Sustainability Analysis of Garlic Production in Sembalun District on Ecological, Economic and Social Dimensions

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Abstract

This study aims to determine the sustainability category of garlic production in Sembalun District based on ecological, social and economic dimensions. The study was conducted in several villages in Sembalun District, East Lombok Regency, West Nusa Tenggara (NTB) Province, involving 50 garlic farmers. Data were collected using interviews based on questionnaires that had been developed and analysed using multidimensional scaling techniques. The study results showed that the ecological and social dimensions were in the good category, while the economic dimension was in the sufficient category. The results of the leverage analysis showed that the level of crop failure and the type of irrigation system attributes were the most sensitive attributes in the ecological dimension. Meanwhile, the attributes that influenced the social dimension were the attributes of participation in health insurance and the availability of farm labour. The two most sensitive attributes in the economic dimension were product marketing and seed prices.

Keywords: sustainability analysis, garlic production, Sembalun district

Introduction

Garlic is one commodity considered necessary by everyone in Indonesia because it has considerable benefits for life (Chen et al., 2024). Garlic utilisation is generally used in households as an essential ingredient for food seasonings (Srihari et al., 2017). In Indonesia, almost every food requires garlic to complement the flavour. Besides being consumed, garlic is also a herbal medicine (Lisiswanti & Haryanto, 2017). In the industrial sector, garlic is used as an industrial raw material. Given the importance of garlic in the daily lives of the Indonesian

people, it is certain that the demand for garlic in Indonesia is relatively high (Pangestika et al., 2015).

The high demand for garlic must be accompanied by increased garlic production in Indonesia. It is necessary to guarantee the availability of garlic to meet public consumption (Y. J. Choi et al., 2024)v. The government has made several efforts to increase garlic production, such as the garlic commodity self-sufficiency program that was carried out in 2019. The government has also designated several districts or cities as garlic production centres. In West Nusa Tenggara (NTB) Province, the Sembalun District located in East Lombok Regency is designated a national garlic production centre (Hadiawati et al., 2022). 2019 garlic production in Sembalun District reached 172,359 kw (Danasari et al., 2023). However, this production declined in subsequent years, as shown in Table 1.

Table 1. Production and Harvested Area of Garlic in West Lombok District

Year	Harvested Area (Ha)	Productions (Kw)	Productivity (Kw/Ha)
2019	1.453	172.359	118,62
2020	1.151	113.157	98,31
2021	677	55.861	82,57
2022	288	38.088	132,3

Data Sources: NTB Satu Data

Meanwhile, based on a report analysing the development of domestic and international prices on the staple garlic related to government policies, the government has allocated a garlic import plan of 148,282 tons in 2023, which is 90% of the total national garlic demand. The report also mentions that national garlic prices have increased due to movements in harvest prices in China caused by the long duration of winter, which has caused the quality of garlic to decline. This dependence on garlic imports (Sugiarti, 2020) has led to a decrease in the desire of local farmers to cultivate garlic. Garlic production in Indonesia is still low and tends to decline from the previous year (Wahyuni et al., 2023). The price of local garlic is considered unable to compete with imported garlic.

The existence of a pattern of decline in garlic production and productivity in Sembalun District and the increasing quantity of garlic imports is an impetus for researchers to analyse the sustainability of garlic farming in Sembalun District as a national garlic centre. The sustainability of garlic production needs to be considered using the concept of sustainable agriculture, which is oriented towards ecological, social, and economic aspects (H. W. Choi et al., 2024). These aspects refer to the sustainable development goals (SDGs). Observing these various aspects will provide a comprehensive picture of the sustainability of garlic production.

Based on the description above, this study aims to determine the sustainability category of garlic production in Sembalun District based on ecological, social and economic dimensions. This research is very important to do considering the need for comprehensive evaluation results on several dimensions to know what needs to be improved to maintain the sustainability of garlic production in Sembalun District.

Sustainability Analysis of Garlic Production in Sembalun District on Ecological, Economic and Social Dimensions

Literature Review

The theories described below relate to sustainable agriculture and how to determine the sustainability category of garlic production in Sembalun District.

Sustainable Agriculture

In simple terms, sustainability can be defined as an effort made by some or all parties to keep something going. Sustainable agriculture is the effort and ability to maintain optimal agricultural production (Noor et al., 2014). The concept of sustainable agriculture is closely related to the concept of sustainable development, where sustainable development is a development that is considered to meet the needs of the present without disrupting the ability of the next generation to meet their needs in the future (Mitchell et al., 2010). Sustainable development generally has three dimensions: social, economic, environmental, and ecological (Susiana, 2015).

The ecological dimension focuses on utilising the owned environment that considers the stability of natural ecosystems, including biological life systems and natural materials (Firmansyah, 2022). For example, in agriculture, if the utilisation of natural resources exceeds its carrying capacity, it will affect its sustainability, causing decreased productivity, the emergence or increase of pest or disease attacks, and other impacts related to the environment. Ecological dimensions include weather factors, rain intensity, and soil fertility (Noviani and Setiawati, 2021). The economic dimension emphasises strengthening the economy and business development (Syamsiah et al., 2023), such as average income, subsidies, market scale and financial viability (Nuraini and Mutolib, 2023). The social dimension emphasises community relations, workload, health and safety (Maulidah and Muhaimin, 2021).

Determining the Sustainability of Agricultural Commodity Production

The sustainability of several aspects of the agricultural sector is determined using the Multidimensional Scaling (MDS) method (Juhandi et al., 2023; Rachman et al., 2023). MDS analysis is an ordination analysis in a reduced space by plotting the position or point of an object along axes arranged based on certain relationships and interpreting it as a diagram or graph (Saputro et al., 2023). In MDS, the observed object points are mapped into a two-dimensional or three-dimensional space to approximate the original object. MDS can project multidimensional diversity in a simple and easy-to-understand manner and provide quantitative information on the resulting projections. In principle, MDS maps the perceptual distance between one unit and another by scaling them so that the similarities or differences between these units are known (Rouf et al., 2023).

Research Method

This study used a quantitative research design to determine and define the sustainability category of garlic production in Sembalun District. The Multidimensional Scaling (MDS) approach was used together with the help of the RAPFISH VBA Microsoft Excel program. The

research respondents involved were 50 people, and the respondents were selected by accidental sampling. This research was conducted in several villages in Sembalun District.

Data were collected through interviews and direct observations with respondents following a questionnaire guide developed based on the three dimensions used, namely ecological, economic and social. The number of attributes for each dimension is different. The scale of each attribute uses a Likert scale. Interview sessions with farmers were conducted in a centralised location, such as at the home of one of the farmers or in their fields. A summary of the attributes of each dimension is given in Table 2.

Table 2. Attributes of Each Dimension

No.	Ecological Dimension	Economic Dimension	Social Dimension
1	Land Type	Production Quantity	Health Insurance Participation
2	Land Area	Selling Price	Agricultural Extension Participation
3	Frequency of Fertilizer Use	Average Income	Land Use Conflict
4	Average Use of Organic Fertilizer	Change in Profit	Farm Business Sustainability
5	Average Use of Organic Pesticides	Access to Capital	Labor Availability
6	Level of Pest Attack	Product Marketing	-
7	Irrigation Availability	Sales Rate	-
8	Type of Irrigation System	Seed Price	-
9	Harvest Failure Rate	Fertiliser Price	-
10	-	Pesticide Price	-

MDS analysis is used to determine the sustainability category of garlic production. In MDS, observed object points are mapped into a two-dimensional or three-dimensional space to approximate the original object. The ordination technique in MDS is based on the square of the Euclidean distance, which in n-dimensional space can be written using the following equation (Clarke and Warwick, 2001),

$$d_{ij} = \sqrt{\sum (x_{ij} - x_j)}$$

Where d_{ij} is the Euclidean distance, x_{ij} is the attribute score value, x_j is the average attribute score, $i = 1,2,3 \dots, m$ and $j = 1,2,3 \dots, n$.

The ordinance of an object point in MDS is approximated by regressing Euclidean distance (d_{ij}) from the point i to the point j, with origin (d_{ij}) as in the following equation,

$$\hat{d}_{ij} = \alpha + \beta d_{ij} + e$$

Where $\hat{d}_{ij}$ is the estimated value, and e is the error.

The approximation technique used is the ALSCAL algorithm, where. This method optimises the squared distance to the squared data (origin = d_{ij}), or can be written with the following formula.

$$S = \left\{ \frac{\left(\sum_i \sum_j (d_{ij} - \hat{d}_{ij})^2 \right)}{\left(\sum_i \sum_j (d_{ij}) \right)^2} \right\}^{1/2}.$$

S is referred to as the stress value. The next step is to perform a goodness of fit test to measure how accurately the configuration of a point can reflect the original data. The goodness of fit in MDS is reflected in the magnitude of the S-stress value. A low S-stress value indicates model fit, while a high S-stress value indicates the opposite. A fit model is marked by an S-stress value less than 0.25 (S < 0.25).

The sustainability category of each dimension of garlic production is determined using four categories, namely the first category is a score of 0-25 with a poor sustainability category, a score of 26-50 with a less sustainability category, a score of 51-75 with a moderate sustainability category and a score of 76-100 with a good sustainability category (Saputro et al., 2023).

Result and Discussion

All respondents were male, with 96% married and the rest (4%) unmarried. The respondents came from Sembalun Bumbung Village, Sembalun Village, Sembalun Timba Gading Village, and Sembalun Lawang Village in Sembalun District, East Lombok Regency. Respondents ranged in age from 19 to 63 years, with farming experience from 1 year to 44 years. Most respondents manage private land, which is 94% and the rest rent land or become farm labourers from the cultivated land.

Based on the analysis using the MDS Rapfish method, it was found that the sustainability index of garlic production in Sembalun District in the ecological and social dimensions was 82.24 and 76.61, respectively, or both were in a suitable category. At the same time, the sustainability index in the economic dimension is 60.46 or in the moderate category. A detailed explanation for each dimension will be provided by adding the interpretation of the leverage analysis results. Leverage analysis is used to analyse sensitivity and determine attributes sensitive to changes in sustainability scores (Fauzi, 2019). If the results of the leverage analysis of an attribute provide a value that is getting bigger, then the attribute is more sensitive in influencing the sustainability score. Therefore, this attribute needs to be improved to increase the sustainability index in each dimension.

Table 3. Sustainability Index on Each Dimension

No.	Dimensions	MDS Index	Stress	R^2	Category
1	Ecology	82,24	0,13	0,95	Good
2	Economic	60,46	0,14	0,94	Enough
3	Social	76,61	0,14	0,95	Good

Ecological Dimension

The results of the leverage analysis on the ecological dimension show that the level of crop failure and the type of irrigation system are the two most sensitive factors for the sustainability index on the environmental dimension (Figure 1). Since the sustainability index in the ecological dimension is in a suitable category (Dėnė et al., 2024), these two factors are actually at a level that tends to be good as well. In other words, based on the survey results, respondents generally feel that the level of crop failure has decreased compared to the previous harvest, and the type of irrigation system owned to support garlic cultivation activities is mostly semi-technical and technical irrigation. (Jang et al., 2024)

Sembalun District is a highland area at 800-1200 masl, so water availability is sufficient and has appropriate humidity as a requirement for garlic growth (Danasari et al., 2022). Thus, ecologically(Carullo et al., 2024), Sembalun District is very supportive of increasing garlic productivity, which affects its sustainability. Nonetheless, garlic harvest failure is not inevitable. The results of interviews with farmers show that weather factors, pests and diseases cause the average failure of garlic harvest. Garlic plants often experience rotting on the bulbs (Iemaaniah et al., 2024) caused by infections, fungi or pests. (Wójcik et al., 2024)v

Meanwhile, weather factors also contribute greatly to this crop failure (Astiko, 2018). Climate extremes cause drought problems (Nunsina, 2024) and the threat of other disasters, such as landslides and floods. Too much rainfall will cause the paddy soil to become waterlogged, leading to the rotting of the tubers (Lingga, 2021; Haq et al., 2022). On the other hand, this plant can also lack water because the garlic plant breeding system is shallow (Harmanto et al., 2022).

In terms of water availability, this area had problems irrigating agricultural land, but finally, this area has sufficient water availability due to the government's development of irrigation systems (Ahmed et al., 2024). Currently, the irrigation system used is piping, shallow wells and reservoirs (Danasari et al., 2023). In a news release from the West Nusa Tenggara Provincial government, the government has built agricultural reservoirs at several points in Sembalun District and a piped irrigation system (DPMPTSP NTB, 2018). The existence of an adequate irrigation system impacts water adequacy during the garlic cultivation process, which will affect garlic productivity. Irrigation following the procedure will also contribute to increased garlic harvest failure. This is because if irrigation is not done in accordance with recommendations, garlic growth will be disrupted (Wishna-Kadawarage et al., 2024). However, so far, farmers have found ways to solve these problems. Suppose the sustainability index in the ecological dimension is to be maintained or improved. In that case, the harvest failure rate needs to be reduced, and the current type of irrigation system needs to be made more permanent and well-organised.
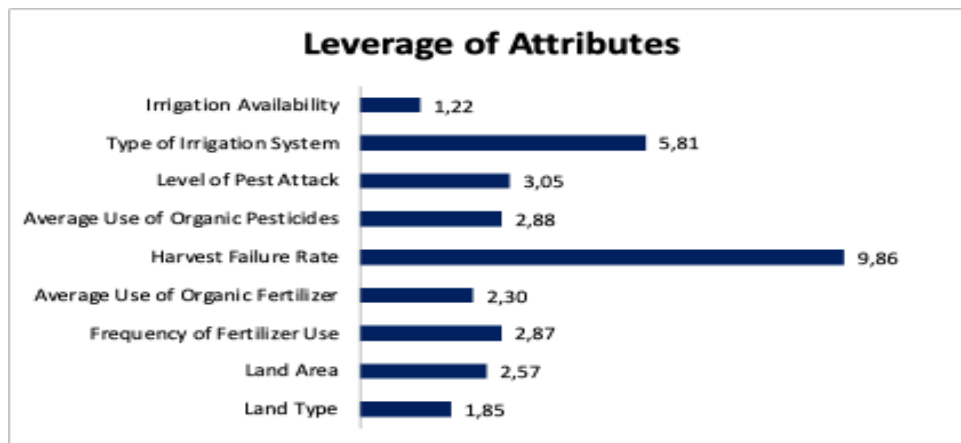
Figure 1. Results of Leverage Analysis on the Ecological Dimension

Economic Dimension

In the economic dimension, the results of the leverage analysis show that product marketing attributes and seed prices are sensitive variables to the sustainability index of garlic production (Figure 2). Marketing of garlic farmers' products in Sembalun District is limited, as most sell their products only to intermediaries or local collectors (Maryati et al., 2023). This shows the low marketing ability of garlic farmers in Sembalun District. Based on data collected from respondents, around 92% of respondents stated that they sold garlic to middlemen. This causes losses for the farmers, as the selling price tends to be below the base price.

On the other hand, garlic production inputs are also very expensive, including the cost of garlic seeds. Although Sembalun District is the centre of garlic production, the price of garlic seeds is still high, ranging from Rp.45,000-55,000 per kg. This is because garlic farmers in Sembalun sell garlic products in fresh form, and only a small portion is stored for seedlings (Maryati and Mulyawati, 2024).

Based on this description, the analysis results show that the level of sustainability in the economic dimension is strongly influenced by product marketing and seed prices. The better the marketing ability and the more affordable the cost of seeds, the higher the sustainability of garlic farming from an economic perspective.
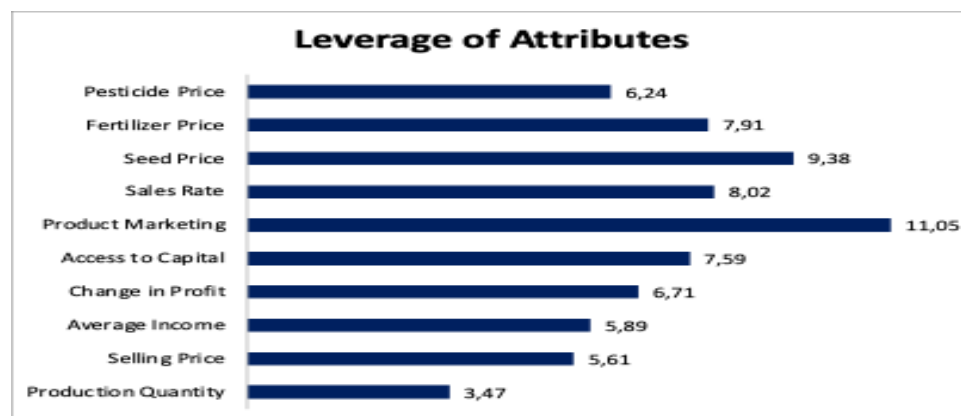

Figure 2. Results of Leverage Analysis on the Economic Dimension

Social Dimension

The results of the leverage analysis of the social dimension show that ownership of insurance and other social security for themselves and their farms can increase the sustainability of garlic , one of which is the BPJS Health attribute. This attribute positively influences the social dimension where if garlic farmers in Sembalun have and are active as BPJS Health participants, the sustainability index in the social dimension will increase. In other words, if farmers feel assured of their right to health services, this will support their productivity at work, resulting in increased garlic productivity.

The results show that the number of garlic farmers registered as BPJS participants is 11 out of 50 respondents. The rest of the farmers were not registered as active participants and did not continue to make regular payments after having previously been registered as participants. Farmers' non-participation in the BPJS Kesehatan program occurs because they feel that the premium fee paid per month is too high while the premium will not be returned even if, during a certain period, the farmer does not make a claim (Mania, Jati and Fatmasari, 2017). Some other farmers also consider BPJS Kesehatan not an important and urgent need (Kusumaningrum and Azinar, 2018) because the health problems experienced so far can still be cured without intensive treatment.

The issue of labour availability is also one factor that needs to be considered because, recently, many people have lost interest in becoming farmers or farm labourers (Rahaju, 2018). So far, the labour force has been dominated by older farmers who involve their wives or family members as labourers because young people are very little interested in becoming farmers or farm labourers (Rofidduddin and Kristina, 2022). This results in the absence of regeneration of farmers or farm labourers. One of the factors that cause this is an assumption that a farm labourer's income is so low that they cannot meet their daily needs (Safitri and Yulianto, 2019).

Thus, to increase the sustainability of garlic production, more attention is needed on the issue of increasing youth interest in contributing to agriculture as young farmers or farm workers (Ali et al., 2024). In addition, efforts are also required to make farmers interested in using BPJS Kesehatan or other types of health insurance.
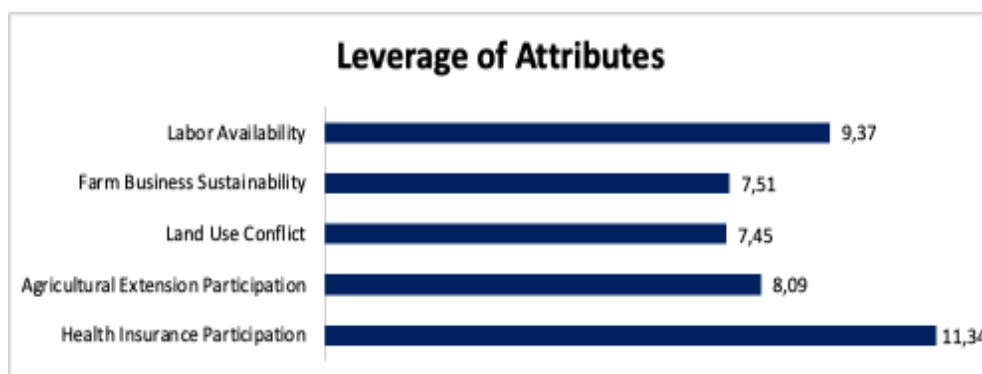
Leverage of Attributes

Attribute	Value
Labor Availability	9,37
Farm Business Sustainability	7,51
Land Use Conflict	7,45
Agricultural Extension Participation	8,09
Health Insurance Participation	11,34

Figure 3. Results of Leverage Analysis on the Social Dimension

Conclusion

Based on the explanation in the results and discussion section, it is found that the sustainability category in the ecological and social dimensions is good, while the economic dimension category is sufficient. In the ecological dimension, the two most sensitive attributes are the level of crop failure and the type of irrigation system. Meanwhile, in the social dimension, the attributes of participation in health insurance and availability of labour are the most sensitive factors. The two attributes that influence the economic dimension are product marketing and seed price.

Declaration of conflicting interest

The authors declare that there is no conflict of interest in this work.

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