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Research Article

Sustainability Analysis of Shallot Farming in Simanindo District, Samosir Regency

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Abstract: *This research aims to analyze the sustainability of shallot farming to assess its sustainability status in Simanindo District, Samosir Regency, based on the economic, ecological, social, technological, and institutional dimensions. The analytical method employed in this study is the Multidimensional Scaling (MDS) using RAP-farm software. The research results indicate that red onion farming in Simanindo District, Samosir Regency, has a sustainability level with the criteria of "sufficiently sustainable" from the perspective of 5 sustainability dimensions, namely economic, ecological, social, technological, and institutional dimensions, based on the multidimensional scaling (MDS) analysis. The dimension with the highest index and sustainability status is the institutional dimension at 89.59, while the other 4 dimensions are 39.62 (economic), 59.32 (ecological), 52.67 (social), and 23.85 (technological).*

Keywords: *Farming, Economic, Multidimensional Scaling (MDS), Agriculture.*

I. INTRODUCTION

The sustainability of agriculture is greatly influenced by the environmental consequences and socio-economic aspects arising from agricultural activities. In order to enhance the state of agriculture, changes and improvements need to be made. We need to consider perspectives from various dimensions, encompassing aspects such as ecology, economics, as well as social and cultural elements within the framework of sustainability [1].

Through the analysis of these five dimensions, we can evaluate to what extent the potato farming system on sloping land in Gowa Regency has achieved the desired level of sustainability. This holistic approach enables stakeholders to understand and improve the various aspects that influence agricultural sustainability comprehensively. The sustainability index and its status are assessed through the analysis of five dimensions of the farming system: Economic Dimension, Ecological Dimension, Social Dimension, Technological Dimension, and Institutional Dimension. The Economic Dimension must be able to provide a stable contribution to agricultural business operators. The Ecological Dimension, aiming to minimize negative impacts on ecosystems and maintain natural balance, is a crucial aspect within this dimension. The Social Dimension is included in the assessment of agricultural sustainability and needs to be viewed from the farming environment. The Technological Dimension has a significant impact on sustainability in agricultural processing. Meanwhile, the Institutional Dimension influences sustainability and is a consideration that agricultural practitioners must also take into account [2].

Samosir Regency is one of the central districts for shallots in North Sumatra. It was once a prominent region for shallots in Indonesia and contributed significantly to meeting the consumer demand for shallots. Almost all sub-districts in Samosir Regency cultivate shallots, but there are five sub-districts that are the largest contributors of shallots in the region. The central sub-districts for shallots in Samosir Regency are Pangururan, Simanindo, Sianjur Mula Mula, Harian, and Palipi. The data for these central sub-districts in Samosir Regency is presented in Table 1.

Table 1. Central Sub-Districts for Shallots in Samosir Regency, Year 2022.

No	Sub- Districts	Harvest Area (Ha)
1	Sianjur Mula Mula	25
2	Harian	20,40
3	Sitiotio	15,60
4	Onan Rungu	14,40
5	Nainggolan	8,90
6	Palipi	18,20
7	Ronggur Nihuta	1

8	Pangururan	79,70
9	Simanindo	36,90
Total		**220,1**

Source: *Samosir Regency in Figures Year 2022.*

From the table above, it can be observed that the Pangururan Sub-District has a harvested area of 79.70 hectares, the Simanindo Sub-District has 36.90 hectares, the Sianjur Mula Mula Sub-District has 25 hectares, the Harian Sub-District has 20.40 hectares, and Palipi Sub-District has 18.20 hectares. Among these, Simanindo Sub-District experienced a decrease in harvested area and production, which is one of the reasons why the researcher chose to conduct the study in Simanindo Sub-District. The increase in harvested area and production will serve as indices and indicators for the sustainability of the farming system [3].

Simanindo Sub-District is a major red shallot production center in Samosir Regency. Known as a hub for red shallot cultivation, this sub-district plays a crucial role in the region's agricultural industry. The red shallots from Simanindo are renowned for their quality and have become a flagship commodity that significantly contributes to the local economy. With its robust agricultural potential, Simanindo plays a vital role in meeting the demand for red shallots not only within this regency but also in the surrounding areas. Below is the data on red shallots in Simanindo Sub-District, Samosir Regency.

Table 2. Harvested Area and Production Data of Red Shallots in Simanindo Sub-District for the Last 5 Years.

Years	Harvest Area (Ha)	Production (Ton)
2017	31	235,40
2018	77	740
2019	54	458
2020	45	207
2021	36,90	57,061

Source: *Simanindo Sub-District in Figures 2022.*

Based on the table above, it can be observed that there was a decrease in the harvested area of red shallots in the Simanindo Sub-District to 36.90 hectares, with a production of 57,061 tons in the year 2021. Meanwhile, in the year 2020, the harvested area was 45 hectares with a production of 207 tons. There is a difference in harvested area of 8.1 hectares and a difference in production of 149,939 tons compared to the previous year.

Based on the discussion above, this becomes the rationale for the researcher to choose the title "Sustainability Analysis of Red Shallot Farming in Simanindo Sub-District, Samosir Regency". The aim is to determine the sustainability status of shallot farming as a reference for farmers, government, and relevant stakeholders, especially in the horticultural commodity sector.

II. LITERATURE REVIEW

Sustainable farming is a concept that encompasses the holistic management of agricultural systems to meet current food and economic needs without jeopardizing the capacity of future generations to satisfy their own demands. In this context, sustainable farming involves the interconnected aspects of environmental, economic, and social sustainability. By integrating these three aspects, sustainable farming can help create agricultural systems that are resilient to climate change, efficient in resource use, and socially equitable, enabling them to endure over the long term [4].

In the context of agriculture, the economic dimension refers to aspects related to costs, income, and profits derived from agricultural activities. This involves calculating various financial elements such as production costs, marketing expenses, and the income generated from selling agricultural products. Farmers' income from agricultural production should be sufficient to cover various daily needs such as food, clothing, water, electricity, and education without relying on subsidies. However, in practice, farmers often face significant financial challenges. Large financial risks and uncertainties in food and dairy production can affect their economic stability. These risks include market price fluctuations, extreme weather changes, plant or animal diseases, and unstable input costs. All these factors can lead to inconsistent income and threaten farmers' economic well-being. By prioritizing resource allocation wisely and adopting the right strategies, farmers can enhance their economic sustainability and reduce financial risks. A holistic and well-planned approach will help ensure that agricultural income is adequate to meet daily needs and support long-term well-being [5].

The social dimension is often considered an add-on in sustainable development policies, but its role is crucial in determining agricultural sustainability. The social dimension refers to farmers' social behavior and the societal aspects related to agricultural activities. The higher the social value of farmers, the wiser they are in managing agricultural practices [6]. Farmers' social behavior affects how readily new technologies and sustainable agricultural practices are adopted. Farmers who are open to change and innovation are more likely to adopt environmentally friendly and efficient technologies, which

contribute to the sustainability of their agricultural activities. Cooperation among farmers and between farmers and government agencies or non-governmental organizations enhances the effectiveness and sustainability of agricultural programs. Collaboration in resource management, such as joint irrigation systems or training programs, can strengthen agricultural systems and maximize sustainable outcomes. The social dimension plays a very important role in agricultural sustainability. Neglecting social aspects can lead to instability in agricultural systems and long-term negative impacts on communities and the environment. To achieve holistic sustainability, it is crucial to integrate the social dimension into agricultural policies and practices, ensuring that economic benefits do not come at the expense of social welfare and environmental health.

The ecological dimension, in the context of agricultural sustainability or ecological systems, refers to aspects related to the interactions between living organisms and their environment. This dimension encompasses various elements that both influence and are influenced by ecological functions, environmental health, and system sustainability. The ecological dimension includes all aspects related to the interactions between living organisms and their environment and how these interactions impact the sustainability and health of ecosystems. Effectively understanding and managing the ecological dimension is crucial to ensure that agricultural practices and natural resource management support long-term sustainability and environmental health [7].

Post-harvest technology plays a crucial role in the agricultural value chain, especially in ensuring that the agricultural products produced are of good quality before reaching consumers. Post-harvest involves a series of activities carried out after harvest, such as processing, drying, storage, packaging, and transportation. Each stage in this post-harvest process can affect the final quality of the product, including its nutritional value, texture, taste, and shelf life. Overall, post-harvest technology is not just about maintaining product quality; it is also about creating a more efficient, sustainable, and profitable agricultural system for all parties involved in the supply chain [8].

III. RESULTS AND DISCUSSION

The results of the multidimensional analysis using the RAP-Farm technique and MDS method indicate that the sustainability of shallot farming in Simanindo District, Samosir Regency, has an index of 51.93. This places sustainability in the category of moderately sustainable, considering that the value falls within the range of 50.01-75.00. This assessment is based on 20 attributes covering five main dimensions: economic (6 attributes), ecological (6 attributes), social (4 attributes), technological (2 attributes), and institutional (2 attributes). Therefore, the attributes from these five dimensions collectively provide a positive overview of the current shallot farming system.

To obtain sustainability indices for each dimension in detail and identify the attributes that have a significant impact on the sustainability of shallot farming, RAP-Farm analysis and leverage analysis were conducted in each dimension (economic, ecological, social, technological, and institutional). This analysis provides in-depth insights into the factors influencing the sustainability of potato farming in the area. It can serve as a foundation for better decision-making efforts to enhance agricultural sustainability in the future. By considering economic, ecological, social, technological, and institutional aspects, strategic steps can be formulated to advance the agricultural sector sustainably [9].

Table 3. Index and Status of Shallot Farming in Simanindo District, Samosir Regency

Dimension	Index	Status
Economic Dimension	39,62	Less Sustainable
Ecological Dimension	53,92	Quite Sustainable
Social Dimension	52,67	Quite Sustainable
Technology Dimension	23,85	Bad Sustainable
Institutions Dimension	89,59	Good Sustainable
Multidimensional	51,93	Less (Less Sustainable)

Source: *Prime Data, processed*

Stress analysis of MDS in each of the 5 sustainability dimensions, including economic, ecological, social, technological, and institutional dimensions, as well as the technological dimension in the sustainability of shallot farming, has an average value of < 0.25. The smaller the stress value, the better the output of the MDS analysis [8]. The coefficient of determination (R2) in each dimension and its average value is high, indicated by the value approaching 1. Based on these two statistical parameters (Table 2), it is concluded that all attributes used in each dimension are able to describe the sustainability of shallot farming. Below is the table of Rap Analysis results for each dimension and the table of the statistical parameter (goodness of fit) analysis of the sustainability index of shallot farming in Simanindo District, Samosir Regency [10].

Table 2. Statistical Parameters (Goodness of Fit) Analysis of Shallot Farming Sustainability Index in Simanindo District, Samosir Regency.

Parameter statistic	Dimension				
	Economic	Ecological	Social	Technology	Institutions
Stress	0,22	0,23	0,19	0,23	0,23
R^2	0,93	0,94	0,92	0,91	0,91

Source: *Prime Data, processed*

A) Sustainability Status of the Economic Dimension and Sensitive Attributes of the Economic Dimension

The sustainability status and dominant attributes influencing the economic dimension can be seen in Figure 2. The MDS analysis results using Rap-Farm show that the sustainability index value of the economic dimension of shallot farming in Simanindo District, Samosir Regency, is 39.62. This value indicates that the sustainability status of shallot farming is Less Sustainable. Factors influencing the economic dimension that need to be considered and managed well should be maintained. It is known that out of the six (6) attributes analyzed, there are three (3) sensitive attributes that affect shallot farming, namely (1) revenues with a value of 3.87, indicating that it is necessary to increase the level of revenues in terms of farming sustainability [11]), (2) farming costs with a value of 2.23, indicating that the sensitivity of high or low farming costs affects the sustainability of shallot farming. This should be a concern for government policies [12] and (3) production with a value of 2.10, which supports decision-makers in implementing the right steps to increase production and the sustainability of shallot farming [13].

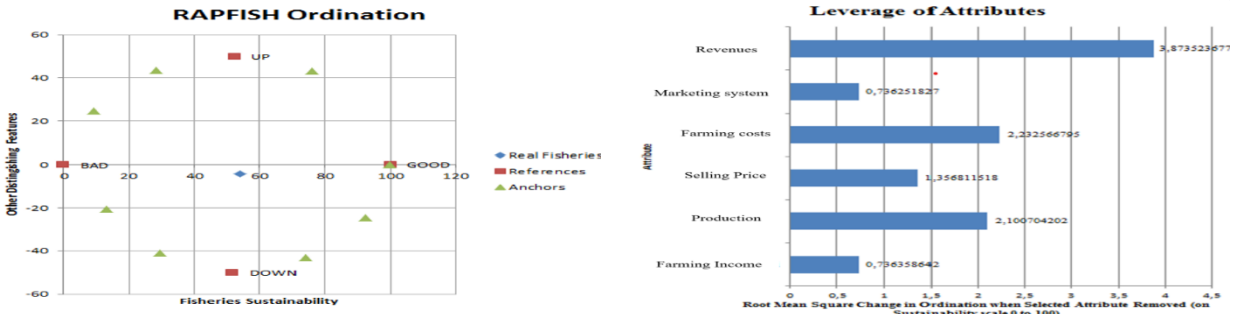

Fig. 1 Results of Leverage Analysis for Shallot Sustainability in the Economic Dimension

B) Status of Ecological Sustainability and Sensitive Attributes in the Ecological Dimension

The sustainability status and dominant attributes influencing the ecological dimension can be seen in Figure 3. The MDS analysis using Rap-Farm shows that the sustainability index value of the ecological dimension for red onion farming in Simanindo District, Samosir Regency, is 53.92. This value indicates that the sustainability status of red onion farming is "Quite Sustainable". Factors affecting the ecological dimension need to be carefully considered and managed in order to be sustained.

From the six attributes analyzed, three sensitive attributes affect red onion farming: (1) Land suitability with a value of 16.18. The assessment of land suitability is crucial in efforts to improve production and plan environmentally friendly farming sustainability [14]. (2) Land potential with a value of 13.14. To achieve environmentally friendly land use, the emphasis should be on implementing novel management systems capable of providing multiple ecosystem services on a variety of land types. Integrated Agricultural Systems is an alternate method that promotes adjusting agricultural activities to local conditions to enhance synergistic resource exchange and long-term provision of ecosystem services [15]. (3) Pest attack rate with a value of 11.15. Agriculture in the biophysical context refers to plant growth and how elements such as soil fertility, climate, and pests influence it. The primary focus is on how management techniques and environmental factors influence yield. Much research on agricultural sustainability has explored the potential to maintain or improve crop productivity [16].

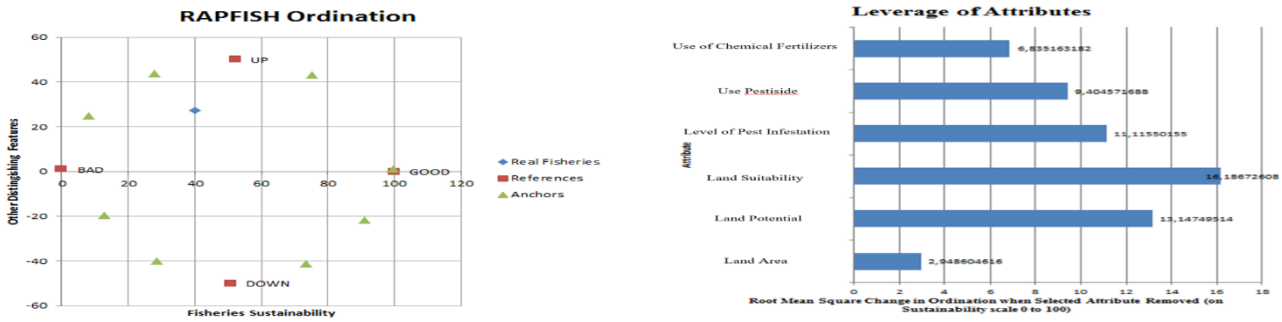

Fig. 2 Sustainability Leverage Analysis of Shallot Farming in the Ecological Dimension

C) Status of Social Dimension Sustainability and Sensitive Social Dimension Attributes

The sustainability status and dominant attributes influencing the social dimension can be seen in Figure 4. The MDS analysis with Rap-Farm shows a sustainability index value of 52.67 for the social dimension of shallot farming in the Simanindo District, Samosir Regency. This value indicates that the sustainability status of shallot farming is Quite Sustainable. Factors influencing the social dimension need to be considered and managed well to ensure their preservation. It is known that out of the four (4) attributes analyzed, there is one sensitive attribute influencing shallot farming, namely the culture of shallot farming, with a value of 6.59. The culture of mutual cooperation is closely related to the Batak tribe, especially in Simanindo District, Samosir Regency. Mutual assistance enhances the work ethic and spirit of shallot farmers. This is considered essential for the sustainability of shallot farming.

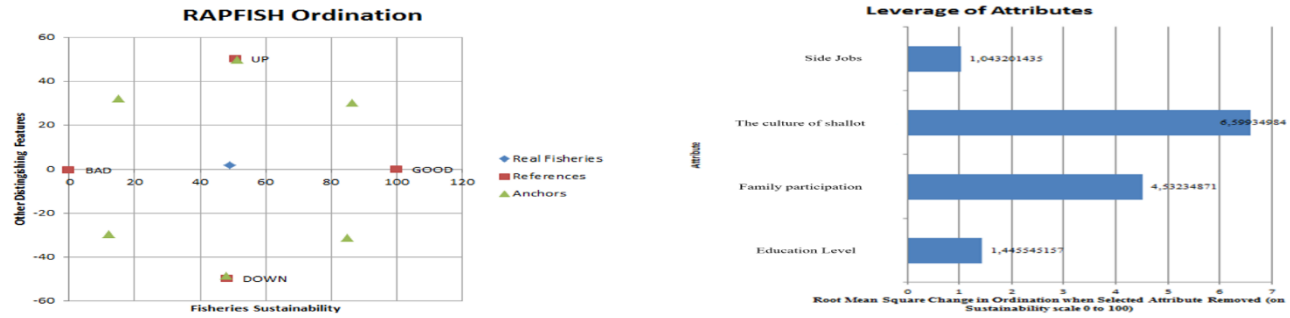

Fig. 4 Results of the Leverage Analysis of Shallot Sustainability in the Social Dimension

D) Status of Sustainability in the Technology Dimension and Sensitive Attributes of the Technology Dimension

The sustainability status and dominant attributes influencing the technology dimension can be seen in Figure 5. The MDS analysis with Rap-Farm shows that the sustainability index value of the technology dimension of shallot farming in Simanindo District, Samosir Regency, is 23.85. This value indicates that the sustainability status of shallot farming is Poorly Sustainable. Factors influencing the technology dimension need to be considered and managed well in order to be maintained. It is known that out of the two (2) attributes analyzed, there is one sensitive attribute influencing shallot farming, namely the type of shallot technology with a value of 10.42. The adoption of technology is one of the important factors in the sustainability of shallot farming. Technology can facilitate farmers in cultivating crops like shallots [17].

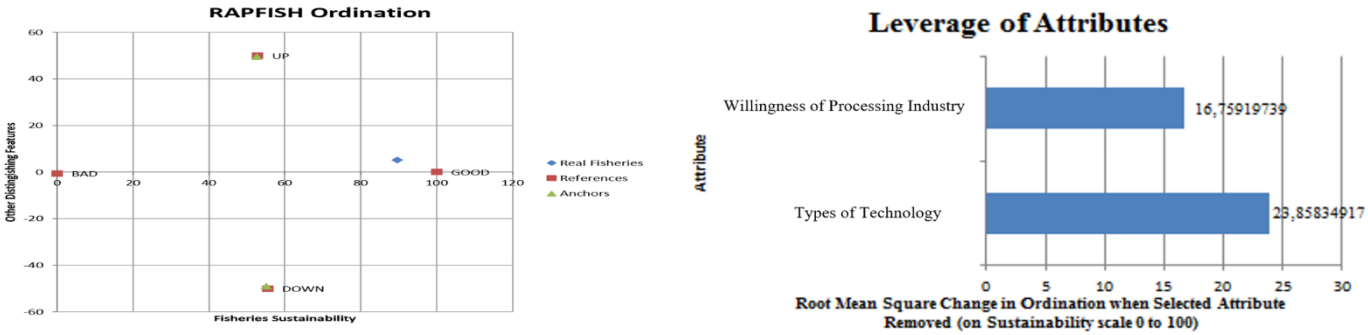

Fig. 5 Results of the Leverage Analysis of Shallot Sustainability in the Technology Dimension

E) Sustainability Status of Institutional Dimension and Sensitive Attributes of Institutional Dimension

The sustainability status and dominant attributes influencing the institutional dimension can be seen in Figure 6. The MDS analysis results with Rap-Farm indicate a sustainability index value of 89.59 for the institutional dimension of shallot farming in the Simanindo District, Samosir Regency. This value indicates that the sustainability status of shallot farming is sustainably Good. Factors influencing the institutional dimension need to be considered and managed well and, therefore, maintained.

It is known that out of the two (2) attributes analyzed, there is one sensitive attribute influencing shallot farming, namely the institution of shallot farmer groups with a value of 10.42. Institutions need to be considered for the sustainability of farming. This is because farmers obtain a lot of information in farming activities. The role of government institutions is also needed to support the work of farmers in the Simanindo District, Samosir Regency [18].

Fig. 6 Results of the Leverage Analysis of Shallot Sustainability in the Institution Dimension

IV. CONCLUSION

Shallot farming in the Simanindo District of Samosir Regency exhibits a level of sustainability rated as "moderately sustainable" across five dimensions of sustainability: economic, ecological, social, technological, and institutional. These assessments are derived from Multidimensional Scaling (MDS) analyses. The institutional dimension stands out with the highest index and sustainability rating at 89.59, while the other four dimensions are scored at 39.62 (economic), 59.32 (ecological), 52.67 (social), and 23.85 (technological). Each dimension highlights priority attributes that will be used to formulate policy scenarios for the sustainable development of shallot farming in the Simanindo District, Samosir Regency. Priority attributes in the economic dimension include revenue, farming costs, and production, with respective scores of 3.87, 2.23, and 2.10. In the ecological dimension, priority attributes are land suitability (16.18) and land potential (13.14). The social dimension's priority attribute is the culture of shallot farming, with a score of 6.59. Lastly, in the technological dimension, the priority attribute is the type of shallot technology, with a score of 10.42. In the institutional dimension, the priority attribute is the farmers' group institution, also scoring 10.42.

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