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Sustainability of garlic cultivation at Tegal Regency, Central Java Province, Indonesia

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Abstract. Indonesia is an agricultural country that produces any agricultural product. Garlic is one of the horticulture products that are currently cultivated vastly. According to the national garlic development plan by the Ministry of the Agriculture of the Republic of Indonesia, the way to obtain self-sufficiency in garlic is developing seed centers and import arrangements. The objective of this research is to analyze the sustainability of garlic farming and to determine the leverages factors for garlic development. The study was conducted in Tegal, which is one of the central of Garlic Development in Central Java Province. The methodology used is analysis using Multidimensional Scaling (MDS). There are 43 attributes of 5 dimensions involved in the study, which are ecology, economic, social, infrastructure, and legal-institutional aspect. The result of the research showed that Garlic cultivation has a status as sustainable, with a sustainability index value of 66.44. The leverage factors that affect garlic development are pesticide use, waste management, planting plan, consumption level, productivity, labor efficiency scheme, land management, community empowerment, agriculture extension, storage technology, access to technology, marketing institution, and implementation of land conversion regulations.

Keywords: Attributes, Dimensions, Leverage Factor, Multidimensional Scaling (MDS)

1. Introduction

One of the horticultural commodities that are currently a concern for the Indonesian government is Garlic. According to the national plan of Ministry of Agriculture [1], Tegal Regency is included in the area of Central Java, which has potential as a national development of Garlic cultivation to supply the needs of self-sufficiency Garlic in Indonesia. The national plan development of Garlic will be carried out through the acceleration program of Garlic self-sufficiency in Indonesia and reducing import. Garlic is a commodity that is much favored by the community because, in addition to being a support for cooking, it is also widely used as a raw material for herbal medicines [2]. The Indonesian consumption rate of Garlic per capita from 2013 to 2017 is 0.300 ounces, 0.355 ounces, 0.359, and 0.313 ounces [3].

As a strategy for farming development, the concept of sustainable agriculture can be used. It is an agricultural concept that can fulfill a consumption product without damaging the future of agriculture resources [4]. Sustainable agriculture is a socio-economically viable agricultural production and does not cause long-term environmental degradation [5,6]. The objectives of this study are (i) to know the

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sustainability status of Garlic cultivation, and (ii) to determine the leverages factors that are sensitive to the sustainability of garlic cultivation.

2. Method

The research was done from March to May 2019 at Tegal Regency, Central Java Province, Indonesia. Geographically, the study area is located at 108°57'6"-109°21'30" East longitude and 6°50'41"-7°15'30" South latitude with an area of 87,879 hectares. Tegal Regency has 18 sub-districts [7]. The research location area is presented in figure 1.

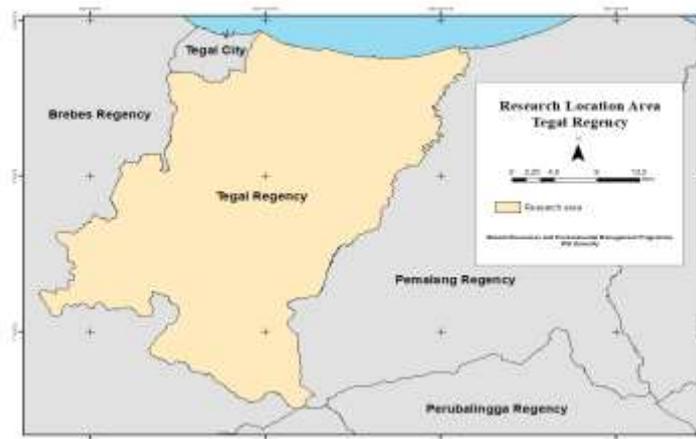


Figure 1. Research Location Area

Primary data was obtained through field surveys and in-depth interviews. Respondents in this study consisted of farmer groups, government officials from the Regional Planning and Development Agency, Ministry of Agriculture, and the Ministry of Public Works. The method used in this study is Multidimensional Scaling (MDS), which evaluates the attributes of each predetermined dimension. The dimensions of this study are ecological, economic, social, infrastructure, and legal institutional. Steps of analysis include: (i) determining attributes, in this study we use 43 attributes in the 5 dimensions analyzed; (ii) assessment of each attribute by respondents on an ordinal scale; (iii) multidimensional scaling analysis to determine ordination and stress value; (iv) evaluation of Garlic's index value and sustainability status in a multidimensional and in each dimension; (v) conducting a sensitivity analysis to determine sensitive attributes influences sustainability, and (vi) leads the Montecarlo analysis in order to take into account the aspects of uncertainty.

The determination of attributes is based on literature that discusses sustainable development such as laws, standard operating procedures (SOP), and discussions with experts. There are four indicator categories used to determine sustainability status, namely: 0-25 (unsustainable), 26-50 (less sustainable), 51-75 (sustainable) categories, and 76-100 (very sustainable) [8]. The MDS technique in Rap application is done by calculating the closest distance from Euclidian distance based on equation follows:

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (Z_1 - Z_2)^2} + \dots \quad (1)$$

The ordination an object on MDS is then measured by regressing the distance of Euclidian (d_{ij}) from point i to point j , with the origin (σ_{ij}) [9]

$$D_{ij} = \alpha + \beta d_{ij} + \varepsilon \quad (2)$$

The technique used to regressing the equation is the ALSCAL algorithm. ALSCAL optimizing the distance square of the data (origin), which in three dimensions (ijk) is written in the equation called S-stress [10]

$$s = \sqrt{\frac{1}{m} \sum_{k=1}^m \left[\frac{\sum_i \sum_j (d_{ijk}^2 - o_{ijk}^2)^2}{\sum_i \sum_j o_{ijk}^4} \right]} \quad (3)$$

The squared distance is the weighted Euclidian distance:

$$d^2_{ijk} = \sum_a = 1 w_{ka} (x_{ia} - x_{ja})^2 \quad (4)$$

Sensitivity analysis is used to determine the most sensitive attributes affecting sustainability. The higher the attributes value, it means that the attribute has sensitively affect sustainability. Montecarlo analysis is used to calculate the value of uncertainty or predict the effect of errors at a 95% confidence level. The MDS analysis results are said to be accurate, can be seen from the S-Stress value of less than 0.25, and the coefficient of determination (R^2) approaches to 1.

3. Result and discussion

The land condition for Garlic cultivation at this time illustrated its sustainability status. In this research, Garlic's sustainability factors are viewed from various dimensions, namely ecology, economy, social, infrastructure, and institutional law.

3.1. Dimension of Ecology

The results of MDS on environmental dimensions showed that sustainability status index is 65.21. It means that it is quite sustainable, as presented in figure 2. The leverage factors that affect are pesticide use with a value of 8.85, waste utilization with a value of 7.60, and planting plan of 6.19.

Farmers prefer to use synthetic pesticides than using natural enemies or biological agents. The handling of natural enemies or biological agents tends to produce relatively low yields, it is needed to be applied by professionals, and it requires awareness in utilizing natural resources in their environment [11] [12].

The utilization of waste carried out by farmers has not been fully implemented. The usage of waste is using rice straw, a natural mulch. Farmers obtain rice straw from other farmers around the cultivation area. The Garlic planting plan is carried out throughout the year, and this is due to the high production that is to be achieved in the context of Garlic self-sufficiency. Leverage factors for environmental dimensions are presented in figure 3.

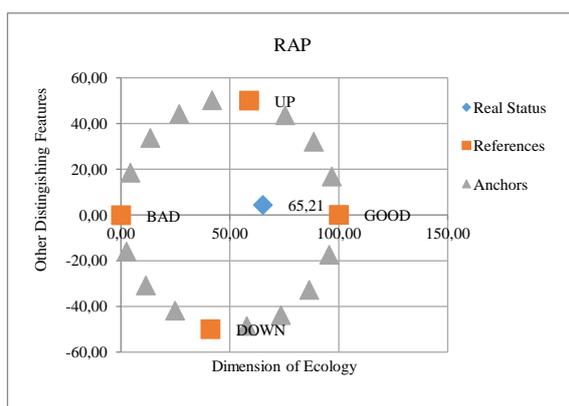


Figure 2. Sustainability of dimension ecology

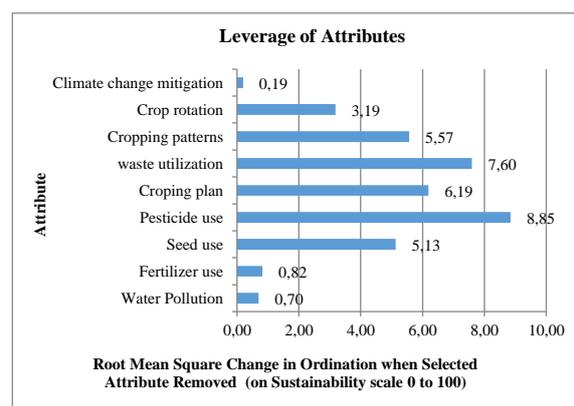


Figure 3. Factors in dimensions of ecology

3.2. Dimension of Economic

The results of MDS on the economic dimension showed that sustainability status index is 43.06. It means that this is less sustainable as indicated in figure 4. Leverage factors that affect are consumption level with a value of 10.45, crop productivity with a value of 8.39, and labor efficiency with a value of 8.34.

The National Garlic Development program was carried out because there is high demand for 479,800 tons, but the product available is only 16,200 tons [1]. The need for Garlic is not only used for consumption as raw materials but also used as planting material for the Garlic self-sufficiency national program. The agricultural sector is still the most significant contributor to employment in Indonesia. About 35.70 million Indonesians are involved in various forms of agriculture, forestry, and fisheries activities [3]. Leverage factors in the economic dimension are presented in figure 5.

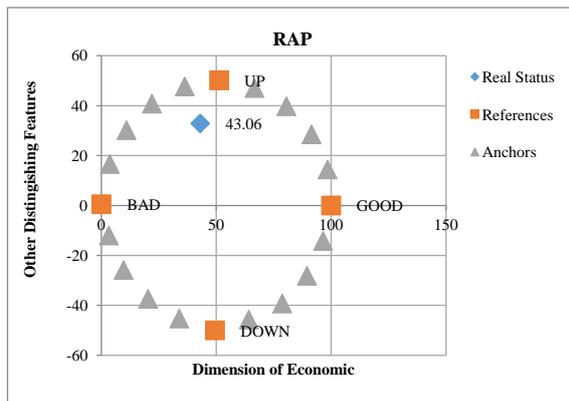


Figure 4. Sustainability of Dimension Economy

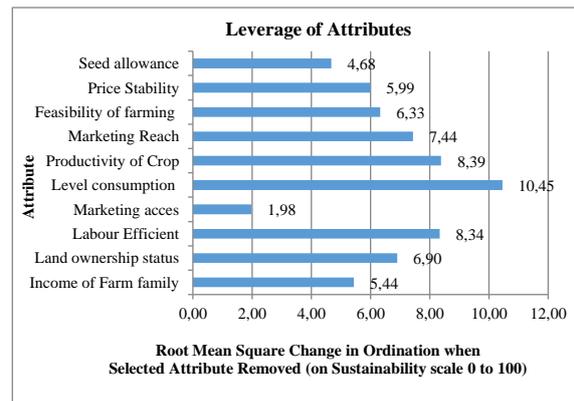


Figure 5. Factors in Dimensions of Economy

3.3. Dimension of Social

The results of the MDS on the social dimension showed that the sustainability status index is 77.90, which means very sustainable (figure 6). Leverage factors that influence are land management patterns with a value of 8.86, community empowerment with a value of 4.76, and agricultural extension activities with a value of 4.54.

The empowerment is strengthening factors of production, distribution and marketing, strengthening the community to gain access to knowledge and skills [13]. Results of observations in the field indicate that empowerment is carried out through field schools by sending delegations of representatives of farmer groups to attend field schools outside the Regency. Empowerment also began to be carried out for women farmer groups through training in making Garlic processed products, namely Black Garlic. This fact needs to be enhanced by the roles and capabilities of these groups to improve sustainability status [14].

The results of field observation indicate that extension activities were carried out based on the schedule and material that had been set by the local instructor. However, the implementation of counseling was carried out based on the needs of the group of farmers themselves. Kamaruzzaman [15], which has conducted a study of communication methods by agricultural extension workers showed that the means of communication of agricultural extension workers with group meetings could be considered effective. Leverage factors in the social dimension are presented in figure 7.

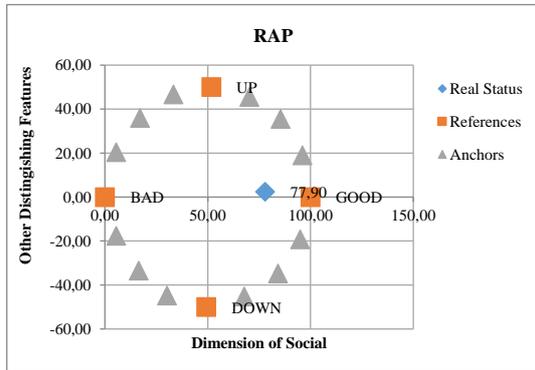


Figure 6. Sustainability of Dimension Social

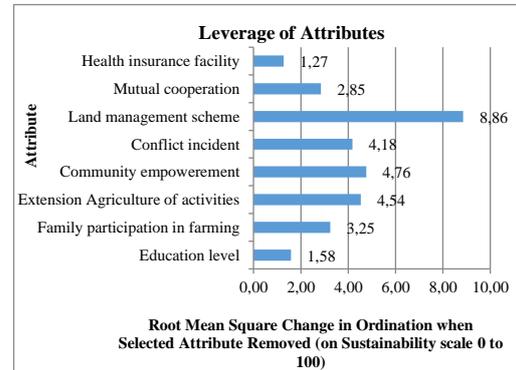


Figure 7. Factors in Dimensions of Social

3.4. Dimension of Infrastructure and Technology

The results of the MDS indicate that dimensions of infrastructure and technology have a value of 57.16, which means that it is in the category of fairly sustainable (figure 8). Leverage factors that affect are infrastructure and technology with a value of 8.38, access to technological developments with a value of 6.65.

Generally, Garlic cannot be directly used as seed because it should be dried first and should be wait for the dormancy period of 4 to 5 months after the harvest period [16]. Farmers in the area have difficulty in obtaining planting material because they have to wait for the dormancy period to be finished. For that reason, farmers generally take planting material from other regions such as Temanggung in Central Java, Batu in East Java, and even in Lombok. It needs to be emphasized that technology can be used for drying, especially in the rainy season and technology to break the garlic dormancy period. Plans for the construction of Instore drying will be carried out for the drying process, especially during the rainy season. Access to technological developments for farmers is obtained from extension agents, farmer groups when there are gatherings and devices for young farmers. Access to technological developments was achieved, including in garlic cultivation. The results of the research by Andiyati [17] explained that the most accessed media to get information is meeting, followed by electronic media and print media. Age is significantly related to the level of access to information. The leverage factor in the infrastructure dimension is presented in figure 9

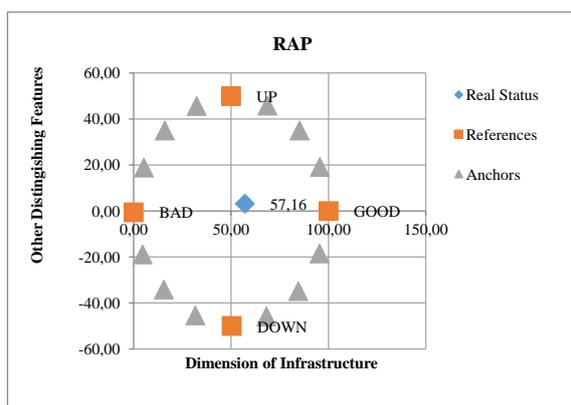


Figure 8. Sustainability of Dimension Infrastructure

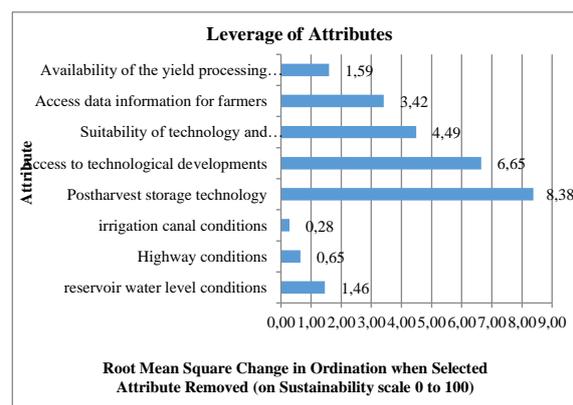


Figure 9. Factors in Dimensions of Infrastructure

3.5. Dimension of Legal and Institution

The results of the MDS indicate that the legal and institutional dimensions have a sustainability status index of 83.88. It means that it is very sustainable which is presented in figure 10. The leverage factors

that affect are marketing institutions with a value of 5.65 and the application of land conversion companies with a value of 4.49.

The marketing of agricultural products is essential because agriculture has unique characteristics. They are very distinctive and different from non-agricultural products because they require special handling. The absence of marketing agency for garlic products is still a problem in the agricultural sector in Tegal Regency. In the current condition, marketing is carried out through partnerships, by selling to partners, in this case they are importers who have entered into a cooperation contract to carry out the rules of Permentan Number 86 of 2013 concerning Recommendations on the Import of Horticulture Products.

The application of land conversion policies has been carried out by the local government, but because of the increasing need to support development, there are often uses that are beyond the plan. There is an interest that makes the government dilemma concerning the conversion of agricultural land. The government is obliged to accelerate the pace of economic growth through the development of sectors such as industry, property, tourism, and services. However, on the other hand, the local government should also pay attention to maintain the existence of agricultural lands to preserve agricultural resources. The leverage factor in the infrastructure dimension is presented in figure 11.

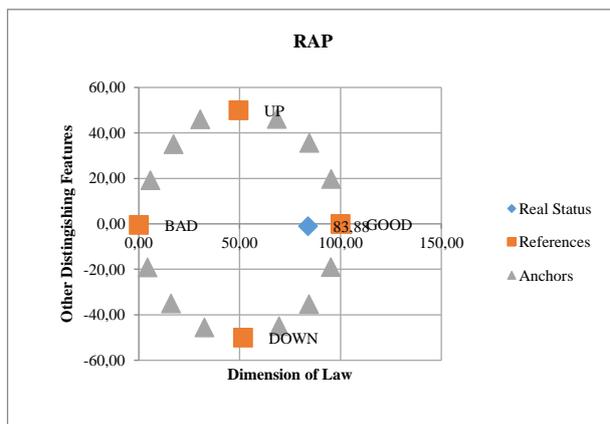


Figure 10. Sustainability of dimension of law

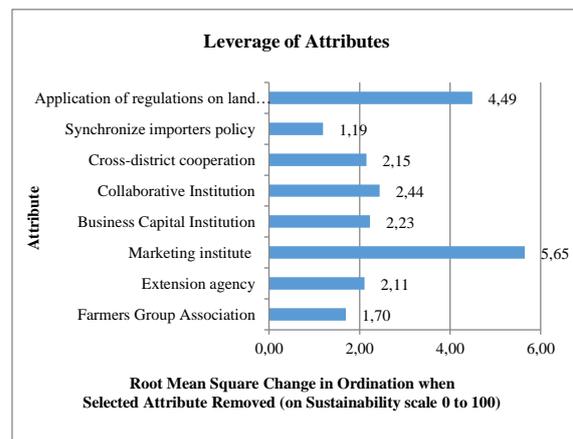


Figure 11. Factors in dimension of law

3.6. Status of Garlic Farming Sustainability

The results of the MDS analysis results in the sustainability index for 5 dimensions. The sustainability status index in garlic farming is 66.14. Dimensions that need to be considered are the economic dimension because it is on the status index 43.06 which means it is not sustainable. The sustainability index of garlic farming and its validation in detail are presented in table 1.

Table 1. Garlic farming sustainability index and validation.

Dimension	Index status	Montecarlo	Different	RSq	Stress
Ecology	65.21	63.61	1.6	0.9460665	0.1320902
Economy	43.06	43.39	0.33	0.945388	0.130615
Social	77.90	75.24	2.66	0.9436895	0.1330506
Infrastructure	57.16	56.11	1.05	0.9470614	0.1364806
Law and institution	83.88	80.16	3.72	0.9527127	0.1348426

From table 1, it can be seen that the difference between the results of Multidimensional Scaling analysis with Montecarlo is not more than 5. The difference shows that errors in making scores on each attribute are relatively small, variations in ratings due to differences in opinion are relatively small and

errors in data and data entry can be avoided. The stress value in the MDS analysis in each dimension has a value of less than 0.25, where the smaller the stress value, the better the MDS analysis output. The value of R^2 in each dimension and average has a high value. This fact can be seen from the magnitude of the value that is almost close to 1.

The results of the analysis showed the need for improvement and policy by taking into account the influencing factors. Policy formulation and development can be done based on the factors that have the most influence on the status of sustainability and then do a scenario for these factors. The results of the comparison between the present condition and the outcome of the scenario are presented in table 2.

Table 2. Comparison of Sustainability Status

Dimension	Status		
	Existing	Priority	Progressive
Ecology	65.21	68.34	81.95
Economy	43.06	51.28	54.22
Social	77.90	85.58	86.88
Infrastructure	57.16	70.63	74.52
Law	83.88	87.38	88.97
Sustainability	65.44	72.64	77.30

The visualization of the comparison between the current status and the scenario is presented in figure 12. In the existing condition, garlic farming has a sustainability status of 65.44, which means it is already in a fairly sustainable category. Policy interventions applied to priorities can increase the value of sustainability status to 71.73, or enter in the category of sufficient sustainability. With policy interventions which are carried out progressively, the value of sustainability status will become 79.25 or included in the sustainable category. The value comparison of the state between conditions is presented in table 2 above.

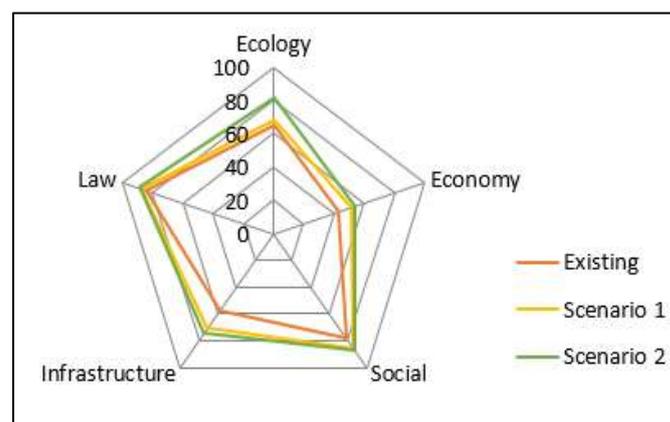


Figure 12. Visualization of Sustainability of Garlic Scenario

4. Conclusion

The results of the MDS analysis show that the value of the sustainability index of garlic farming in the Tegal Regency is 65.44, which means it is quite sustainable. The leverage factors are the use of pesticides, waste treatment, planting plans, consumption levels, productivity, labor efficiency, land management patterns, community empowerment, counseling, storage technology, access to technology, marketing institutions, and implementation of land conversion policies. With policy interventions which

are carried out progressively, the value of sustainability status can be increased to become the sustainable category.

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