Sustainability Assessment of Shallot Farming in Humbang Hasundutan, North Sumatra

Dany Juhandi[1], Dwidjono Hadi Darwanto[2], Masyhuri Masyhuri[3], Jangkung Handoyo Mulyo[4], Tri Martini[5]

{dany.juhandi@mail.ugm.ac.id[1], dwidjonohd.sosek@ugm.ac.id[2], masyhuri@ugm.ac.id[3], jhandoyom@ugm.ac.id[4], tri.martini@brin.go.id[5]}

Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta Indonesia[1,2,3,4],
Research Center for Sustainable Production System and Life Cycle Assessment, National Research and Inovation (BRIN), Jakarta 10340, Indonesia[5]

Abstract. Farming activities have a substantial impact on the economic, social, and environmental sustainability of an area.Shallot farming, for instance, heavily relies on the usage of anorganic fertilisers and pesticides that hold a tendency to pollute the surrounding environment.The limited land area results in low profits for farmers.The primary objective of this study is to evaluate the sustainability of shallot farming practices in the Humbang Hasundutan Regency through the application of a Multidimensional Scaling approach.The findings indicate that, on the whole, the sustainability of the farm is at a moderate level.The economic sustainability, on the other hand, is at a low level. Regarding the social and environmental facets of sustainability, the farm is at a moderate level.

Keywords: sustainability, sustainable assessment, multidimensional scaling.

1 Introduction

Farming activities starting from input supply, ground tillage, planting, nurture, harvesting and post-harvesting affect the economic, social and environmental aspects. These three aspects are the main pillars of the concept of sustainability that first emerged in 1987 through an article entitled "Our Common Future". Farming activities need to pay attention to every aspect of sustainability for the benefit of future generations.

Farm intensification activities during the Green Revolution had adverse impacts on the environment such as soil degradation and slow land productivity growth [1]. The Green Revolution provided interventions for farming in the form of modern inputs, superior seeds, fertilizers and pesticides aimed at increasing production [2]. The green revolution was able to provide food for the population, even improving health conditions and deaths due to hunger [3], but other negative impacts are only being felt now.

Farming yields in the forms of production, income and profit are the main goals of farmers. However, these goals need to be concerned with environmental conditions and future

IRCEB 2023, September 26, Malang, Indonesia

DOI 10.4108/eai.26-9-2023.2350720

generations. These conditions can be accomplished through sustainable farming activities. Sustainable farming aims to meet current needs without sacrificing the future through efforts to ensure environmental quality [4].

Horticultural crop farming requires more intensive maintenance than food and plantation crops. Horticultural crops are relatively more susceptible to pests and plant diseases so they need intense control. However, the use of pesticides for pest control in horticultural crops has residues on plants that have the potential that could threaten consumer health [5].

Shallot plants are a major commodity in Humbang Hasundutan Regency, North Sumatra [6]. Climatically and geographically this district is suitable for horticultural crops. In 2021, Humbang Hasundutan Regency produced 13,283.9 tons of shallot production and a land area of 670 hectares, so the productivity was 19.82 tons/hectare [7]. When compared to Indonesian shallot productivity, it is only 9.93 tons/hectare [8]. The behavior of shallot farmers in increasing production through pest and disease control using pesticides that are not as recommended has a significant effect on environmental conditions [9]. Farmer behavior is influenced by the level of education to increase income [10]. The level of education affects the perception of farmers for sustainable agriculture [11]. The average length of education of shallot farmers in Humbang Hasundutan is 11 years, meaning that farmers only complete education up to junior high school level.

Based on the above problems, this paper aims to assess the economic, social and environmental sustainability of shallot farming. The aspects of sustainability assessed are economic, social and environmental. The assessment uses the Multidimensional Scaling (MDS) approach.

2 Literatur Review

Initially, the concept of sustainability had three pillars: economic, social, and environmental (Figure 1a). In 2001 [12] adopted these three pillars and then added one aspect of sustainability so that there were four pillars of sustainability (Figure 1b). The concept of sustainability has also been widely used in various disciplines. The field of agriculture is closely related to the concept of sustainability because of farming activities that are related to economic, social and environmental aspects.

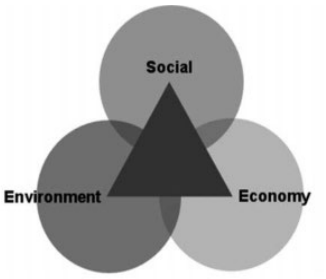

Fig. 1a. Three pillars of Sustainability

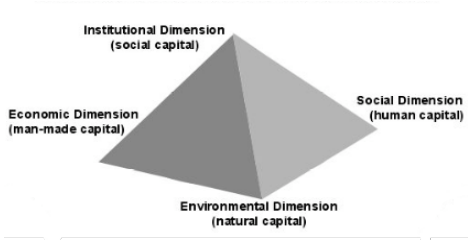

Fig. 1b. Four pillars of Sustainability

The economic aspect has indicators of sustainable growth and capital efficiency. Social aspects have indicators of equity, participation, social mobilization, and empowerment. Environmental aspects have indicators of ecosystem integration, natural resources, biodiversity and environmental carrying capacity. Sustainable development is still difficult to achieve because its application is still sectoral while sustainable development requires a strong integrated cross-sector and multidisciplinary program [13].

In farming activities, sustainable development is not only about increasing production and productivity but also needs to protect and preserve agricultural resources for long-term economic growth so that it requires appropriate technology, policies and appropriate resource management [14]. Various technologies in agriculture have been developed to achieve sustainable development, such as seedling technology, agricultural tools and machinery, and cultivation technology.

The concept of organic farming that uses organic pesticides and organic fertilizers is one way to reach sustainable agriculture. Research conducted by [15], [16] shows that organic farming is effective in increasing productivity, quality of life and is environmentally suitable as a result of the concept of sustainable agriculture. Nevertheless, the development of organic farming as one of the concepts of sustainable agriculture has several obstacles.

The challenges in organic farming include (a) consumers of organic products are still small so that the demand for products is low, (b) organic labeling of products is not from an authorized organization, (c) many farmers are not interested in organic farming, (d) farmers are less aware of the organic farming system, (e) the need for farmer organizations that support organic farming, (f) the absence of partnerships between farmers and entrepreneurs [17]. These challenges require the involvement of farmers, government, and entrepreneurs so that organic farming can be sustainable.

3 Methods

3.1 Research Location

A total of 10 sub-districts exist in Humbang Hasundutan District. The research was held in three sub-districts of shallot production centers namely Pollung, Doloksanggul and Lintong Nihuta located in Humbang Hasundutan Regency. The three sub-districts have the highest shallot production, namely Pollung 4,962.6 tons, Doloksanggul 1,100 tons and Lintong Nihuta 899.5 [7].

3.2 Sample

There were 50 farmers who became respondents in this study from three sub-districts. Respondents were shallot farmers who were selected based on several criteria, namely having planted shallots several times, farming experience of more than 3 years and land area ≤ 1 hectare.

3.3 Data and Data Collecting

This paper uses an ordinal data scale. The data used is primary data obtained through interviews using questionnaires. Interviews were conducted using Rapid Appraisal Methods to

assess economic, social and environmental aspects. The economic aspect uses 7 factors, the social aspect uses 6 factors and the environmental aspect uses 9 factors so that there are 22 factors asked to respondents. All factors were analyzed using licensed Multipleaspect Sustainability Analysis (MSA) software. The output of MSA is the sustainability value of each aspect and can develop scenarios for strategies to improve sustainability status.

3.4 Data Analysis

Sustainability assessment using the Multidimensional Scaling approach with the use of licensed MSA software. There are three aspects assessed: economic, social and environmental. Each aspect has a different number of factors.

- The economic aspect is based on 7 factors
- The social aspect is based on 6 factors
- The environmental aspect is based on 9 factors

A total of 22 factors were analyzed using MSA software. The software will output a score and sustainability level for each of the three aspects of sustainability. Some sustainability categories based on the following index scores [18]:

- Index score 0 - 20 = unsustainable
- Index score > 20 - 40 = low sustainability
- Index score > 40 - 60 = moderate sustainability
- Index score > 60 - 80 = sustainable
- Index score > 80 - 100 = very sustainable

4 Result and Discussions

Table 1. shows that the value of economic sustainability of farming is 38.14, social sustainability of farming is 47.17 and environmental sustainability is 66.67. In general, the sustainability value of shallot farming is 50.66 which is at the moderate sustainable level. Based on the three aspects assessed, it shows that the highest and lowest environmental aspects are economic aspects. This means that the economic aspects of farming are at a low level of sustainability.

Table 1. Sustainability Value

No.	Aspect	Existing
1	Economy	38.14
2	Social	47.17
3	Environment	66.67
Total Average		50.66
Status Sustainability		Moderate Sustainable

Source: MSA Software

4.1 Economic Sustainability

Economic sustainability was measured based on seven factors. Based on these seven factors, it shows that the lowest factors are the availability of agricultural processing industries, agricultural insurance and the percentage of farm income to the whole household income. These three factors have a low rating due to several obstacles faced by farmers.

The availability of a processing industry has an important role for farming, and the environment [19]. The processing industry can be an alternative if production prices are not affordable, farmers can process crops to create value-added products so that they can get better prices. However, the government needs to prepare processing industry technology on a scaled-down basis that is easily accessible, adopted and operationalized by farmers.

The challenges of developing the processing industry in Indonesia stated by [20] include the need for infrastructure improvements, high costs, farmers who do not understand technology and land conditions in Indonesia. The establishment of a processing industry is necessary with the support of human resources, capital and policies. In addition to the availability of the processing industry, the availability of agricultural insurance is required by smallholders.

Farmers require agricultural insurance as a preventive measure to minimize risks in farming. Farming has some risks like crop yield loss caused by weather, climate and plant pests. However, agricultural insurance has yet to be widely recognized by farmers even though some studies [21] show that agricultural insurance is crucial for farming. In fact, agricultural insurance can increase production [22] and improve farmer welfare [23]. At the domestic level [24] shows that agricultural insurance can also contribute to Gross Domestic Product (GDP), besides farmers' income.

Despite the fact that agricultural insurance is less well known, farmers' perception of insurance is that it can be a costly affair. Even though the cost is smaller than the risks they can face in a crop loss. Some of the factors that influence the participation of farmers in agricultural insurance are the degree of education, farming experience, premium period and the risk involved [25].

Farmers' willingness to pay can be reflected in the third factor that has a low value for the economic sustainability aspect, which is the percentage of farm income to aggregate household income. The percent of farm income is low because the shallot field area is small so it requires sustainable land management. As stated by [26] sustainable land management can raise farmers' income.

Farm income can rise by increasing the scale of farming such as field area, capital, seeds and labor. The average field area of shallot farmers in Humbang Hasundutan is 3,041 m2 or 0.3 hectares, meanwhile the minimum field area of food crops for the welfare of Indonesian farmers is 0.65 - 0.74 hectares [27]. Thus, the field area of shallot farmers in Humbang Hasundutan is less than the minimum land area to reach welfare so it can be explained that the percent of farm income is less than the aggregate income of the household.

4.2 Social Sustainability

Social sustainability was measured based on six factors. Indonesian farmers face many problems with land tenure due to the fact that their lands remain uncertified. Land tenure influences the implementation of sustainable agriculture. As stated by [28], self-owned cultivation field motivates farmers to practicing sustainable agriculture rather than non-owned cultivation field. The clarity of land tenure rights makes farmers feel more secure in cultivation activities due to the reduced risk of losing land tenure. Besides the farmers' rights, the farmers' responsibilities towards the environment in Pasal 6 of Law of the Republic of Indonesia Number 23 of 1997 concerning Environmental Management are (a) everyone is

obliged to maintain the preservation of environmental functions and prevent and overcome environmental pollution and destruction, (b) everyone who conducts business and/or activities is obliged to provide correct and accurate information regarding environmental management.

Farmers' knowledge about cultivation is derived from their own experience and information from other farmers. Agricultural extension has an important role in improving farmers' knowledge. However, agricultural extension faces many obstacles such as low farmer participation due to busy schedules and work in another field, as well as issues of extension infrastructure due to the relatively far from the farmer's house to the location of the program [29].

The concept of sustainable agriculture is interpreted as the integration of economic, social and environmental aspects [30]. It requires extension and assistance to change the conventional farming activities to sustainable agriculture. It is difficult to change farmers' habits, which requires assistance and a solid relationship between farmers and extension staff. Adopting new technology takes a long time by farmers, it cannot be instantly.

4.3 Environment Sustainability

Environmental sustainability was measured based on 9 factors. Two of the nine factors analyzed were relatively low, i.e. water availability and weed prevention. Water availability for cultivation is related to irrigation. Irrigation used by farmers is mostly conventional irrigation, which cannot ensure the continued availability of water for crops.

The availability of water for crops is very essential to ensure that they grow well. But aside from infrastructure issues, the most important thing is the knowledge of farmers on the accurate time to supply water. Crop needs water when the amount of water used to fulfill the evapotranspiration of plants in to grow well [31]. Evapotranspiration is a plant water requirement that is limited as the depth of water needed for optimal plant growth in a disease-free state, growing without stagnation of soil moisture content and fertility and the surrounding environment. If the plant's water requirement is precisely given, the application of water will be efficient. Using water efficiently will maintain environmental sustainability [32].

The growth of crops is also affected by weeds. Weeds affect crop growth and yield [33]. Weeds can cause (a) decreased land quality and value, (b) increase production costs, (c) ineffective and inefficient fertilizer application, (d) create water management problems, (e) harm livestock, (f) cause a feeling of discomfort for humans, (g) become a hidden spot for pests and diseases, and (h) become a rat's nest [34]. Farmers can reduce weed growth by manual, mechanical, biological, and chemical treatments.

Manual methods for weed control by pulling weeds using labor, mechanical treatments using tools such as hoes, biological treatments using other living organisms, and chemical treatments using chemicals such as herbicides. In most cases, farmers mostly use anorganic herbicides to reduce weeds in the field. The excessive use of these pesticides can impact the quality of the environment. Moreover, it decreases [35] the dependence of pesticides whose supply is uncertain will be an issue in their efficient use. This condition will cause losses to the farm.

Alternative ways can be done by farmers to reduce the use of an inorganic pesticides by using organic pesticides. Farmers' choice to use organic pesticides is influenced by availability,

effectiveness, price and farmer awareness [36]. Therefore, anorganic pesticides are more often used by farmers because their use is more practicable, easier to obtain at affordable prices and the benefits are instantly perceived by farmers [37]. The use of inorganic pesticides is continuously increasing, it can be shown that the growth of its use grew by 20% globally and use increased by 153% in the low income countries [38].

5 Conclusions

The sustainability status of shallot farming in Humbang Hasundutan Regency, which is one of the leading producers of this commodity in North Sumatra, is at the "moderate sustainable" level. The environmental sustainability aspect is at the "sustainable" level and the social sustainability aspect is at the "moderate sustainable" level. Whereas, the economic sustainability aspect is at "low sustainable".

Economic sustainability is affected by the availability of processing industries, agricultural insurance and the percentage of farm income to aggregate household income. The social sustainability aspect is affected by the factors of knowledge about land tenure issues and sustainable agriculture. Environmental sustainability is affected by factors such as water supply and weed prevention.

Acknowledgments

We are grateful to the Final Project Recognition of Universitas Gadjah Mada Number: 5075/UN1.P.II/Dit-Lit/PT.01.01.2023 for funding this research and the National Research and Innovation Agency for providing software facilities to analyze the power of this research.

References

[1] P. L. Pingali and W. Improvement, “Green Revolution: Impacts, limits, and the path ahead,” vol. 109, no. 31, pp. 12302–12308, 2012.

[2] P. B. R. Hazell, “The Asian green revolution,” *Food Secur. Vol. Two – Prod. enough food, Part One – Sources Agric. growth*, no. November 2009, 2020.

[3] J. von der Goltz, A. Dar, R. Fishman, N. D. Mueller, P. Barnwal, and G. C. McCord, “Health Impacts of the Green Revolution: Evidence from 600,000 births across the Developing World,” *J. Health Econ.*, vol. 74, p. 102373, 2020.

[4] M. S. Abubakar and M. L. Attanda, “The Concept of Sustainable Agriculture: Challenges and Prospects,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 53, no. 1, 2013.

[5] E. Amilia, B. Joy, and S. Sunardi, “Residu Pestisida pada Tanaman Hortikultura (Studi Kasus di Desa Cihanjuang Rahayu Kecamatan Parongpong Kabupaten Bandung Barat),” *Agrikultura*, vol. 27, no. 1, pp. 23–29, 2016.

[6] D. Juhandi and A. E. Purba, “Rencana Kebijakan dan Program Pembangunan Hortikultura Lahan Kering untuk Provinsi Sumatera Utara : Sudah Tepatkah ? Abstrak,” *Agrimor*, vol. 6, no. 2502, pp. 88–100, 2021.

[7] BPS, “Kabupaten Humbang Hasundutan Dalam Angka 2023,” Humbang Hasundutan, 2023.

[8] Kementan, "Outlook Bawang Merah: Komoditas Pertanian Subsektor Hortikultura," Jakarta, 2020.
[9] D. R. Dhiaswari, A. B. Santoso, and E. Banowati, "Pengaruh Perilaku Petani Bawang Merah dan Penggunaan Pestisida terhadap Dampak bagi Lingkungan Hidup di Desa Klampok Kecamatan Wanasari Kabupaten Brebes," *Edu Geogr.*, vol. 7, no. 3, 2019.
[10] R. sepriyanti Burano and T. Y. Siska, "Pengaruh Karakteristik Petani Dengan Pendapatan Petani Padi Sawah," *Menara Ilmu*, vol. XIII, no. 10, pp. 68–74, 2019.
[11] R. Virianita, T. Soedewo, S. Amanah, and A. Fatchiya, "Persepsi Petani terhadap Dukungan Pemerintah dalam Penerapan Sistem Pertanian Berkelanjutan," *J. Ilmu Pertan. Indones.*, vol. 24, no. 2, pp. 168–177, 2019.
[12] J. Stenberg, *Bridging Gaps: Sustainable Development and Local Democracy Processes*, vol. 84, no. 23–24. Sweden, 2001.
[13] R. S. Rivai and I. S. Anugrah, "Konsep dan Implementasi Pembangunan Pertanian Berkelanjutan di Indonesia," *Forum Penelit. Agro Ekon.*, vol. 29, no. 1, p. 13, 2016.
[14] M. O. Adnyana, "Pengembangan Sistem Usaha Pertanian Berkelanjutan," *Forum Penelit. Agro Ekon.*, vol. 19, no. 2, p. 38, 2016.
[15] A. Gamage *et al.*, "Role of organic farming for achieving sustainability in agriculture," *Farming Syst.*, vol. 1, no. 1, p. 100005, 2023.
[16] M. Rani, P. Kaushik, S. Bhayana, and S. Kapoor, "Impact of organic farming on soil health and nutritional quality of crops," *J. Saudi Soc. Agric. Sci.*, no. xxxx, 2023.
[17] H. Mayrowani, "The Development of Organic Agriculture in Indonesia," *Forum Penelit. Agro Ekon.* , vol. 30, no. 2, pp. 91–108, 2012.
[18] O. Gunduz, V. Ceyhan, E. Erol, and F. Ozkaraman, "An evaluation of farm level sustainability of apricot farms in Malatya province of Turkey," *J. Food, Agric. Environ.*, vol. 9, no. 1, pp. 700–705, 2011.
[19] H. Wang, C. Liu, L. Xiong, and F. Wang, "The spatial spillover effect and impact paths of agricultural industry agglomeration on agricultural non-point source pollution: A case study in Yangtze River Delta, China," *J. Clean. Prod.*, vol. 401, no. February, p. 136600, 2023.
[20] J. C. Kilmanun and D. W. Astuti, "Potensi Dan Kendala Revolusi Industri 4.0. Di Sektor Pertanian," *Pros. Semin. Nas. Kesiapan Sumber Daya Pertan. dan Inov. Spesifik Lokasi Memasuki Era Ind. 4.0*, pp. 35–40, 2020.
[21] N. Oppong Mensah, E. Owusu-Sekyere, and C. Adjei, "Revisiting preferences for agricultural insurance policies: Insights from cashew crop insurance development in Ghana," *Food Policy*, vol. 118, no. December 2021, p. 102496, 2023.
[22] C. An, X. He, and L. Zhang, "The coordinated impacts of agricultural insurance and digital financial inclusion on agricultural output: Evidence from China," *Heliyon*, vol. 9, no. 2, p. e13546, 2023.
[23] T. Ai, J. Zhang, and J. Shao, "Study on the coordinated poverty reduction effect of agricultural insurance and agricultural credit and its regional differences in China," *Econ. Anal. Policy*, vol. 78, pp. 835–844, 2023.
[24] S. Liu, M. Huang, and Y. Li, "Chinese Agricultural Insurance Development in a VAR Model," *Procedia Comput. Sci.*, vol. 202, pp. 399–407, 2022.
[25] R. K. Bannor, H. Oppong-Kyeremeh, B. Amfo, J. K. M. Kuwornu, S. K. Chaa Kyire, and J. Amponsah, "Agricultural insurance and risk management among poultry farmers in Ghana: An application of discrete choice experiment," *J. Agric. Food Res.*, vol. 11, no. January, p. 100492, 2023.

[26] Y. Zeng, K. He, J. Zhang, and P. Li, "Adoption and ex-post impacts of sustainable manure management practices on income and happiness: Evidence from swine breeding farmers in rural Hubei, China," *Ecol. Econ.*, vol. 208, no. February, 2023.
[27] S. H. Susilowati and M. Maulana, "Luas Lahan Usaha Tani dan Kesejateraan Petani: Eksistensi Petani Gurem dan Urgensi Kebijakan Reforma Agraria," *Anal. Kebijak. Pertan.*, vol. 10, no. 1, p. 17, 2016.
[28] A. Pratiwi and J. P. Moeis, "Sustainable Farming: Respons Petani Tanaman Pangan terhadap Kepemilikan Lahan Pertanian," *J. Ekon. dan Pembang. Indones.*, vol. 22, no. 1, pp. 43–71, 2022.
[29] H. F. Allen, M. M. Batubara, and H. Iswarini, "Kendala Penyuluhan Dalam Melaksanakan Aktivitas Penyuluhan Pada Usahatani Kopi Di Kecamatan Dempo Utara Kota Pagar Alam," *J. Soc.*, vol. 4, no. 2, pp. 105–110, 2015.
[30] R. R. Weil, "Defining and Using the Concept of Sustainable Agriculture," *J. Agron. Educ.*, vol. 19, no. 2, pp. 126–130, 1990.
[31] U. Haryati, "Teknologi Irigasi Suplemen untuk Adaptasi Perubahan Iklim pada Pertanian Lahan Kering," *J. Sumderdaya Lahan*, vol. 8, no. 1, pp. 43–57, 2014.
[32] V. Singh, P. K. Singh, S. K. Jain, S. K. Jain, C. Cudennec, and T. Hessels, "Examining evaporative demand and water availability in recent past for sustainable agricultural water management in India at sub-basin scale," *J. Clean. Prod.*, vol. 346, no. February, p. 130993, 2022.
[33] S. Nakka, M. Jugulam, D. Peterson, and M. Asif, "Herbicide resistance: Development of wheat production systems and current status of resistant weeds in wheat cropping systems," *Crop J.*, vol. 7, no. 6, pp. 750–760, 2019.
[34] N. R. Smith Simatupang, Herman Subagio, Linda Indrayati, "Gulma Pasang Surut," *Gulma Pasang Surut*, pp. 1–15, 2015.
[35] G. J. Doole and T. K. James, "Profitable management of a finite herbicide resource," *Crop Prot.*, vol. 172, no. March, p. 106314, 2023.
[36] N. Y. Praditya and Syafrial, "Analisis Faktor-Faktor Keputusan Pembelian Petani Padi Terhadap Produk Pestisida Nabati," *J. Ekon. Pertan. dan Agribisnis*, vol. I, no. 2, pp. 1–7, 2017.
[37] Purwanti Pratiwi Purbosari, H. Sasongko, Z. Salamah, and N. P. Utami, "Peningkatan Kesadaran Lingkungan dan Kesehatan Masyarakat Desa Somongari melalui Edukasi Dampak Pupuk dan Pestisida Anorganik," *Agrokreatif J. Ilm. Pengabdi. Kpd. Masy.*, vol. 7, no. 2, pp. 131–137, 2021.
[38] A. Shattuck, M. Werner, F. Mempel, Z. Dunivin, and R. Galt, "Global pesticide use and trade database (GloPUT): New estimates show pesticide use trends in low-income countries substantially underestimated," *Glob. Environ. Chang.*, vol. 81, no. May, p. 102693, 2023.