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RESEARCH ARTICLE

Reclamation Strategies for Sustainable Agriculture on Post-Mining Land: A Case Study in East Kalimantan, Indonesia

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ABSTRACT

Mining activities often leave behind degraded land requiring restoration and sustainable utilization. This study aims to (1) analyze the suitability of post-mining land for agriculture, (2) assess the socio-economic conditions of surrounding communities, and (3) evaluate sustainability factors influencing post-mining land use. A land evaluation was conducted using a matching system, while socio-economic data were collected through purposive sampling interviews across four post-mining sites in East Kalimantan, Indonesia. The land suitability analysis identified three viable agricultural uses: rice cultivation (342.94 ha), corn production (209.51 ha), and pasture-raised cattle grazing (377.81 ha), with distribution across sites LP1, LP2, LP3, and LP4. The sustainability of each site was assessed across five dimensions: ecological, economic, social, legal, and infrastructure, using composite sustainability indices. Results showed varying sustainability levels: ecological (59.37, moderately sustainable), economic (80.35, highly sustainable), social (70.43, fairly sustainable), legal (57.42, moderately sustainable), and infrastructure (85.53, highly sustainable). These findings indicate that while economic and infrastructural conditions are favorable for sustainable land use, ecological and legal aspects require targeted improvements. The moderate social sustainability score suggests a need for greater community engagement and benefit-sharing mechanisms. These findings provide actionable insights for improving post-mining land use and promoting sustainable development in East Kalimantan, Indonesia.

Introduction

The coal mining industry in Indonesia, particularly in East Kalimantan, is carried out through open-pit mining systems characterized by land change and degradation, low soil organic matter content, and low pH levels. Mining activities often result in environmental degradation, including soil erosion, loss of biodiversity, and contamination. In East Kalimantan, open-pit coal mining has left large areas of land degraded, posing challenges for local communities dependent on these lands for livelihoods. Addressing these issues through sustainable reclamation strategies is crucial to mitigate long-term impacts on the environment and society. This study explores strategies for utilizing post-mining land sustainably, focusing on agriculture and community development in Kutai Kartanegara Regency [1].

Every closed mine site is unique; therefore, sustainable post-mining land use requires careful evaluation of the potential and limitations of mining sites, such as contamination and other hazards. These include landscape, topography, drainage deterioration, erosion, air quality, low soil pH and organic matter content, vegetation, including forest ecosystems, depletion of wood reserves, noise pollution, and acid-generating materials that affect human health. The remnants of rock and surface overburden, landslide-prone areas,

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degraded land, and disruptive mining equipment further compound this situation [2–7]. Integrating the science of remediation with mining policies and regulations is a reliable option that, when implemented, can balance economic development and environmental degradation for a safer future [8]. The optimal solution is to physically and chemically stabilize mining sites and restore them to sustainable environments capable of supporting and regenerating local biota or wildlife habitats [9]. By harnessing the environmental potential of post-mining areas in terms of natural typologies and anthropogenic factors, these areas can be utilized for socioeconomic transition activities, creating opportunities for stakeholders both presently and in the future. Effective environmental planning and management will minimize the adverse impacts of mining on the environment and contribute to its preservation [10].

The remnants of rock and surface overburden, landslide-prone areas, degraded land, and disruptive mining equipment further compounded this situation [2,4,5,7,8,11]. This has caused water pollution, soil erosion, and other environmental damage, contributing to and exacerbating China's land scarcity issue. Mine closures can occur due to external factors, such as unfavourable commodity prices or low market prices, changes in ownership, and resource depletion. This means that both economic benefits (wages and taxes) and environmental and social sustainability cease to be obtained during the post-mining phase [11–13]. The selection of the most appropriate land use for the reclaimed mining areas is a key in the overall complex process due to the diverse criteria and parameters (geotechnical, environmental, legal, economic, social) considered, as well as the need to achieve acceptance of the reclamation plan by the local community. Therefore, assessing the risks of post-mining land use should consider the type of land use and its potential future uses [14,15]. Despite the often-negative perception of post-mining landscapes, they can hold natural, cultural, and economic potential and unique greenfield sites. Common strategies to address surface mining-related damage involve backfilling mining voids and revegetating the area [16,17].

Post-mining land use can encompass various sectors, such as agriculture and tourism [14,15,18–20], fisheries and aquaculture[14,18], tourism and recreation development [19,20], livestock farming [21], sports facilities [14,16], forestry and revegetation [14,15,22], which are explored to transform the post-mining landscape into productive and sustainable resources that cater to a range of economic, social, and environmental needs. Mine closure transforms an active mine into a series of safe and stable land forms that are non-polluting, provide habitat and ecosystem services, and/or support economic activities by new land users. Mines are closed when resources are depleted or mining is no longer economically viable because of high mining costs or low market prices. This initiative includes the implementation of the concept of corporate social responsibility (CSR), which serves as a crucial pillar of communication between the mining industry and community, highlighting a shared commitment to sustainability and mutual well-being [13,16,23].

A successful mine reclamation process not only restores the land to its original condition but also enhances it and integrates the land into the local economy and natural ecosystem. This creates a more sustainable environment, resilient to climate change and other environmental pressures. It also allows for the appreciation of natural and cultural heritage, provides science lessons, and supports ecological education [24,25]. An important aspect of open-pit coal mining activities in Indonesia is how to conduct environmental restoration or management after mining operations cease and ensure that the sustainability of the mining environment is maintained. This enables various socio-economic activities to derive economic benefits as a continuation of coal mining in the post-mining land. One of the critical challenges in managing post-mining areas in Indonesia is ensuring economic sustainability after mining operations cease. To better understand this challenge, it is useful to examine case studies from other regions with similar experiences. For instance, Poland, a country with a long history of coal mining, has faced significant challenges in transitioning its post-mining cities to sustainable economic models. These cities, located in regions where mining activities have ceased, offer valuable lessons in economic diversification and the creation of new job opportunities. By studying the economic status of post-mining cities in Poland, Indonesia can gain insights into strategies for addressing the socio-economic impacts of mine closures and ensuring sustainable development in post-mining areas [26].

To leverage sustainable post-mining land use, it is essential to integrate and organize all interconnected factors, such as the local potential around mining areas, stakeholder needs, resolution of existing legal issues, and development of best practices for post-mining land utilization that benefit both companies and communities. Mine reclamation is a crucial process to restore land disturbed by mining activities. One of the main objectives of the reclamation process is to determine the optimal land use after mine closure, following technical guidelines for land evaluation for agricultural commodities. These findings are consistent with the economic landscape of Kutai Kartanegara Regency, where the local economy heavily relies on the mining sector, mainly exporting to the global market. The mining sector contributes 62.82% to the economy of Kutai Kartanegara [27]. Implementing mineral and coal mining business activities in Indonesia is regulated by Government Regulation No. 78 of 2010 concerning reclamation and post-mining, as well as the Ministerial Decree of Energy and Mineral Resources No. 1827 of 2018 on Guidelines for Good Mining Environmental Management Practices. In Appendix IV, post-mining land through reclamation can be utilized through revegetation and/or other designations. Other designations may include a) residential areas, b) tourism, c) water sources, and d) cultivation areas. The regulation of the management and control of damages caused by coal mining activities in social, economic, and environmental aspects should be handled properly, following good mining practices [28,29].

Materials and Methods

Study Site

The scope of this research focuses on discussions based on the research objectives. The limitations of this study are that it was conducted on post-mining land owned by *PT Multi Sarana Avindo* (PT MSA) with operational locations in Loa Janan District, Kutai Kartanegara Regency, East Kalimantan Province. Soil samples were taken on post-minimum land (LP) in the concession areas of the PT MSA, specifically at LP 1, LP 2, LP 3, and LP 4, and soil analysis was conducted at the Soil Laboratory of Mulawarman University in Samarinda (Figure 1).

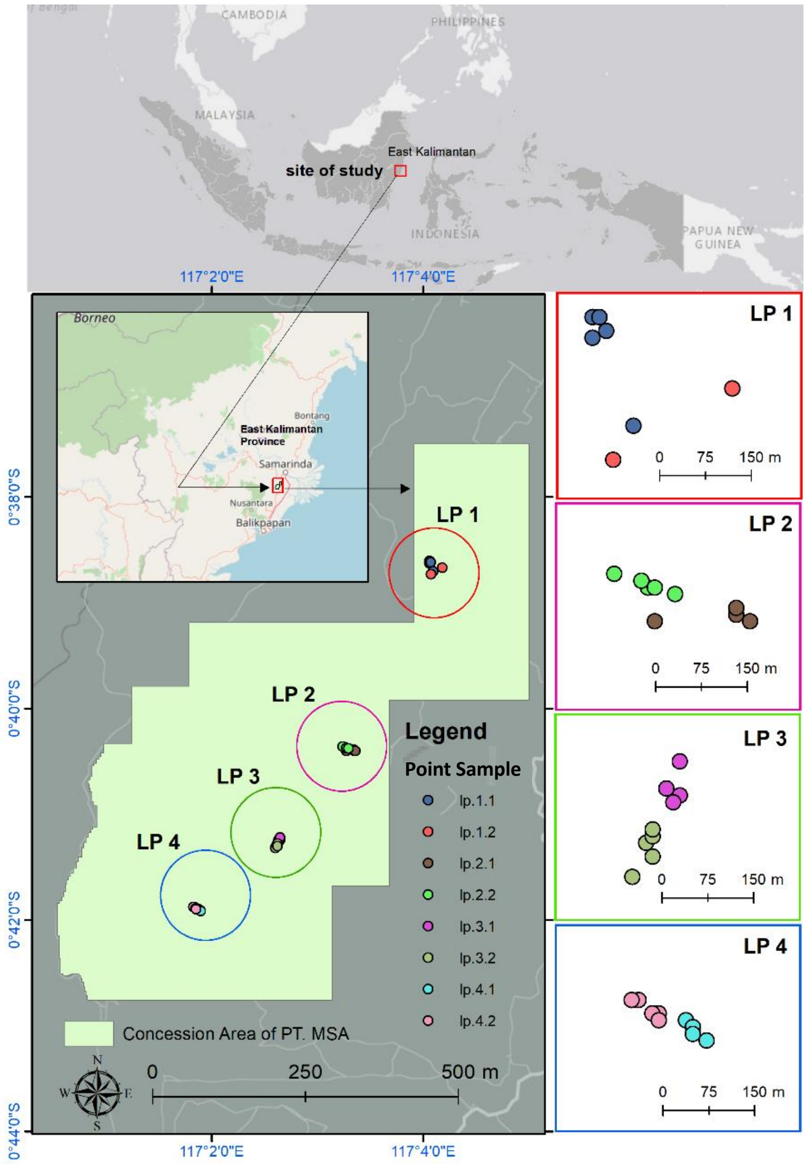

Figure 1. Map of study area.

Data Collection

The types of data collected included soil-type maps, topographic maps, geological maps, physical soil data, soil sampling methods, measurement interviews, questionnaires, environmental observation, documentation, and literature studies. Data analysis techniques involved descriptive land suitability analysis, tabulation, and multidimensional scaling (MDS) analysis using the Rapfish Method.

Data Analysis

Land Suitability Analysis

Land suitability assessment is conducted using a matching system that involves the characteristics of the land with criteria for specific commodities. Land suitability evaluation is used to estimate the level of suitability of the land for certain commodities and other alternative commodities. The criteria for the land suitability assessment were based on the technical guidelines for land evaluation for agricultural commodities issued by the Indonesian Agency for Agricultural Research and Development in 2011. This process helps determine the most suitable land use options and crop based on the specific characteristics of the land. The criteria for land suitability assessment are based on the Technical Guidelines for Land Evaluation for Agricultural Commodities published in 2011 by Djaenudin et al. [30]. The primary data included laboratory analysis results, social questionnaire responses from the community, and the outcomes of discussions with stakeholders and/or experts. The secondary data encompassed various thematic maps, rainfall data, population statistics, policies, regulations obtained from relevant agencies, and literature reviews.

Socio-Economic Analysis

To comprehend the social, economic, and community perceptions in the vicinity of the mining area and their impacts, both during active mining and post-mining phases, a factor analysis was conducted. Factor analysis groups numerous variables into a smaller set of factors that exhibit similar characteristics and tendencies, thereby facilitating easier data processing. In the factor analysis, the Measure of Sampling Adequacy (MSA) was employed.

The socio-economic conditions of the community include education levels below high school, income levels below Rp 3 million, and long-term residency (> 10 years), with the main occupations being farmers or planters. The community hopes that the post-mining land will be utilized for agricultural and plantation purposes. The anticipated forms of social assistance include free medical treatment, clean water assistance, infrastructure development, staple food aid, and training programs. Community expectations regarding post-mining land use: Research results indicate that the majority of respondents (56%) express urgent needs for the implementation of rehabilitation and reclamation programs for post-mining land. In line with this, 44% of respondents expressed hope that the land could be directed towards agricultural crop production or plantation activities.

The survey results indicated that coal mining operations pose various legal challenges. Approximately 43% of respondents indicated that mining activities lead to legal issues related to land compensation, while 37% of respondents highlighted environmental damage as a legal consequence of mining activities. Regarding the frequency of conflicts related to coal mining activities, 43 respondents mentioned conflicts such as land compensation disputes, environmental damage, conflicts over indigenous land, illegal mining, and non-compliance with CSR standards. The community's perception of the presence of mining on environmental conditions is significant, with 40% of the respondents believing that the presence of coal mines causes severe environmental damage. This highlights the importance of addressing the legal and environmental challenges associated with coal mining to ensure sustainable and responsible mining practices.

Results

Post-Mining Land Suitability for Various Commodities

Post-mining land suitability for various commodities was determined based on the highest or lowest constraints. These constraints were used to formulate a land utilization plan. The selection process for land use activities was guided by specific criteria related to land suitability. The second consideration in post-mining land use planning was the selection of commodities that do not require special processing. These commodities were chosen based on their compatibility with the available resources and infrastructure. Post-mining land use plans focus on activities with direct economic value, including agriculture, cultivation of crops, and livestock farming. Specific examples include: crops such as corn and vegetables. Livestock such as cattle. Table 1 presents the land allocation for these activities across different post-mining sites (LP1, LP2, LP3, and LP4). The post-mining land use plan includes the utilization of land for rice and pasture-raised cattle, with respective areas (ha) on each post-mining site as follows: rice covering an area of 342.94 ha. Pasture-raised cattle over an area of 377.81 ha. Detailed information is presented in Table 1.

Table 1. Land use plan in the study area.

Commodities	Post-mining land				Total area (ha)
	LP 1	LP 2	LP3	LP 4	
Rice covering area	148.83	71.64	43.31	79.16	342.94
Pasture-raised cattle over an area	81.88	55.80	133.74	106.39	377.81
Corn spanning	21.48	122.12	-	65.91	209.51
Total (ha)	252.19	249.56	177.05	251.46	930.26
The area that has not been mined (ha).	695.88	524.14	887.85	997.43	3,105.29
Study area (Mining Permit) (ha)	948.07	773.69	1,064.90	1,248.89	4,035.55

Analysis of Socio-economic Conditions of the Community Around the Mining Area

Furthermore, 80% of the local community reported an increase in income due to the presence of the coal mine. Legal issues arising from coal mining activities were identified through the survey. Approximately 43% of respondents expressed concerns that mining activities lead to legal issues related to land compensation.

Legal issues arising from coal mining activities were identified through the survey: Approximately 43% of respondents expressed concerns about land compensation. About 37% of respondents identified environmental degradation as a legal concern. Around 10% of respondents pointed out land conflicts. A small portion (1%) of respondents mentioned illegal mining as a legal concern. Other legal impacts: A notable 9% of respondents highlighted other legal impacts arising from mining activities. The community's expectations regarding post-mining land are as follows: 56% of respondents expressed a preference for rehabilitation and reclamation programs. 44% of respondents hoped for agricultural production, particularly crops and plantations, as a foundation for utilizing post-mining land.

The results of the factor analysis used to categorize respondents' perceptions of various impacts are as follows: environmental impact: The Kaiser-Meyer-Olkin (KMO) = 0.642, economic impact: KMO = 0.698, social impact: KMO = 0.660, legal impact: KMO = 0.580, infrastructure impact: KMO = 0.575. The multidimensional assessment yielded a sustainability index value of 69.25 on a sustainable scale of 0-100. The obtained Palapa value was based on the evaluation of 53 attributes encompassing five dimensions: ecology, economy, society, law, and infrastructure. These results categorized the post-mining land use as moderately sustainable. The sustainability index values for each dimension are as follows: ecology: 59.37% (reasonably sustainable), economy: 80.35% (highly sustainable), social: 70.43% (reasonably sustainable), legal: 57.42% (reasonably sustainable), infrastructure: 85.53% (highly sustainable). Despite these variations, all dimensions fall within the category of "good" sustainability status.

The sustainability dimension of ecology is related to the physical, chemical, and biological aspects of the post-mining environment, with an obtained index of 59.37%, categorized as reasonably sustainable. The analysis of sustainability leverage attributes revealed four prominent attributes: land arrangement (Root Mean Square/RMS = 2.86), vegetation growth (RMS = 2.45), erosion (RMS = 1.91), land capability (RMS = 1.74). The sustainability dimension of the economy includes 10 attributes with a sustainability index of 80.35%, indicating high sustainability. The analysis of leverage attributes reveals two significant factors: regional revenue contribution (RMS = 7.27), economic activities (RMS = 6.60).

The social sustainability dimension encompasses 10 attributes with a sustainability index of 70.43%, categorizing it as reasonably sustainable. Analysis of leverage attributes reveals three key drivers for the sustainability of post-mining land utilization in the social dimension: community awareness for environmental improvement (RMS = 6.23), the role of non-governmental organizations (RMS = 4.68), potential conflicts (RMS = 4.32). While, the legal sustainability dimension encompasses 10 attributes, yielding an index value of 57.42%, categorized as reasonably sustainable. Analysis of leverage attributes reveals three key factors with relatively higher RMS values: land compensation (RMS = 4.90), cross-sectoral cooperation (RMS = 4.17), law enforcement (RMS = 3.26). The sustainability dimension of infrastructure and technology encompasses 12 attributes, yielding an index of 85.53%, categorizing it as highly sustainable. Analysis of leverage attributes reveals three key contributors to the sustainability of infrastructure and technology aspects: water pollution control techniques (RMS = 4.70), technical knowledge of chemical and physical properties (RMS = 3.92), land treatment system technology (RMS = 2.82).

Discussion

The level of land suitability with the highest or lowest constraints was critical in formulating an effective and efficient post-mining land utilization plan. These criteria ensured that decisions were based on solid scientific data and practical considerations regarding land suitability. By placing the principle of land suitability at the center of post-mining land development, management efforts were directed toward achieving the most beneficial economic and ecological outcomes. The selection of commodities that do not require special processing was a key consideration in post-mining land use planning. This approach was based on the understanding that economic activities requiring additional processing infrastructure, such as palm oil mills or rubber processing plants, often involve significant initial investments and high operational costs. Furthermore, such activities can have a greater environmental impact, including increased water resource consumption. By focusing on commodities that do not require special processing, this strategy minimizes both financial and ecological burdens, making it more sustainable and feasible for local communities.

The focus on activities with direct economic value, such as agriculture and livestock farming, reflects a strategic decision to avoid the need for complex processing infrastructure. For instance, crops like corn or vegetables, and livestock such as cattle, can be marketed directly without requiring significant processing. This approach not only reduces the need for investment in processing infrastructure but also minimizes the ecological burden of post-mining activities. By prioritizing commodities that do not require special processing, this strategy ensures both economic efficiency and environmental sustainability. The selection of activities that do not require special processing has positive implications for the social and economic sustainability of the surrounding communities. These activities are often more readily adopted by the local population because they do not require technical skills or large investments, thus providing immediate economic benefits. Additionally, the benefits of these activities are more directly felt by the community, supporting the development of inclusive and sustainable local economies.

The land use plan focusing on activities that do not require special processing represents a strategic approach to balancing economic value, ease of implementation, and environmental sustainability. This approach is grounded in scientific principles that prioritize efficiency, adaptation to local conditions, and sustainable economic development. By considering these factors, the strategy creates a solid foundation for the long-term success of post-mining land use plans, ensuring both ecological and economic benefits for the surrounding communities. The third consideration in post-mining land use planning is the preference of the community. This approach emphasizes the importance of integrating the needs, hopes, and local knowledge into the planning process to ensure that development is not only technically feasible but also socially acceptable and supports the improvement of the quality of life of the surrounding communities. By incorporating community preferences, such as empowerment programs, skills development, and capacity building, the planning process strengthens local ownership, minimizes land-use conflicts, and reflects a commitment to inclusive and participatory development principles. Therefore, community preferences serve as a crucial basis for determining the long-term success of post-mining land use, actively supporting social development and the well-being of the communities in Kutai Kartanegara Regency.

Activities in land utilization designed with considerations for community preferences, such as empowerment programs, skills development, and capacity building, tend to receive broader support. This approach strengthens local ownership of the development process, minimizes land-use conflicts, and reflects a commitment to inclusive and participatory development principles. Therefore, community preferences serve as a crucial basis in determining the long-term success of post-mining land use, actively supporting social development and the well-being of the communities in Kutai Kartanegara Regency. These findings are consistent with the economic landscape of Kutai Kartanegara Regency, where the local economy heavily relies on the mining sector, particularly through exports to the global market. The mining sector contributes 62.82% to the economy of Kutai Kartanegara [27]. Underscoring its critical role in shaping the region's socio-economic conditions. This highlights the interdependence between the mining industry and the economic welfare of the local community.

The findings highlight the interdependency between the mining industry and the economic welfare of the local community. This is evidenced by the reported income improvement and the various social and economic initiatives undertaken by the coal company to address the needs of the local population. Additionally, the survey results indicate that land compensation is a significant legal issue, with approximately 43% of respondents expressing concerns about fair compensation for land affected by mining operations. This underscores the need for effective policies and corporate initiatives to ensure equitable outcomes for affected communities. The findings suggest that land compensation is a significant legal issue, likely referring to disputes or conflicts regarding fair compensation for land taken over by mining operations. Environmental degradation, identified by 37% of respondents, could encompass issues such as pollution, ecosystem disruption, and other negative impacts on the environment, potentially leading to legal action. Land conflicts, mentioned by 10% of respondents, may arise due to disputes over land rights, use, or ownership between various stakeholders, including local communities, mining companies, and government authorities. Although illegal mining was mentioned by only 1% of respondents, it remains a notable legal concern in the context of mining activities.

Illegal mining often leads to violations of regulations, resulting in legal penalties or actions against those involved in such activities. Additionally, the survey results indicate that 9% of respondents identified other legal impacts arising from mining activities. These impacts could encompass a range of legal issues, such as labor disputes, safety concerns, or regulatory violations. These findings highlight the need for stricter enforcement of regulations and better oversight of mining operations to mitigate potential legal challenges. These findings highlight the community's strong desire to restore the environment and ensure sustainable land use after mining operations cease. The preference for rehabilitation and reclamation programs (56%) underscores the importance of addressing environmental degradation caused by mining activities. Similarly, the emphasis on agricultural production (44%) reflects the community's aspiration to utilize post-mining land for productive and sustainable purposes. These aspirations align with broader goals of ecological restoration and economic sustainability in post-mining areas.

The KMO value is a measure used to assess the adequacy of the data for factor analysis. Higher KMO values generally indicate better suitability of the data for factor analysis. In this study, the obtained KMO values for the five dimensions (environmental, economic, social, legal, and infrastructure impacts) ranged from 0.575 to 0.698, indicating that the data fall within the moderate range. While these values are not exceptionally high, they suggest that the data is suitable for factor analysis. This finding supports the reliability of the factor analysis conducted in this study. Factor analysis was conducted to group respondents' answers into underlying factors representing their perceptions of environmental, economic, social, legal, and infrastructure impacts related to mining activities. This approach helped identify common patterns in respondents' opinions and simplified the interpretation of the data. The sustainability index value of 69.25 (Figure 2), categorized as moderately sustainable, indicates that while post-mining land management in Kutai Kartanegara has been attentive to ecological, economic, social, legal, and infrastructural aspects, there is still room for improvement. The evaluation of 53 attributes across five dimensions highlights the complexity of achieving balanced sustainability in post-mining land use.

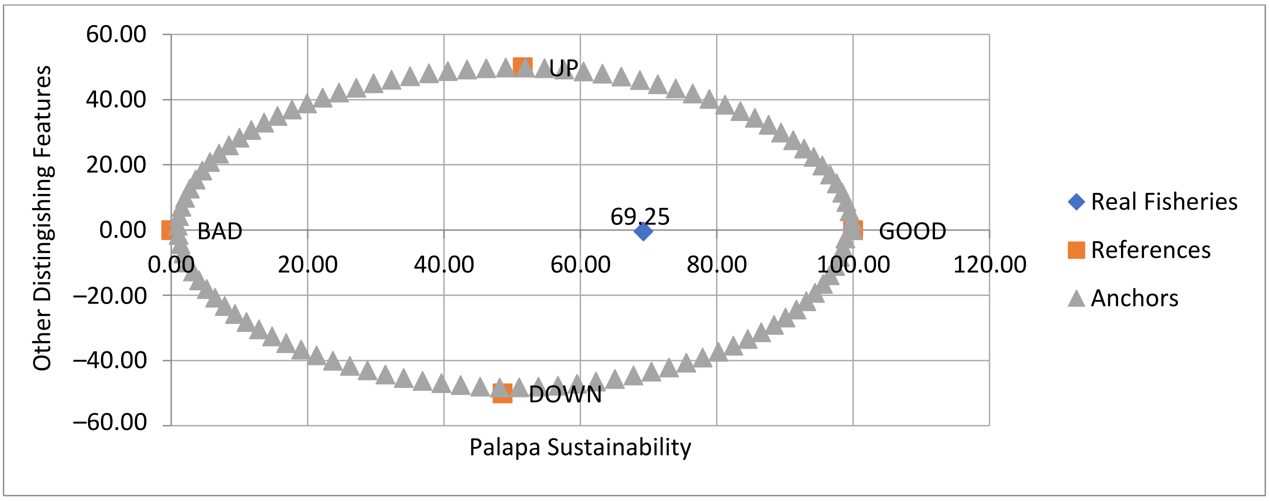

Figure 2. Multidimensional assessment yielded a sustainability index value.

The analysis results indicate that post-coal mining land management in Kutai Kartanegara has been attentive to ecological, economic, social, legal, and infrastructural aspects. For instance, the infrastructure dimension scored the highest (85.53%), reflecting a strong focus on technological and infrastructural development. In contrast, the legal dimension scored the lowest (57.42%), suggesting room for improvement in addressing legal challenges, such as land compensation and regulatory compliance. Despite these variations, the overall "good" sustainability status across all dimensions underscores the success of sustainable post-mining land utilization efforts in the region. This balanced approach highlights the importance of integrating diverse aspects of sustainability to ensure long-term benefits for both the environment and local communities. In Figure 3, the kite diagram illustrates the Palapa sustainability values as a trade-off between the highest and lowest dimensions, indicating that the five researched dimensions fall into the moderately sustainable category. The relatively high RMS values of the four prominent attributes—land arrangement, vegetation growth, erosion, and land capability—highlight their significance in influencing ecological sustainability. These attributes emphasize the importance of post-mining land arrangement programs, as these lands have undergone excavation and opening. Without conservation and rehabilitation programs, such lands can have adverse effects on the environment, including the communities living nearby. This underscores the need for strategic planning and implementation of sustainable practices to mitigate environmental impacts and ensure long-term ecological resilience.

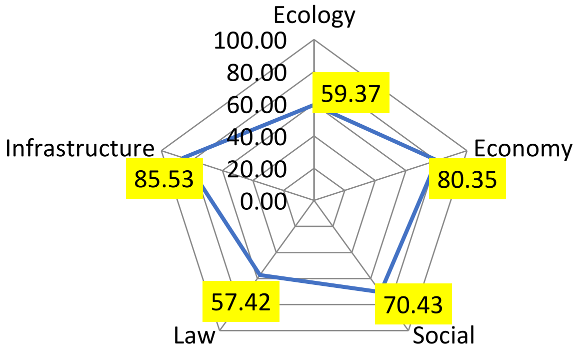

Figure 3. Kite diagram of the sustainability index.

The sustainability index of 80.35% for the economic dimension highlights the strong potential for sustainable economic utilization of post-mining land. The prominence of two leverage attributes (regional revenue contribution (RMS = 7.27) and economic activities (RMS = 6.60)) underscores their critical role in ensuring economic sustainability. These attributes suggest that efforts to enhance regional revenue and promote diverse economic activities are essential for managing post-mining land effectively. Furthermore, the income of the post-mining community is a crucial factor, as it tends to decrease after the cessation of mining operations. This highlights the need for strategic planning to sustain livelihoods and support economic resilience in post-mining areas.

The sustainability index of 70.43% for the social dimension highlights the importance of addressing social factors in post-mining land management. The prominence of three leverage attributes—community awareness for environmental improvement (RMS = 6.23), the role of non-governmental organizations (RMS = 4.68), and potential conflicts (RMS = 4.32)—underscores their critical role in ensuring social sustainability. These attributes indicate that fostering community awareness about environmental issues is essential, as it reflects a broader social consciousness toward environmental stewardship. Additionally, the involvement of non-governmental organizations can enhance community engagement and support conflict resolution, which is crucial for minimizing disputes over land use and resource allocation. This highlights the need for strategies that integrate social awareness and institutional collaboration to achieve sustainable post-mining land use.

The legal sustainability index of 57.42% highlights the importance of addressing legal challenges in post-mining land management. The prominence of three leverage attributes—land compensation (RMS = 4.90), cross-sectoral cooperation (RMS = 4.17), and law enforcement (RMS = 3.26)—underscores their critical role in ensuring legal sustainability. These attributes indicate that resolving disputes over land compensation, fostering collaboration between sectors, and enforcing regulations are essential for minimizing legal conflicts and promoting fair practices. This highlights the need for robust legal frameworks and effective enforcement mechanisms to support sustainable post-mining land use.

The high sustainability index of 85.53% for the infrastructure and technology dimension highlights the critical role of advanced infrastructure and technological innovations in post-mining land management. The prominence of three leverage attributes—water pollution control techniques (RMS = 4.70), technical knowledge of chemical and physical properties (RMS = 3.92), and land treatment system technology (RMS = 2.82)—underscores their significance in ensuring sustainable outcomes. These attributes indicate that effective pollution control, technical expertise, and innovative land treatment systems are essential for minimizing environmental impacts and enhancing the usability of post-mining land. This emphasizes the need for investment in technology and infrastructure to support long-term ecological and economic resilience in post-mining areas.

Conclusion

The post-mining land use plan consists of 1) Rice covering an area of 342.94 ha in LP1, LP2, LP3, LP4; 2) Pasture-raised cattle over an area of 377.81 ha in LP1, LP2, LP3, and LP4; and 3) Corn spanning 209.51 ha in LP1, LP2, and LP4. These are strategies for sustainable post-mining land use in Kutai Kartanegara Regency. Despite legal issues regarding land compensation and impacts on public infrastructure, mining activities have increased income. Community environmental awareness is crucial post-mining. The sustainability status and supporting factors analysis for post-mining land utilization shows a relatively good ecological, economic, social, legal, infrastructure, and technological sustainability level. Given that the post-mining lands under study can be utilized for various economic activities, planning in more detail before the company undertakes utilization, focusing on flagship commodities or those with the highest potential for enhancing community economics, is crucial. The process should proceed by considering driving factors within each dimension.

Author Contributions

A: responsible for research methodology, including land suitability analysis and discussion of the results of the analysis; **SRPS**: responsible for discussions and conclusions regarding strategies and plans for post-mining land use to support sustainable agriculture; **HH**: carry out sustainability analysis using MDS (Multidimensional Scaling) software and prepare discussions related to the results of the analysis; **EIKP**: focuses on discussing and writing economic analysis, using the benefit-cost analysis method to evaluate the economic benefits of land use.

Conflicts of Interest

There are no conflicts to declare.

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