 3. The results of the Monte Carlo analysis of the value of Rap-Bangker with a 95% confidence interval

Dimensions	MDS	Montecarlo	Delta
Ecology	41.15	41.31	0.16
Socio-cultural	60.28	60.97	0.69
Economy	56.73	56.04	0.69

Table 4. Statistical parameters (goodness of fit) index analysis and sustainability status Moa Buffalo development

Dimensi	RSq	Stress
Ecology	0.95	0.13
Socio-cultural	0.95	0.13
Economy	0.95	0.14

analysis are adequate if the stress value is less than 0.25 (25%) and the coefficient of determination (R2) approaches 1.0. The stress value is close to zero, then the resulting output is more similar to the actual situation, the better / fits the model (Kavanagh, 2001). The MDS analysis model obtained has high accuracy (goodness of fit) (Fisheries.com, 1999).

Conclusions

The ecological, socio-cultural, and economic dimensions are the dimensions that support the sustainable development of the Moa buffalo with the status of the ecological dimension is less sustainable, the socio-cultural dimension is sustainable, the economic dimension is sustainable. The attributes that are sensitive to the effect of increasing the sustainability index of the Moa buffalo development are Availability of water for buffalo, The quantity of forage during the dry season, Type of animal feed given, Feed Carrying Capacity, Quantity of waste, Utilization of buffalo waste for organic fertilizer, Availability of biogas plants, The role of buffalo as socio-cultural, There is a culture in regulating the pastoral system, Access to media and information, Formal education, Buffalo raising systems, Capital independence, Availability of family labor in managing buffalo business, Avail*ability of production facility.* This research only comes to the analysis of sensitive factors affecting the sustainability of the development of the Moa Buffalo, so further studies are needed relating to strategic policy interventions for sensitive factors so that they can increase the index and status of sustainability.

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