Development of Sustainable Attributes in Cayenne Pepper Agribusiness Using Multidimensional Scaling Techniques

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Development of Sustainable Attributes in *Cayenne Pepper* Agribusiness Using Multidimensional Scaling Techniques

A Case Study in Ponorogo Regency

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ABSTRACT

Cayenne pepper is an important horticultural crop in Ponorogo Regency based on its large contribution in increasing the Gross Regional Domestic Product. The harvested area of cayenne pepper in Ponorogo Regency fluctuates, mainly due to harvesting activities that are not simultaneous and the occurrence of flooding in several areas which has eroded the harvested area. These things eventually lead to price fluctuations. The purpose of this research was to determine the sustainability status of cayenne pepper agribusiness and to formulate policies for the development of cayenne pepper commodities. This study uses the Multidimensional Scaling method based on an assessment of 5 dimensions, namely ecological, economic, social, technological and institutional dimensions. The results showed that the cayenne pepper agribusiness in Ponorogo Regency was categorized as "quite sustainable" with a sustainability index value of 56.08. This shows that the cayenne pepper commodity has the potential to be developed in the future. The sustainability status of the ecological, technological, and institutional dimensions is in the “quite sustainable” category, while the economic and social dimensions are in the “less sustainable” category. The development of cayenne pepper agribusiness in Ponorogo Regency can be achieved through increasing the performance of sensitive attributes in each dimension.

Keywords: *Cayenne pepper, Multidimensional scalling, Sustainability.*

1. INTRODUCTION

Cayenne pepper is one of the most important agricultural commodities in Ponorogo Regency, East Java Province based on its contribution to regional income. Based on the harvested area, cayenne pepper has the highest harvested area compared to other commodities in the last 4 years with an average harvested area of 605 ha per year [1]. However, it turns out that the harvested area of cayenne pepper fluctuates, from 2017 to 2020, respectively, is 743 ha, 601 ha, 609 ha, and 467 ha. Some of the reasons for this include the inconsistent harvest season and the occurrence of floods in several areas that have eroded the harvested area. The conditions mentioned above have caused the supply of cayenne pepper to become discontinuous and often this commodity becomes scarce in the market. Furthermore, this causes prices to fluctuate and causes farmers to be reluctant to plant cayenne pepper again..

The government has made various efforts to overcome the problems mentioned above, including strengthening the availability of food based on self-reliance, increasing the ease and ability to access food, increasing the quantity and quality of food consumption, as well as improving the quality and safety of food. [2]. However, these efforts have not improved the situation because they have not touched the root of the problem, therefore a holistic and structured development strategy is needed both in the short and long term in a sustainable manner. The sustainable development approach is essentially a development activity that combines economic, social, environmental, infrastructure and technology aspects as well as legal and institutional aspects [3].

In order to overcome the problem of discontinuous supply and price fluctuations that increasingly threaten the sustainability aspect of cayenne pepper agribusiness, it is necessary to conduct research on the development

of sustainability attributes. The problem of this research is that the sustainability status of cayenne pepper agribusiness is not yet known and the attributes of sustainability as the basis for determining policies are also unknown. This study aims to assess the sustainability status and formulate a policy scenario for the development of cayenne pepper agribusiness with a case study in Ponorogo Regency, East Java province.

2. LITERATURE REVIEW

The sustainable agriculture approach is a perspective that integrates at least the economic, social and environmental aspects in a synergistic manner. The sustainable economic approach is based on the concept of maximizing revenue streams. The concept of social sustainability is human-oriented and the relationship between the preservation of social stability. The review of environmental sustainability aspects focuses on efforts to maintain the stability of biological systems and the physical environment. Specifically [4] created the concept of Sustainable Agricultural Intensification (SAI) which was originally defined as increasing agricultural production without adverse environmental impacts and without increasing agricultural area. Over time, the concept has been expanded to integrate social, economic, and environmental components, each covering different aspects or performance indicators. Sustainable agriculture approaches have been further developed, such as [5] adding legal/institutional dimensions and infrastructure/technology dimensions as well as [6] adding a quality system dimension in measuring the sustainability of the agricultural sector. Researches with an agricultural sustainability approach have been carried out in various fields, such as in the food sector [4], forestry [7], agriculture [8] and [9], and fishery [10].

Multiimensional Scaling (MDS) is an analytical technique that is widely used in measuring the dimensions mentioned above. MDS is a statistical analysis to determine the similarity and dissimilarity of the variables described in geometric space. [11] suggests that MDS analysis is used to assess each attribute on an ordinal scale based on the sustainability criteria of each dimension. Ordination analysis based on the MDS method is used to compile an index and sustainability status of existing conditions, both in general and in each dimension. The scores of each attribute in each dimension are analyzed multi-dimensionally to determine one or several points that reflect the sustainability position of the agricultural sector development studied relative to two reference points, namely the "bad" point and the "good" point as illustrated in Figure 1 ([12]).

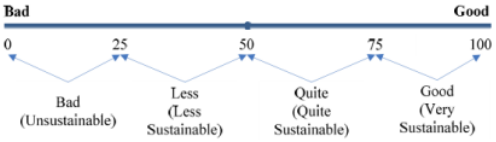

Figure 1 Two points of reference for bad and good

The results of the analysis will reflect how far the sustainability status of each dimension is. After the analysis of each dimension has been carried out, then the comparative analysis of sustainability between dimensions can be visualized in the form of a kite diagram.

The Monte Carlo analysis is useful for studying several things, namely: 1. The influence of error in making attribute scores caused by an incomplete understanding of the conditions of the research location or a misunderstanding of the attributes or the way of making attribute scores; 2. The influence of variations in scoring due to differences in opinions or judgments by different researchers; 3. The stability of the MDS analysis process that is repeated (iterations); 4. Error in data entry or missing data; 5. The high value of "stress" from the results of the sustainability analysis, the value of "stress" is acceptable if <25% [13].

3. RESEARCH METHODS

This research was carried out from March to August 2021 in 2 sub-districts, namely Slahung District and Bungkal District based on the highest level of cayenne pepper production in Ponorogo Regency. The sampling technique used is multistage stratified sampling and purposive sampling. The research sample consisted of 30 farmers, 4 collectors, 4 traders, 4 buyers, and 3 experts.

The technique used to collect data is interview technique using a questionnaire that includes 5 dimensions, namely economic, social, environmental, legal/institutional, and infrastructure/technology dimensions. Each dimension consists of 5-6 attributes and each attribute consists of 2-5 indicators.

The stages in data analysis are as follows: (1) Ordination Analysis, namely mapping the results of the assessment on each attribute so that the sustainability status of each dimension can be determined which is expressed on a scale of worst (bad) 0% to best (good) 100%; (2) Leverage analysis is used to determine the sensitive attributes expressed in % and the intervention that needs to be done ([14]); (3) Monte Carlo analysis was used to estimate the effect of the research instrument at the 95% confidence level, namely studying the effects of uncertainty such as scoring errors, the impact of scoring diversity from different assessments, MDS stability in running, and high S-Stress scores; (4) Kite Diagram analysis is used to

determine the value of the sustainability index on all dimensions so that it can be seen which dimensions have the highest and lowest sustainability index values after determining the development scenario.

4. RESULTS AND DISCUSSION

4.1. Ecological Dimension

The sustainability status of the ecological dimension of cayenne pepper agribusiness in Ponorogo Regency is 54.46 ("quite sustainable") as can be seen in Figure 2.

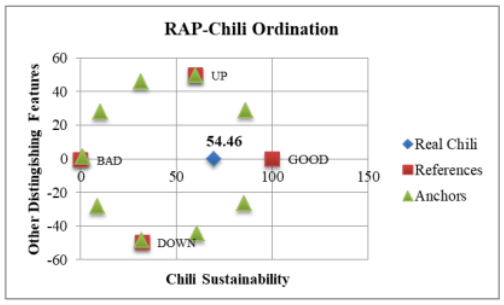

Figure 2 Ecological dimension sustainability status

The influence of each attribute of the ecological dimension on the sustainability of cayenne pepper agribusiness is shown in Figure 3.

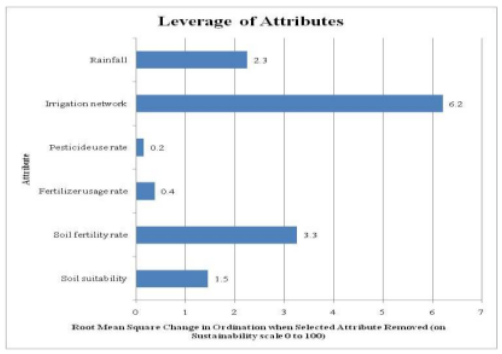

Figure 3 Leverage attributes on the ecological dimension

This dimension needs to be addressed immediately because the sustainability value is not too large in the "quite sustainable" category so that its status is in danger of dropping to "less sustainable". The influencing factors in the ecological dimension that really need to be considered are irrigation networks with a value of 6.2 and soil fertility with a value of 3.3. The irrigation network used by cayenne pepper farmers in Ponorogo Regency generally uses a water pump, besides that in some locations there are water channels from the river. The urgent response is the rehabilitation of irrigation networks in line with the rapid construction of dams. The implementation of rehabilitation can be carried out in a labor-intensive manner where the repair/ rehabilitation/improvement of irrigation networks is carried out in a participatory manner involving the community in order to support food sovereignty.

Soil fertility is the second attribute that must be considered in cayenne pepper agribusiness. Although Ponorogo Regency has an altitude of about 92-2563 meters above sea level with an acidic soil pH of around 4.0-5.5 which is suitable for planting cayenne pepper [1], the level of soil fertility must be prioritized before planting. Farmers in Ponorogo Regency need to take steps to increase soil fertility before planting cayenne pepper, including cultivating the land properly, providing organic fertilizer, and irrigating the land.

4.2. Economic Dimension

In the economic dimension, the sustainability status cayenne pepper agribusiness in Ponorogo Regency can be seen in Figure 4.

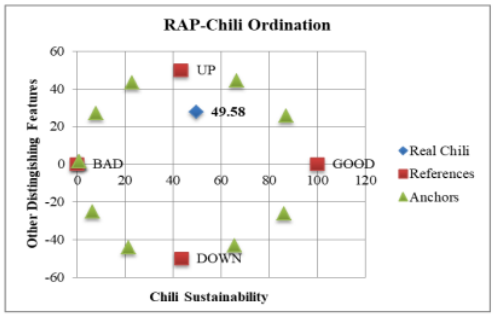

Figure 4 Economic dimension sustainability status

The sustainability value of cayenne pepper agribusiness in Ponorogo Regency is 49.58 ("less sustainable"). This dimension is only 1 point short of being "quite sustainable". Efforts to handle sensitive attributes will increase the status to "quite sustainable". Attributes in the economic dimension that can increase the value of sustainability are price fluctuations and market reach as shown in Figure 5.

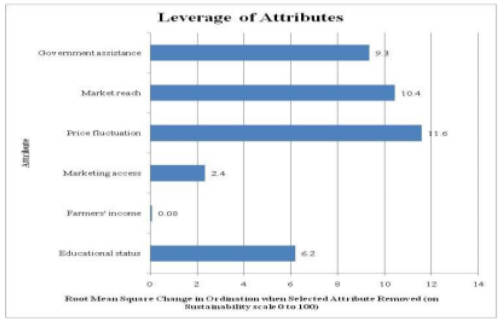

Figure 5 Leverage attributes on the economic dimension

Price fluctuations are influenced by different planting and harvesting times in addition to classical factors such as seasonal production, consumer demand, the number of cayenne peppers entering the region, and the length of distribution channels. Handling price fluctuations can be focused on adjusting the planting time so that the harvest time can be adjusted. Regular harvest times make it easier to manage regional stock supplies, this will stabilize supply and prices. Price stability can be achieved by maintaining supply stability, this can be obtained by maintaining the stability of the cayenne pepper harvested area.

The market reach attribute is the second sensitive attribute. If the market reach is wider, it will add consumers and vice versa. Cayenne pepper farmers in Ponorogo Regency are only able to reach the local market. Farmers sell cayenne pepper to collectors and traders and distribute it to local consumers. The effort that needs to be done is to expand the market reach outside the Regency by increasing the production of cayenne pepper in Ponorogo Regency first.

4.3. Social Dimension

The following is the sustainability status of cayenne pepper agribusiness in Ponorogo Regency based on the social dimension as shown in Figure 6.

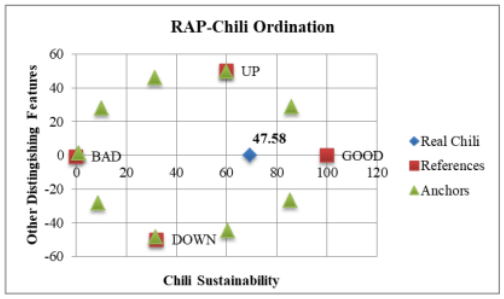

Figure 6 Social dimension sustainability status

The value of the sustainability of the social dimension in cayenne pepper agribusiness in Ponorogo Regency is 47.58 ("less sustainable"). If this dimension gets good treatment immediately, it will be able to change its status to "quite sustainable".

The biggest influence of attributes on the social dimension to the sustainability of cayenne pepper agribusiness in Ponorogo Regency is agricultural extension and community empowerment as shown in Figure 7.

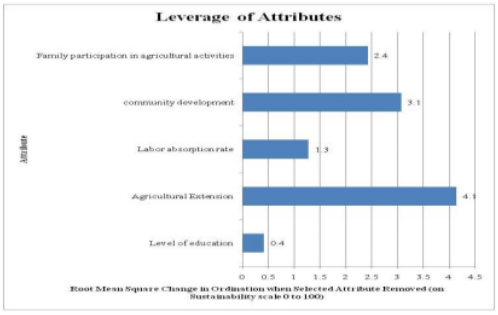

Figure 7 Leverage attributes on the social dimension

Agricultural extension has an important role in providing guidance regarding the correct cultivation of cayenne pepper, from planting to overcoming pests and diseases. Some of the activities carried out by agricultural extension workers are dealing with cultivation problems initiated by Gapoktan. However, agricultural extension workers in Ponorogo Regency are inadequate in number, so additional extension workers are needed so that agricultural extension activities can be optimal. In terms of increasing agricultural extension activities, the government needs to increase the role of the Agricultural Extension Center and its extension workers in increasing crop productivity by increasing the number of visits and by updating the extension content to a more recent one.

Community empowerment is the second most important attribute so that community empowerment needs to be done to improve the performance of cayenne pepper agribusiness. Cayenne pepper farmers in Ponorogo Regency carry out activities ranging from land preparation to overcoming pests and diseases independently. Related to community empowerment, there needs to be socialization from extension workers regarding the cultivation of cayenne pepper properly starting from seed preparation to harvesting so that farmers can be more successful in growing cayenne pepper.

4.4. Technology Dimension

The sustainability of cayenne pepper agribusiness in Ponorogo Regency in terms of the technology dimension is classified as "quite sustainable" with a value of 54.03 as shown in Figure 8.

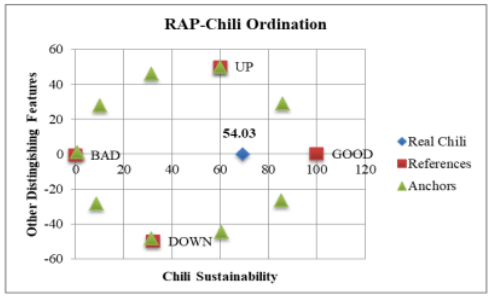

Figure 8 Technology dimension sustainability status

This dimension needs to continuously improve its performance because its sustainability value is in a position close to 50. This means that if it is not handled properly, it can drop its status to "less sustainable". What is the main concern in this dimension? The attribute of the suitability of technology to the needs of farmers and the application of information and communication technology is the most sensitive attribute and must receive attention to increase the sustainability value of the technology dimension as shown in Figure 9.

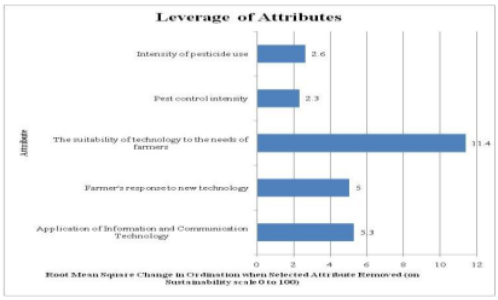

Figure 9 Leverage attributes on the technological dimension

Associated with the attributes of technological suitability, cayenne pepper farmers have not applied appropriate technology, both seed, cultivation and post-harvest technology, but generally still use traditional methods. The government needs to intervene to increase the use of superior seeds, sowing seeds in polybags, plowing the soil using tractors, fertilizing, controlling pests and diseases and good post-harvest handling supported by the increased role of extension workers.

The attributes of the application of information and communication technology (ICT) need to be improved both in production and marketing activities. Effective and efficient access to information will benefit farmers who become more responsive in dealing with problems, both in terms of time and cost. The average farmer in Ponorogo Regency has not applied ICT, especially to seek information about cayenne pepper cultivation. The causative factor is the age factor. In this case, there is a need for socialization and assistance to cayenne pepper farmers to be able to adapt in the use of technology to access various information in an effort to increase production and marketing of cayenne pepper.

4.5. Institutional Dimension

The results of the measurement of the sustainability value on the institutional dimension of cayenne pepper agribusiness in Ponorogo Regency obtained a value of 69.43 ("sufficiently sustainable") as shown in Figure 10.

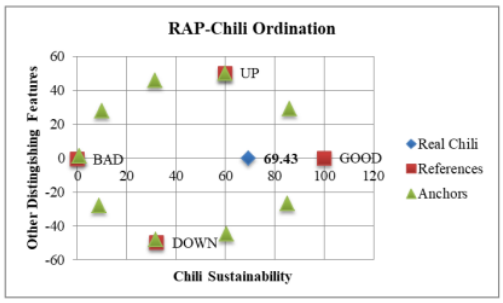

Figure 10 Institutional dimension sustainability status

The most sensitive attributes on the institutional dimensions that affect the sustainability of cayenne pepper agribusiness in Ponorogo Regency are capital institutions and the Agricultural Extension Center as shown in Figure 11.

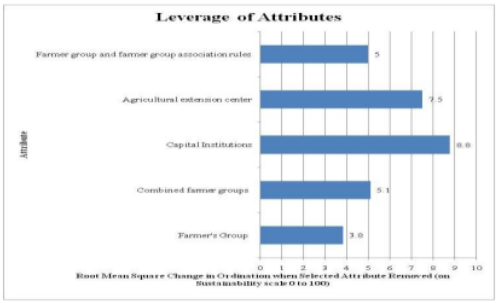

Figure 11 Leverage attributes on the institutional dimension

Farmers' access to capital is limited because the existence of formal financial institutions in rural areas is still very limited [2], so that many farmers are trying to find a source of capital that actually harms farmers. Farmers need capital to plant cayenne pepper, consisting of the costs of cultivating the land and purchasing seeds, fertilizers and pesticides whose prices are increasing. Both regional and central governments need to strengthen capital institutions by increasing capital loan facilities from the government at the Farmer Group level so that it is easy for farmers to access in the interest of increasing the production of horticultural crops as a whole.

Agricultural Extension Center is needed by cayenne pepper farmers in Ponorogo Regency as a shelter for various agricultural activities together, including land management activities and overcoming diseases in cayenne peppers caused by fruit flies. Cayenne pepper plants that are attacked by fruit flies will cause the fruit to fall out and will reduce production. Thus, farmers need extension activities related to the problems faced by cayenne pepper farmers under the auspices of the Agricultural Extension Center.

4.6. Kite Diagram

Rap-Chi analysis and laverage analysis were conducted to determine the sensitive attributes in influencing the sustainability of cayenne pepper agribusiness in Ponorogo Regency. Based on Rap-Chili, it is known that the sustainability of the ecological, technological, and institutional dimensions is quite sustainable because the index value is in the range of 50.00-75.00, while the economic and social dimensions are less sustainable because the index value is in the range of 25.00-50.00. The value of the sustainability index of cayenne pepper agribusiness in Ponorogo Regency for each dimension is summarized in Figure 12.

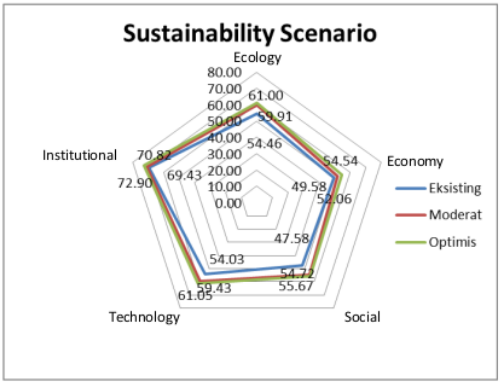

Figure 12 Kite diagram

Based on Figure 12, it can be seen that the value of the sustainability index of cayenne pepper agribusiness in Ponorogo Regency with a moderate and optimistic policy scenario on the ecological, economic, social, technological and institutional dimensions shows a quite sustainable condition. This shows good prospects for cayenne pepper agribusiness in the future in Ponorogo Regency, supported by a holistic development program involving farmers, extension workers and the government.

4.7. Montecarlo

Monte Carlo analysis was performed to estimate the effect of the error at the 95% confidence interval. This analysis is a statistical simulation method to determine the effect of random error on the estimation process and is needed to study the effect of uncertainty from several factors such as: 1) scoring errors in each attribute; 2) the impact of scoring diversity from different scoring; 3) MDS stability in running; 4) high value of S-Stress. If the difference between the results of the MDS and Monte Carlo calculations is less than one, then the system under study is quite good (according to real conditions). The comparison of the sustainability index of the MDS analysis with Monte Carlo can be seen in Table 1. The value of S-stress and the coefficient of determination (R^2) also serves to determine whether or not additional attributes are needed, and at the same time reflect the accuracy of the dimensions studied with the actual situation. [15]. The stress and R^2 values for the five dimensions are presented in Table 2.

Based on Table 1, it can be seen that the difference between the results of the MDS and Monte Carlo analysis shows a value of less than 1 for all dimensions. This shows that the error in the MDS analysis is not significantly different from the Monte Carlo analysis, meaning that the effect of uncertainty from some of the factors mentioned above can be avoided. Based on Table 2, it can be seen that if the stress value is between 0.14 – 0.16 or the difference in stress value is 0.02, the MDS analysis has high accuracy. Thus, in this case the MDS analysis has high accuracy (good and fit) to assess the sustainability index of cayenne pepper agribusiness.

5. CONCLUSION

The results of the analysis show that the cayenne pepper agribusiness in Ponorogo Regency is categorized as "quite sustainable" with a sustainability index value of 56.08. This indicates that the cayenne pepper commodity has the potential to be developed in the future. In the context of developing cayenne pepper agribusiness, government policy interventions are needed, including rehabilitation of irrigation networks, controlling price fluctuations, increasing agricultural extension, application of agricultural technology, and increasing the role of capital institutions.

To ensure sustainability, it is necessary to take a holistic approach by involving all stakeholders (farmers, extension workers and the government) in the context of developing cayenne pepper agribusiness in Ponorogo Regency, East Java Province.

Table 1. The value of the sustainability index of the MDS and Monte Carlo analysis

Dimension	MDS	Monte Carlo	Difference
Ecology	54,46	53,89	0,57
Economy	49,58	48,75	0,83
Social	47,58	46,87	0.71
Technology	54,03	53,05	0,98
Institutional	69,43	68,68	0,75

Table 2. Stress value and the value of determination (R^2) Rap-Chilli result in the Ponorogo Regency

Dimension	Value of Stress	Value of R^2	Number of Iteration
Ecology	0.1467976	0.9461985	3
Economy	0.1331084	0.9519652	3
Social	0.1543102	0.9365079	3
Technology	0.1511826	0.9385676	3
Institutional	0.1523646	0.9385676	3

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