

Sustainability of Agricultural Land Management in Critical Areas in Malang Regency, Indonesia

Anisa Zairina^{1ab*}, Soemarno^{2c}, Arief Rachmansyah^{3d}, Bagyo Yanuwadi^{4e}, Gettik Andri Purwanti^{5b}, Amin Setyo Leksono^{6e}, Saiful Arif Abdullah^{7ef}

Abstract: This study aims to analyze the status of sustainable management of agricultural land in Pujon and Ngantang, East Java. This research was conducted in Pujon and Ngantang Subdistricts, Malang Regency, East Java, Indonesia. Data was obtained from a social survey by distributing questionnaires to 125 respondents. Respondents were purposely selected from locations prone to landslides. Of the 125 questionnaires distributed, 101 contained valid data. Respondents in this study consisted of farmers, landowners, and communities around landslide-prone lands. Data were analyzed using multidimensional scaling analysis. The sustainability status of landslide-prone land management on the social dimension was 80-100%, indicating very sustainable, while the sustainability index for other dimensions was 50-70% (moderately sustainable). The sustainability index for the ecological and technological dimensions had an exact value of 63.44%, whereas the economic dimension had a value of 63.23%. Attributes of the ecological dimension that significantly affect the sustainability of this dimension were the level of pest attacks on agricultural land, the influence of vegetation, and the slope of the land; for the economic dimension, attributes include opportunities for other sources of income, the stability of crop prices, and the availability of places to sell produce, while the attributes of the technological dimension include knowledge of water management, agricultural land technology, and landslide determination.

Keywords: Critical land, sustainability, ecological dimension, social dimension, economic dimension, technological dimension.

1. Introduction

Nearly half of the total terrestrial land in Indonesia undergoes land degradation. Natural events and human activities can affect land degradation. Unfavorable physical factors in the region, such as heavy rainfall, steep slopes, and soil prone to erosion, are among the key natural factors affecting land degradation (Kubangun et al., 2014; Leksono & Zairina, 2022). Anthropogenic pressures, such as converting forests into agriculture and residential areas, may lead to land degradation. A previous study shows that population growth and behavior are important factors driving anthropogenic pressure (Iswahyudi, 2017). Critical land experiences significant degradation, losing its ability to function as a productive agricultural area or as a vital part of the environment. It is characterized by a decline in physical, chemical, and biological soil properties, often resulting from unsustainable land management approaches. This degradation can cause

reduced agricultural productivity, environmental harm, and even affect water management (Leksono & Zairina, 2022).

Critical land has lost its ability to support the hydrological cycle and land productivity. It can disrupt the balance of the watershed and soil ecosystem. Land degradation can negatively affect soil fertility, decrease the amount of water available during the dry season, and increase the risk of flooding during the rainy season (Rosyada et al., 2015). Reduced soil quality can affect agricultural output and food supply (Hossain et al., 2020; AbdelRahman et al., 2022). Land degradation can progress to critical land if land use management neglects soil and water conservation.

In some areas with limited land availability for agricultural purposes, critical land is inevitably used for agroforestry or agricultural cultivation due to rapidly decreasing arable land resources. Utilizing critical land requires appropriate methods and technology. The development of community forest farming with an agroforestry pattern can be implemented on land with a reasonably steep slope, ranging from 15% to 25%. Adopting an agroforestry system may be the best method to maintain land stability. Therefore, the community should enhance its knowledge and understanding regarding efforts to manage its critical lands to reduce production risks.

Critical land control necessitates appropriate prevention and mitigation strategies. These plans must be supported by thorough studies of restrictions on land use for cultivating agricultural crops, re-vegetation using environmentally friendly technology, and community involvement in sustainable land management. The community is the primary actor in handling and controlling potentially degraded soil. The community's capacity to hold and

Authors information:

^aEnvironmental Science Program, Postgraduate School, Brawijaya University, Malang, INDONESIA. E-mail: anisa.zairina85@gmail.com¹

^bInstitut Pertanian Malang, Malang, INDONESIA, E-mail: anisa.zairina85@gmail.com¹, gettikandri1976@gmail.com⁵

^cDepartment of Soil Science, Faculty of Agriculture, Brawijaya University, Malang, INDONESIA. E-mail: smno@ub.ac.id²

^dDepartment of Civil Engineering, Faculty of Engineering, Brawijaya University, Malang, INDONESIA. E-mail: ariefftub@yahoo.com³

^eDepartment of Biology, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang, INDONESIA. E-mail: yanuwadi@ub.ac.id⁴; amin28@ub.ac.id⁶; saiful@ukm.edu.my⁷

^fInstitut Alam Sekitar dan Pembangunan (Lestari), Universiti Kebangsaan Malaysia, MALAYSIA. E-mail: saiful@ukm.edu.my⁷

*Corresponding Author: anisa.zairina85@gmail.com

Received: March, 2024

Accepted: April, 2024

Published: December, 2025

control potentially degraded lands determine success in landslide mitigation. Thus, community knowledge and skills in sustainable land management are crucial in preventing and mitigating landslides (Holcombe et al., 2013).

Sustainable land management, by integrating ecological, technological, social, and economic dimensions, can protect land and preserve soil quality. The balance of all existing dimensions can improve land use efficiency to support the provision of food sources, community income, and economic development (Liu et al., 2020). Research on the sustainable management of landslide-prone lands still needs to be conducted. Previous studies have focused on safety, risk assessment, monitoring and developing map for land degradation mitigation (McGowran & Donovan, 2021; Baczynski & Bar, 2017; Masrurroh et al., 2023). Sustainable disaster risk management research often attempts to integrate technical and social aspects. In contrast, this research intends to identify the status of sustainable management using ecological, technological, social, and economic dimensions. Therefore, this study aims to analyze the status of sustainable management of landslide-prone lands in Pujon and Ngantang, East Java.

2. Materials and Methods

This research was conducted in the Pujon and Ngantang sub-regencies (112° 22' 9" to 122°28' 92" E and latitude 7° 49' 37" to 7°56' 03" S), Malang Regency, East Java, Indonesia. The study sites were included on the slopes of the Arjuno volcanic complex (Noronha & Arifianto, 2019; Rachmansyah et al., 2021). The research location has an altitude of 870 to 1,100 above sea level. Over 35% of the area is prone to landslides.

Data Collection

Two villages with a high incidence of landslides were selected from the research area. The two villages have 2611 households. Research data was obtained from a social survey by distributing questionnaires. Respondents in this study consisted of farmers, landowners, and communities around landslide-prone lands. Respondents were selected using snowball sampling, starting from village officials, community leaders, the heads of farmer groups, and farmer representatives. The number of respondents is determined using the Slovin formula as follows.

$$n = \frac{N}{1 + N(e)^2}$$

Where n = samples

N = population

e = 0.1

with a population of 2611, the results of the Slovin formula calculation yielded a sample of 96 respondents. The questionnaires were distributed to 125 respondents to meet the minimum sample size. The questions in the questionnaire were categorized into ecological, economic, social, and technological aspects (dimensions). Before being used to collect data, the questionnaire was administered to 30 respondents to assess the validity of the questions. The initial questionnaire contained 56 questions, consisting of 14 questions for each dimension. The test results showed nine invalid questions, including seven in ecological, eight in economic, two in social, and seven in technological dimensions. Therefore, those invalid questions were removed from the questionnaire. The final questionnaire consisted of seven ecological aspects, six economic aspects, 12 social aspects, and seven technological aspects (Table 1).

Table 1. List of valid questions among ecology, economy, social and technology

Dimensions	Attributes
Ecology	<ol style="list-style-type: none"> 1. The degree of influence of the slope level of the land on the vulnerability of managed land 2. The degree of influence of the steep slope of the land on agricultural production 3. The influence of ground movement on the vulnerability of agricultural land 4. The level of influence of landslides on the vulnerability of agricultural land 5. The level of pest attacks on agricultural land 6. The influence of vegetation on landslides 7. The rainfall affects landslides
Economy	<ol style="list-style-type: none"> 1. Stability the product price of the harvest 2. The source of farming capital 3. The existence of a market to sell produce 4. The opportunities for getting additional income 5. The harvest sales system 6. The availability of financial institutions
Social	<ol style="list-style-type: none"> 1. The socio-cultural values enforcement 2. The existence of farmer groups 3. The role of agricultural extension officers 4. The counseling frequency 5. The role of community leaders 6. The community harmony 7. The role of government institutions 8. The role of private institutions 9. The role of NGOs 10. NGO oversight 11. Government oversight 12. The role of village institutions (village-owned enterprises, social institutions)
Technology	<ol style="list-style-type: none"> 1. Understanding landslide risk 2. Understanding slope repair 3. Understanding slope monitoring 4. Understanding water pumping 5. Understanding water management 6. Understanding the availability of agricultural land management technology 7. Understanding the availability of pest control technology

Furthermore, the valid questionnaire was distributed to 125 participants. Of the 125 questionnaires distributed, 115 were returned, and 101 had valid data. Responses from participants were classified based on a Likert scale, with a score of 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. To develop recommended strategies to improve the sustainability of agricultural land management in risky areas, a focus group discussion was convened. This discussion was attended by experienced farmers and the head of the neighborhood association. The discussion was held to formulate strategies based on current shortcomings and determine strategic priorities.

Data Analysis

Response data from respondents were analyzed using Multidimensional Scaling (MDS) analysis. The MDS is a rapid assessment method that allows for multidisciplinary evaluation. It is a multivariate statistical technique used to describe the structure of relationships between data objects based on their graphical similarities in a multidimensional space. The MDS is also a technique that can help researchers identify the key dimensions underlying the evaluation of objects from respondents. The final result of this analysis is a kite diagram that can describe the

position of each dimension. Data analysis starts with validity and reliability tests. The R-squared value is the reliability coefficient of the calculation results. The minimum requirement is reliability if the R-squared value is higher than the R-squared from the table. The value of r is calculated with an error rate of 5%. The reliability test was performed using the product-moment correlation formula from Pearson. It was processed using multidisciplinary rapid assessment by the RAPFISH method (RAPFISH version 3.1). In the sustainability analysis, the measured dimensions are then used on a continuous to intermittent scale. The measure of sustainability regarding the position of the dimensions studied is determined based on the goodness of fit, with an indicator of stress ≤ 0.25 . In addition, the analysis results were categorized into four groups based on the sustainability condition: 0-25 was not sustainable, 26-50 was less sustainable, 51-75 was moderately sustainable, and 76-100 was sustainable.

3. Result

Most respondents were between 30 and 50 years old (more than 80%). This age group was considered productive. The gender distribution was nearly equal, consisting of 52.48% males and 47.52% females. This proportion indicated that gender participation in this study was balanced. Most respondents held a secondary school education level (Table 2).

Table 2. Respondent Characteristics in Pujon and Ngantang, Malang Regency

Characteristics	N (%)	
Age (year)	20–30	15.84
	30-40	40.59
	40-50	40.59
	>50	2.97
Gender	Male	52.48
	Female	47.52
Education	Elementary School	27.72
	Secondary School	62.38
	Bachelor/Diploma	9.90

Sustainability Analysis

The results of the MDS-Rapfish sustainability analysis of four dimensions, including Ecology, Economy, Social, and Technology, were presented in Table 2. Stress values for all dimensions ranged between 0.132 and 0.162, less than 0.25. Furthermore, R-Square values for all dimensions also showed values exceeding 0.90. These results indicated that the MDS analysis satisfies the goodness-of-fit criteria. Therefore, further analysis can be conducted using the available data (Table 3).

Table 3. Summary of MDS-Rapfish Analysis Results

Dimensions	Stress (S)	R-Square (R)
Ecology	0.161	0.939
Economy	0.162	0.943
Social	0.132	0.956
Technology	0.161	0.939

Ecological Dimension

The value of all attributes' ordination in MDS RAPFISH in the ecological dimension showed a score of 63.44%. The score fell within the range of 50-75, indicating it was moderately sustainable (Figure 1).

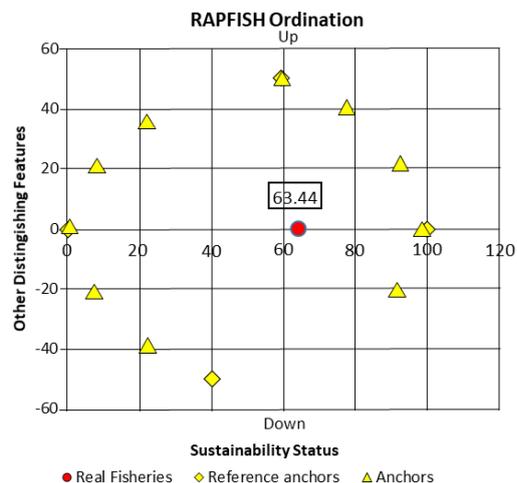


Figure 1. Ecological Dimension Sustainability Status

The ecological attributes that most significantly influence sustainability include the degree of pest infestation on agricultural land, vegetation cover, and land slope. These attributes exhibited higher influence values compared to others, indicating their critical role in sustainable land management. In contrast, attributes with relatively low impact included the perceived effect of land slope on the vulnerability of managed land, the influence of steep slopes on agricultural productivity, and the impact of ground movement on the susceptibility of agricultural land.

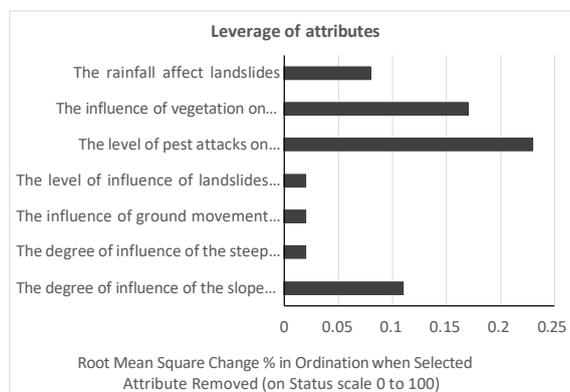


Figure 2. Ecological Dimension Attribute Sensitivity

Economic Dimension

The value of all attributes' ordination in MDS RAPFISH in the economic dimension demonstrated a score of 63.23%. The score was 50-75, which means it was moderately sustainable (Figure 3).

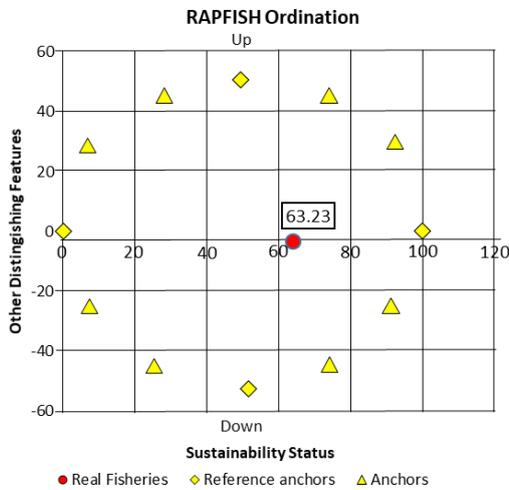


Figure 3. Economic Dimension Attribute Sensitivity

Based on Figure 4, the economic dimension's attributes that significantly affected this dimension's sustainability are opportunities to obtain alternative sources of income and the stability of the selling price of crops. This was indicated by the leverage value of these attributes, which was greater than that of the other attributes. In contrast, economic attributes that had low impacts were the harvest sales system and the source of farming capital.

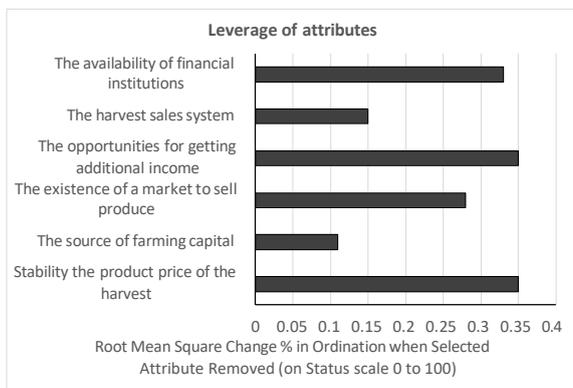


Figure 4. Attribute Sensitivity of the Economic Dimension

Social Dimension

MDS RAPFISH in the social dimension demonstrated a score of 87.18%. The score was in the range of 75-100, which means it was sustainable (Figure 5).

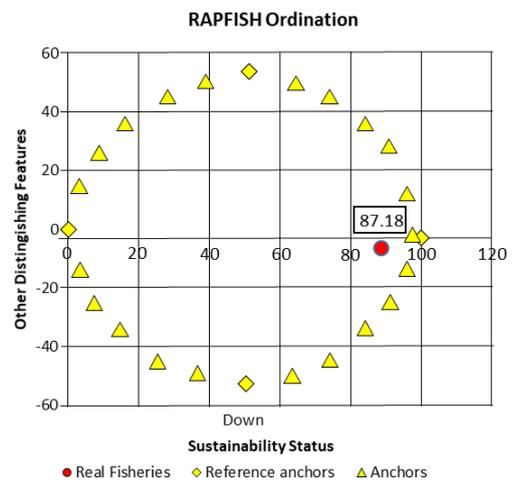


Figure 5. Social Dimension Sustainability Status

The social dimension attributes that greatly influence this dimension's sustainability include the frequency of outreach and the role of private institutions. This attribute has the highest influence values among the others (Figure 6). In contrast, social attributes that had low impacts were the existence of farmer groups and the role of agricultural extension officers.

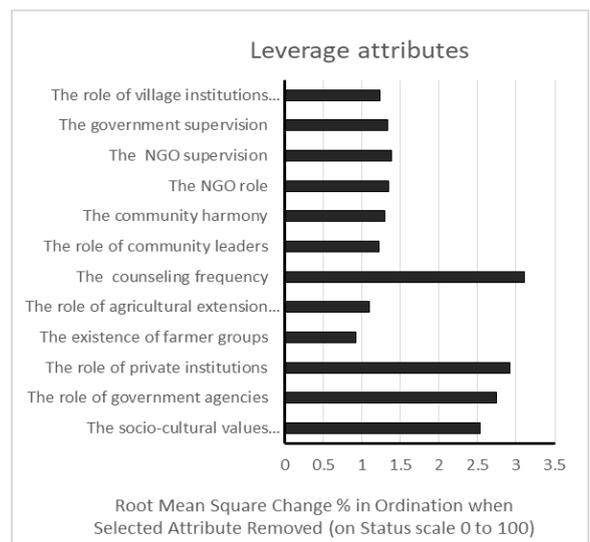


Figure 6. Attribute Sensitivity of the Social Dimension

Technology Dimension

The value of all attribute's ordination in MDS RAPFISH in the technological dimension demonstrated a score of 63.44%. The score was in the range of 50-75, which means it was moderately sustainable (Figure 7).

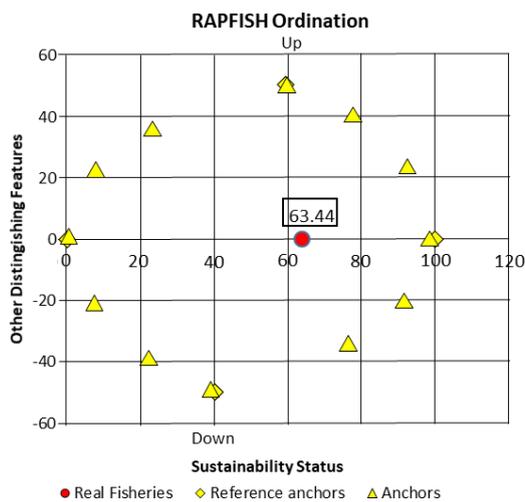


Figure 7. Sustainability Status of the Technology Dimension

Based on Figure 8, the attribute of the technology dimension that significantly influences the sustainability of this dimension is the comprehension of water handling. This is indicated by the impact value of this attribute, which is greater than that of the other attributes. In contrast, technology attributes that had low effects were understanding slope improvement, slope monitoring, and the water pumping system.

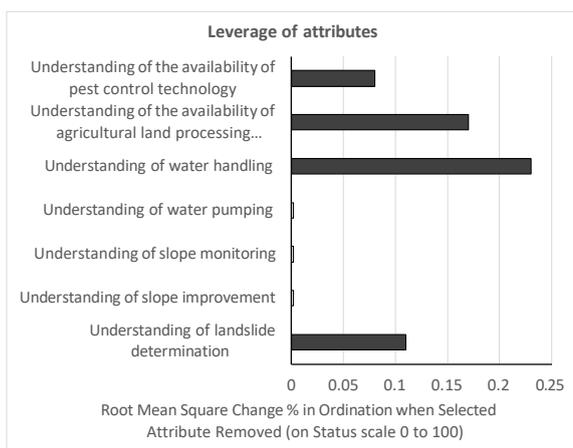


Figure 8. Attribute Sensitivity of the Technology Dimension

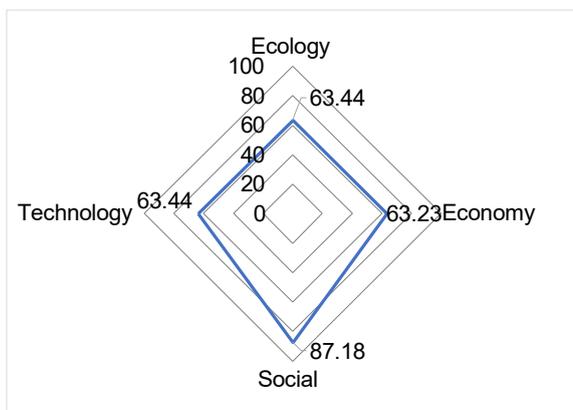


Figure 9. Sustainability Status Flyer Chart

Figure 9 shows a combination of the four dimensions of sustainability examined. Of the four existing dimensions, the social dimension had the highest value, while the economic dimension had the lowest. On average, the sustainability index value of all these dimensions was 69.32. This value suggests that there was still room for improving sustainable land management in landslide-prone areas (50–75). According to this diagram, the sustainability status improved if the index approached 100; on the other hand, if it approached or fell below 0, the sustainability status declined.

Based on the results, this study suggests four strategies as follows. These consist of enhancing farmers’ knowledge and skills in managing and improving steep land areas through targeted training programs and the adoption of appropriate technologies to prevent and reduce land degradation; strengthening farmers’ understanding of agricultural capital and marketing systems through training and collaborative initiatives, such as village cooperatives; establishing and supporting farmer groups to encourage knowledge sharing, collaboration, and collective action; and improving agricultural extension services by promoting best practices, including the selection of suitable crop varieties, effective cultivation techniques, and the application of post-harvest technologies (Table 4).

Table 4. Strategies to improve sustainability of agricultural land management in risky area

No	Strategies	Rank
1	Enhance farmers’ knowledge and skills in managing and improving steep land areas through targeted training programs and the adoption of appropriate technologies to prevent and mitigate land degradation.	3
2	Strengthen farmers’ understanding of agricultural capital and marketing systems through training and collaborative initiatives, such as village cooperatives.	4
3	Establish and support farmer groups to encourage knowledge sharing, collaboration, and collective action.	1
4	Improve agricultural extension services by promoting best practices, including the selection of suitable crop varieties, effective cultivation techniques, and the application of post-harvest technologies.	2

4. Discussion

The results suggest that the status of sustainable management of landslide-prone land in Malang Regency across all dimensions was 69.32. This value indicated that the management of landslide-prone land was moderately sustainable. However, there was an imbalance among the dimensions examined. The social dimension has the highest score (87.18), meaning it was sustainable. In contrast, the sustainability index for other dimensions ranges from 50 to 70% (moderately sustainable). The sustainability index of the ecological and technological dimensions has the same value of 63.44%, while the economic dimension has a value of 63.23%. The results indicated that several ecological attributes significantly influence the ecosystem. Those attributes were identified as the level of pest attacks on agricultural land, the influence of vegetation, and the slope of the land. The high level of public perception regarding the relationship between vegetation, land slope, and landslides shows that the public pays considerable attention to these factors. Apart from the two attributes above, pest attacks on agricultural land also cause concern among people. These results demonstrated that agricultural land is essential in supporting farmers' lives (livelihoods). Some attributes have small values, meaning that farmers still pay little attention to other attributes, for example, the influence of land slope on agricultural production, the influence of land movement on the vulnerability of agricultural land, the influence of landslides on the vulnerability of agricultural land, and the influence of rainfall on landslides. Weak public attention to those attributes may relate to three things. First, these do not directly influence people's lives. Second, these cannot be sensed directly (for example, the influence of ground movements). Third, these occur naturally, including rainfall and other physical factors.

The economic dimension is critical in supporting the community's capabilities in managing the potential of their resources, including land. Among the economic attributes, three have essential roles: the opportunity to obtain other sources of income, the stability of the selling price of agricultural products, and the availability of a place to sell the products that receive special attention from the community. Those attributes may directly influence the economic level of society. Other attributes, such as the source of farming capital, the harvest sales system, and the availability of financial institutions, have garnered less people's attention. There are three possible reasons for the lack of people's attention. First, financial institutions that can support capital are not accessible to the public. Farmers generally use agricultural business credit services at low interest rates. This kind of credit is available and accessible easily. Second, a harvest sales system has been established, so this is no longer a problem for farmers. Third, the community can manage the agricultural system with their capital.

In general, all attributes in the social dimension have high leverage scores. It means that the local community is satisfied with the attribute's performance. Questions related to social aspects were easy for respondents to understand. This relates to their daily lives, which require less external provision of

information.

Attributes in the technological dimension that receive particular attention from the community include understanding water management, agricultural land technology, and identifying landslides. People consider this attribute to have a significant role in supporting their land management efforts. In contrast, some attributes that received low scores include understanding slope repair, slope monitoring, water pumping, and the availability of pest control technology. The technological dimension received a moderate sustainability score. To increase the value of this dimension, people's understanding of those attributes with low scores needs enhancement.

Land management activities include planning, controlling, and evaluating land use and natural resource performance (Izakovičová et al., 2018). Land management aims to adjust the optimal use of land resources, obtain maximum results, and maintain the sustainability of land resources (Anarbayev et al., 2023). Local people must implement appropriate agricultural and non-agricultural land management in landslide-prone areas. On agricultural land, good management practices include crop rotation, cover crops, strip planting, double planting, high-density planting, mulching, reforestation, and agroforestry. The density level requires attention because high density can increase the mechanical load on the slope, thereby increasing the risk of landslides (Suryatmojo & Soedjoko, 2008). In some places, mechanical actions are needed, including minimal tillage, tillage according to contours, making canals and channels according to contours, constructing terraces, and making water channels. Non-agricultural land management consists of improving natural or artificial carrying capacity, cutting water channel slopes, and enhancing water saturation. Land modifications, such as cutting slopes for road construction, housing, agriculture, and stone and sand mining, should be avoided (Hosenuzzaman et al., 2022).

Our findings indicate that key attributes across the three identified dimensions require improvement to enhance land management in the study region. To promote the sustainability of critical land use, this study proposes four strategic recommendations. First, the establishment and support of farmer groups should be prioritized to encourage knowledge sharing, collaboration, and collective action. These groups can expedite the dissemination of skills and best practices among farmers. Second, agricultural extension services must be strengthened by promoting best practices such as selecting suitable crop varieties, effective cultivation techniques, and adopting post-harvest technologies. Improving these services will empower farmers to adopt appropriate technologies and enhance land productivity. Third, farmers' capacity to manage and rehabilitate steep or degraded land should be strengthened through targeted training and the introduction of effective methods. This includes techniques to prevent erosion and landslides, such as terracing, contour farming, strategic vegetation planting, constructing concrete supports, and optimizing irrigation systems. In areas affected by landslides, revegetation with suitable plant species is vital for recovery. Fourth, farmers' understanding of agricultural finance and market access should be enhanced through training

and cooperative models, such as village cooperatives. Many farmers encounter challenges in accessing capital and securing fair returns from their agricultural activities.

Collectively, these four strategies aim to equip communities with the knowledge, tools, and support systems necessary to implement sustainable land management practices, contributing to environmentally sound and economically viable agricultural systems. This implementation aligns with efforts to achieve sustainable development goals (SDGs) through sustainable landscape management. Another study suggests that sustainable landscape management is based on a multifunctional land use system that fosters harmony between production and conservation objectives often faced (Wang et al., 2022). In hilly rural areas, agroforestry systems are considered to reverse land degradation by increasing efficiency through soil quality conservation (Sileshi et al., 2020). An agroforestry system is a landscape unit comprising land uses that combine agricultural and forestry components, including using trees for agriculture (Van Noordwijk, 2021). They represent prominent examples of agroecological land use systems. They represent unique examples of agroecological land use systems. Currently, agroforestry systems attract significant interest from local communities and are recognized as playing an important role in future land management. This system represents a suitable land management model as a form of agricultural transformation toward achieving the SDGs (Waldron et al., 2017), especially regarding climate change mitigation and adaptation (Mosquera-Losada et al., 2018).

Previous research suggests various options to address farmers' vulnerability, including improving rural infrastructure and facilities, designing effective and responsive institutional arrangements, and reducing long-term exposure to disaster risk (Ziadat et al., 2022). Unsustainable land use management is among the primary drivers of land degradation. Resource management that overlooks these factors causes land degradation and vulnerability. Furthermore, extreme climatic conditions will exacerbate land quality decline. Therefore, it is essential to promote more sustainable management efforts, such as selecting suitable land use types, managing drainage systems, conserving sloping land, and implementing sustainable land and water management practices that will increase land sustainability and resilience (Ziadat et al., 2022).

5. Conclusion

This study assessed the sustainability status of landslide-prone land management, yielding an overall score of 69.32, indicating a moderate degree of sustainability. However, the results revealed an imbalance across the evaluated dimensions. The social dimension achieved a high sustainability index of 87.18%, placing it in the "sustainable" category (80–100%). In contrast, the ecological, technological, and economic dimensions all fell within the "moderately sustainable" range (50–70%). Specifically, the ecological and technological dimensions each scored 63.44%, while the economic dimension scored 63.23%. Key ecological factors affecting sustainability included the level of pest

infestations, vegetation cover, and land slope. For the economic dimension, critical attributes were access to alternative income sources, price stability of agricultural products, and the availability of local markets. The technological dimension was shaped by knowledge of water management, the use of agricultural land technologies, and the identification of landslide-prone areas.

6. Acknowledgement

The authors thank the Dean of Graduate School Universitas Brawijaya for supporting the research. The authors also thank the field assistant for helping with the sampling.

7. References

- AbdelRahman, MA., Metwaly, MM., Afifi, AA., D'Antonio, P., & Scopa, A. (2022). Assessment of soil fertility status under soil degradation rate using geomatics in West Nile Delta. *Land*, 11(8), 1256.
- Anarbayev, Y., Pentaev, T., & Rakhimzhanova, G. (2023). Economic Efficiency of Using Internal Land Management Based on Agro-Industrial Enterprises. *Regional Science Policy & Practice*.
- Baczynski, N., & Bar, N. (2017). Landslide monitoring and management challenge in remote Papua New Guinea. In *Workshop on World Landslide Forum* (pp. 343-354). Cham: Springer International Publishing.
- Hadmoko, DS., Lavigne, F., Sartohadi, J., Hadi, P., & Winaryo. (2010). Landslide hazard and risk assessment and their application in risk management and landuse planning in eastern flank of Menoreh Mountains, Yogyakarta Province, Indonesia. *Natural Hazards*, 54, 623-642.
- Holcombe, E., Anderson, M., & Holm-Nielsen, N. (2013). Learning by doing: Community based landslide risk reduction. *Landslide Science and Practice: Volume 7: Social and Economic Impact and Policies*, 297-302.
- Hosenuzzaman, M., Kibria, M. G., Sarkar, R., & Abedin, M. A. (2022). Landslide, agricultural vulnerability, and community initiatives: A case study in Southeast part of Bangladesh. *Impact of climate change, land use and land cover, and socio-economic dynamics on landslides*, 123-145.
- Hossain, A., Krupnik, TJ., Timsina, J., Mahboob, MG., Chaki, AK., Farooq, M., ... & Hasanuzzaman, M. (2020). Agricultural land degradation: processes and problems undermining future food security. In *Environment, climate, plant and vegetation growth* (pp. 17-61). Cham: Springer International Publishing.
- Iswahyudi, I. (2017). Sustainable management of critical land in the Bukit Batabuh Protected Forest. *Jurnal Penelitian Agrosamudra*, 4(1), 91-99. (In Indonesian)

- Izakovičová, Z., Špulerová, J., & Petrovič, F. (2018). Integrated approach to sustainable land use management. *Environments*, 5(3), 37.
- Kubangun, SH., Haridjaja, O., & Gandasmita, K. (2014). Spatial Model of Critical Land Hazard at Bogor, Cianjur and Sukabumi Regencies. *Majalah Ilmiah Globe*, 16(2). (In Indonesian)
- Leksono, A. S., & Zairina, A. (2022). A Review on the Direction of Future Studies on Biocultural Landscapes in Forest and Agroforestry Systems in Indonesia. In *Conserving Biocultural Landscapes in Malaysia and Indonesia for Sustainable Development*, 207-221.
- Liu, J., Jin, X., Xu, W., Gu, Z., Yang, X., Ren, J., ... & Zhou, Y. (2020). A new framework of land use efficiency for the coordination among food, economy and ecology in regional development. *Science of the Total Environment*, 710, 135670.
- Masrurroh, H., Leksono, A. S., & Kurniawan, S. (2023). Developing landslide susceptibility map using Artificial Neural Network (ANN) method for mitigation of land degradation. *Journal of Degraded & Mining Lands Management*, 10(3), 4479-4494.
- McGowran, P., & Donovan, A. (2021). Assemblage theory and disaster risk management. *Progress in Human Geography*, 45(6), 1601-1624.
- Mosquera-Losada, MR., Santiago-Freijanes, JJ., Rois-Díaz, M., Moreno, G., den Herder, M., Aldrey-Vázquez, JA., ... & Rigueiro-Rodríguez, A. (2018). Agroforestry in Europe: A land management policy tool to combat climate change. *Land use policy*, 78, 603-613.
- Rachmansyah, A., Baroto, A., & Rahmawati, IMP. (2021). Landslide Hazard Mapping Using the Analytical Hierarchy Process Method in Arjuno Welirang, East Java. *Rekayasa Sipil*, 15(1), 69-77. (In Indonesian)
- Rosyada, M., Prasetyo, Y., & Haniah, H. (2015). Landslide Hazard Mapping Using the Analytical Hierarchy Process Method in Arjuno Welirang, East Java. *Jurnal Geodesi Undip*, 4(1), 85-94. (In Indonesian)
- Sileshi, GW., Mafongoya, PL., & Nath, AJ. (2020). Agroforestry systems for improving nutrient recycling and soil fertility on degraded lands. *Agroforestry for Degraded Landscapes: Recent Advances and Emerging Challenges*-Vol. 1, 225-253.
- Suryatmojo, H., & Soedjoko, SA. (2008). Vegetation Selection for Landslide Control. *Jurnal Kebencanaan Indonesia*, 1(5), 374-382. (In Indonesian)
- van Noordwijk, M. (2021). Agroforestry-Based ecosystem services: Reconciling values of humans and nature in sustainable development. *Land*, 10(7), 699.
- Waldron, A., Garrity, D., Malhi, Y., Girardin, C., Miller, DC., & Seddon, N. (2017). Agroforestry can enhance food security while meeting other sustainable development goals. *Tropical Conservation Science*, 10, 1940082917720667.
- Waluyo, MRE., Saputra, PY., & Dien, HE. (2020). Klasterisasi Wilayah Tanah Longsor Berdasarkan Dampak Wilayah dan Geografis Menggunakan Metode K-Means (Studi Kasus: Kabupaten dan Kota di Jawa Timur). In *Seminar Informatika Aplikatif Polinema*. (In Indonesian)
- Wang, Q., Wang, H., Zeng, H., Chang, R., & Bai, X. (2022). Understanding relationships between landscape multifunctionality and land-use change across spatiotemporal characteristics: Implications for supporting landscape management decisions. *Journal of Cleaner Production*, 377, 134474.
- Ziadat, FM., Zdruli, P., Christiansen, S., Caon, L., Monem, MA., & Fetsi, T. (2021). An overview of land degradation and sustainable land management in the Near East and North Africa. *Sustainable Agriculture Research*, 11(1), 11-24.