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Revitalization of Marginal Land Utilization from Former Coal Mining in Nagari Muaro Sopan, Padang Laweh District, Dharmasraya Regency

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Abstract:

Open-pit coal mining in Nagari Muaro Sopan, Padang Laweh District, Dharmasraya Regency, has generated extensive marginal land characterized by severe environmental degradation, vegetation loss, and soil contamination. This study investigates comprehensive revitalization strategies for post-mining landscapes through systematic literature review and field observation. Secondary data were collected from peer-reviewed scientific journals, government reports, and reclamation case studies, complemented by primary field observations at mining sites in Nagari Muaro Sopan. Thematic analysis identified seven critical strategies for effective post-mining land revitalization: (1) comprehensive land condition assessment, (2) soil quality restoration through organic amendment and pH adjustment, (3) drainage infrastructure development and water management systems, (4) appropriate native vegetation establishment, (5) ecosystem and biodiversity recovery, (6) local community empowerment through capacity building, and (7) sustainable economic development initiatives. Results demonstrate that integrated implementation of these strategies can substantially mitigate environmental degradation, enhance disaster resilience, and generate sustainable economic benefits for surrounding communities. The study emphasizes that successful revitalization fundamentally requires multi-stakeholder collaboration involving government agencies, mining corporations, and local communities. This framework provides practical guidance for transforming degraded post-mining landscapes into productive, ecologically stable, and economically viable systems in Indonesian contexts.

Keywords: Marginal Land, Reclamation, Revitalization, Coal Mining, Community Empowerment

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Introduction

Indonesia is one of the countries with abundant natural resources. One of these natural resources is coal mining, which belongs to the category of non-renewable resources. Padang Laweh District is located at geographical position 101°43'04"–

101°49'55"E. To the north, Padang Laweh District borders Kuantan Singingi Regency, Riau Province; to the west, it borders Timpeh, Sitiung, Tiumang, and Koto Baru Districts; to the south, it borders Koto Salak District; and to the east, it borders Kuantan Singingi Regency, Riau Province. The condition and topography of Padang Laweh District generally consist of flat land with an altitude of 105 meters above sea level. Padang Laweh District is divided into four nagari (villages): Nagari Batu Rijal with an area of 9.75 km², Nagari Muaro Sopan with an area of 5.44 km², Nagari Padang Laweh with an area of 8.49 km², and Nagari Sopan Jaya with an area of 95.47 km² (Badan Pusat Statistik Kabupaten Dharmasraya, 2025). Padang Laweh District, the mapped area, particularly in Nagari Muaro Sopan, represents former coal mining land of PT Putramas Bumi Agung, which serves as an example of marginal land with high soil degradation levels, altered land structure, and the formation of pit lake depressions. The map shows that this area is dominated by soil types with acidic pH (4.2–5.1), low nutrient content, and high erosion potential.

According to the Ministry of Public Works Regulation No. 18 of 2010 concerning Guidelines for Area Revitalization, revitalization is defined as an effort to increase land or area value through redevelopment that can enhance the previous functions of the area (Ministry of Public Works, 2010, Art. 1, Para. 1). The regulation further defines an area as a region that has a primary conservation or cultivation function (Ministry of Public Works, 2010, Art. 1, Para. 4). Revitalization represents an effort to revitalize an area or part of a city that was once vital but subsequently experienced decline or degradation. This concept extends beyond physical aesthetics improvement and must be complemented by enhancing community economic conditions and promoting local cultural identity. Revitalization is an effort to revitalize an area or part of a city that was once vital/alive but subsequently experienced decline/degradation. Revitalization itself is not merely oriented toward completing physical aesthetics but must also be complemented by improving community economics and introducing existing culture. Marginal land is land with low quality due to several factors such as sloping land topography, parent material dominance, low nutrient and organic matter content, low moisture content, pH that is too low or too high, and accumulation of metal elements that are toxic to plants. The utilization of marginal land has the potential to support national food security if managed with appropriate socio-economic approaches (Tang et al., 2025). Marginal land has low value and is sometimes referred to as "degraded," "unproductive," or "surplus" land. This land is characterized by its inability to produce any crops or generate profit. More specifically, crops produced on marginal land will have lower value than its rental costs. Marginal land is often negatively affected by human activities such as industrial pollution and may also experience water supply shortages or severe slopes.

One common type of marginal land is post-mining land that was previously used for coal mining activities, resulting in significant changes to geological structure, topography, and soil quality. In open-pit mining areas, topsoil is removed, vegetation is lost, and wide depressions are formed, creating marginal land. Nagari Muaro Sopan in Padang Laweh District, Dharmasraya Regency, is one of the areas experiencing degradation due to coal mining activities that have ceased operations in recent years. Post-mining land at this location exhibits characteristics such as unstable ground surface, low nutrient content, acidic pH, and the formation of pit lakes due to deep excavations filled with rainwater. These conditions render the area unproductive if not

rehabilitated. However, recent research indicates that marginal land can be reused through recultivation, revegetation, and innovative utilization approaches based on the local economy. Globally, mine land reclamation emphasizes the restoration of soil ecosystem services as the foundation for sustainability (Lee et al., 2024a).

One negative impact of mining activities is leaving idle and open lands called tailing spreads and overburden, which have minimal benefits and, if left unchecked, have the potential to become critical and difficult-to-develop lands. Law Number 3 of 2020 concerning Mineral and Coal Mining (Minerba) and Law Number 11 of 2020 concerning Job Creation mandate that post-mining land must undergo reclamation, namely activities carried out throughout the mining business stages to organize, restore, and improve the quality of the ecosystem environment so it can function again according to its designation. Although the Minerba Law has mandated that holders of Mining Business Permits (IUP) are obliged to carry out reclamation and post-mining activities, the reality in the field shows ongoing coal mining exploitation activities. The reuse of mining waste and mineral processing faces complex technical and environmental challenges (Hu et al., 2025).

Despite extensive international research on mine land reclamation and restoration, limited empirical studies have examined the specific challenges and effective strategies for revitalizing marginal land in tropical coal mining regions of Indonesia. While global literature provides general frameworks for post-mining ecological restoration (Lee et al., 2024b) (Tang et al., 2025), contextual factors such as tropical rainfall patterns, acidic lateritic soil conditions, socioeconomic characteristics of rural communities in West Sumatra, and institutional governance structures require tailored approaches. Furthermore, existing studies predominantly focus on isolated technical aspects of reclamation, with insufficient attention to integrated strategies that simultaneously address environmental restoration, disaster risk reduction, and community-based sustainable development. The case of Nagari Muaro Sopan presents a critical opportunity to develop comprehensive revitalization frameworks applicable to similar post-mining landscapes across Indonesia's coal-producing regions.

This study addresses the critical need for contextualized post-mining land revitalization strategies in Indonesian tropical settings. The specific objectives are threefold: first, to assess the environmental degradation characteristics and challenges of marginal land resulting from coal mining activities in Nagari Muaro Sopan; second, to identify and synthesize comprehensive revitalization strategies appropriate for tropical post-mining landscapes through systematic literature review and field observation; and third, to develop an integrated framework for sustainable post-mining land management that balances ecological restoration with disaster risk reduction and socioeconomic development. By achieving these objectives, this research aims to provide evidence-based guidance for policymakers, mining corporations, and local communities engaged in post-mining landscape transformation.

Methods

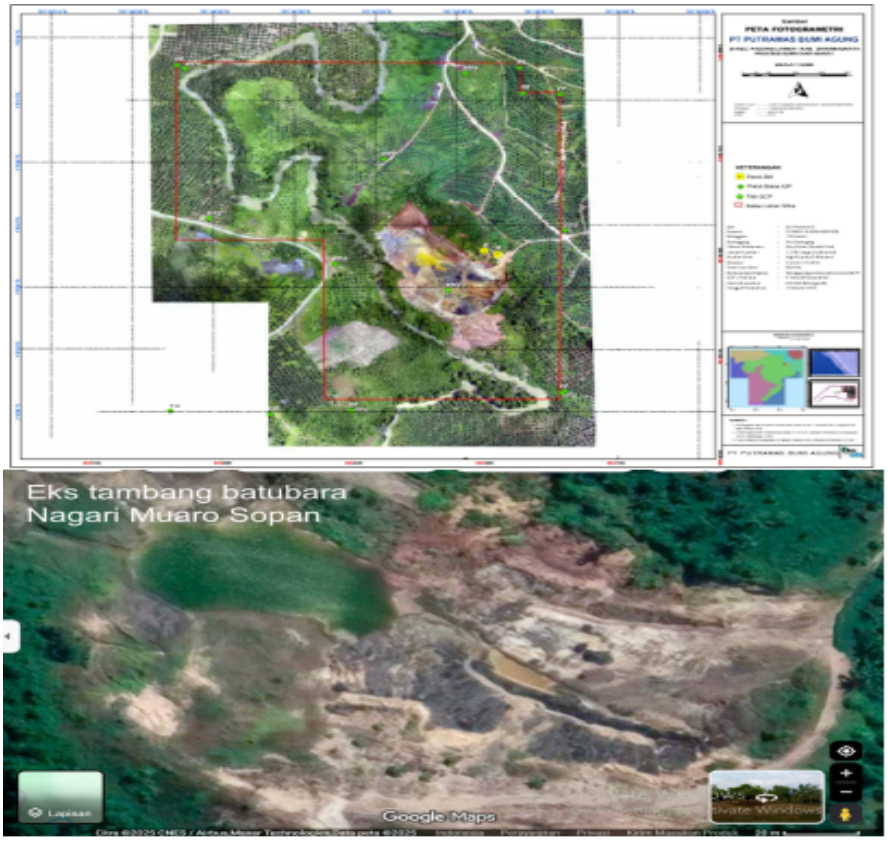
Research Design

This study employs a qualitative research design integrating systematic literature review with field-based case study analysis. The literature review component synthesizes global best practices and theoretical frameworks for post-mining land revitalization, while the case study component examines the specific contextual conditions and

challenges in Nagari Muaro Sopan, Padang Laweh District, Dharmasraya Regency. This methodological approach enables the development of contextualized revitalization strategies grounded in both international scientific evidence and local empirical realities.

Research Location

The research site was purposively selected in Nagari Muaro Sopan, Padang Laweh District, Dharmasraya Regency, West Sumatra Province, Indonesia. This location exhibits characteristic features of post-mining marginal land, including extensive pit lakes, excavation cliffs, overburden soil deposits, and degraded vegetation cover resulting from former coal mining operations by PT Putramas Bumi Agung. Nagari Muaro Sopan encompasses four hamlets (jorong): Jorong Batang Takau, Jorong Muaro Sopan, Jorong Rimbo Aia Dingin, and Jorong Sungai Sakai. The site's geographical coordinates, topographical conditions, and mining legacy make it representative of similar post-mining landscapes across Indonesia's coal-producing regions.



Source: Field Analysis, 2025

Image 1. Marginal Land Map of Padang Laweh District

Research Method

This study employs a qualitative analytical method, where relevant and important data are selected and analyzed from various published journals. Data collection is conducted through literature review encompassing various sources such as scientific journals, books, and recent data adjusted to relevant location conditions. Qualitative approaches are used to understand social dynamics in post-mining landscapes (Simpson et al., 2025).

Data Collection Techniques

Data collection employed a multi-method approach comprising three primary components:

1. Systematic Literature Review

A comprehensive review of peer-reviewed scientific literature was conducted through systematic searches in academic databases including Scopus, Web of Science, and Google Scholar. The search strategy employed the following keywords and Boolean operators: ("post-mining restoration" OR "mine reclamation" OR "marginal land revitalization") AND ("coal mining" OR "open-pit mining") AND ("soil restoration" OR "ecosystem recovery" OR "community empowerment"). The review focused on publications from 2020-2025 to ensure currency of findings, with particular attention to studies addressing tropical and subtropical mining contexts. A total of 45 relevant journal articles, government reports, and technical documents were analyzed, focusing on reclamation strategies, soil restoration techniques, vegetation establishment methods, water management systems, and community-based approaches to post-mining land use.

2. Field Observations

Direct field observations were conducted in January 2025 to document the physical, ecological, and socioeconomic conditions of post-mining areas in Nagari Muaro Sopan. Observational protocols included photographic documentation of land topography, soil conditions, water management infrastructure, existing vegetation cover, pit lake formations, and current land use patterns. Field observations also documented community activities related to post-mining land utilization and informal reclamation efforts. These empirical observations provided contextual validation for literature-derived strategies and enabled identification of site-specific challenges and opportunities.

3. Secondary Data Collection

Official statistical data and government reports were obtained from relevant institutions including: (a) Badan Pusat Statistik (Central Statistics Agency) Kabupaten Dharmasraya for demographic and land use data; (b) Dharmasraya Regency Agriculture Office for agricultural production and land capability information; (c) Dharmasraya Regency Environmental Office for environmental impact assessments and mining compliance records; and (d) archived documentation regarding PT Putramas Bumi Agung's mining operations and cessation.

Data Analysis

Data analysis employed thematic analysis methodology to synthesize findings from multiple data sources. The analytical process comprised five iterative stages:

1. Stage 1: Data familiarization – Systematic review of all collected literature, field notes, and photographic documentation to gain comprehensive understanding of post-mining revitalization concepts and local conditions.
2. Stage 2: Initial coding - Identification of recurring themes, concepts, and strategies across literature sources and field observations, with particular attention to technical interventions, community engagement approaches, and policy frameworks.
3. Stage 3: Theme development – Clustering of initial codes into coherent thematic categories representing distinct components of post-mining revitalization strategies.

Seven major themes emerged through this analytical process: land assessment, soil restoration, water management, vegetation establishment, ecosystem recovery, community empowerment, and economic development.

4. Stage 4: Theme refinement – Critical evaluation and refinement of thematic categories through constant comparison between literature findings and field observations, ensuring alignment with local contextual realities.
5. Stage 5: Framework synthesis – Integration of refined themes into a comprehensive revitalization framework applicable to tropical post-mining landscapes in Indonesian contexts.

Data triangulation was employed to enhance analytical rigor by cross-validating findings from literature sources, field observations, and secondary data. This triangulation process strengthened the validity and credibility of the synthesized revitalization strategies.

Results And Discussion

Nagari Muaro Sopan is a nagari located in Padang Laweh District, Dharmasraya Regency, West Sumatra Province, Indonesia. The boundaries of Nagari Muaro Sopan are as follows: to the north, it borders Nagari Padang Laweh; to the east, it borders Tebo Regency, Jambi Province; to the south, it borders Nagari Sopan Jaya; to the west, it borders Tiumang District. Nagari Muaro Sopan consists of 4 jorong (hamlets): Jorong Batang Takau, Jorong Muaro Sopan, Jorong Rimbo Aia Dingin, and Jorong Sungai Sakai (BPS Kabupaten Dharmasraya, 2025). To improve environmental conditions in former mining areas, revitalization and reclamation measures are necessary. The Ministry of Public Works Regulation Number 18 of 2010 concerning Guidelines for Area Revitalization defines revitalization as an effort to increase land or area value through the redevelopment process so that the area's functions can be improved or enhanced compared to before (Ministry of Public Works, 2010, Art. 1, Para. 1). In its implementation, the revitalization approach must be able to identify and utilize environmental potential, such as historical aspects, meaning, location uniqueness, and distinctive characteristics of a place, to create better and sustainable functions. In its implementation, the revitalization approach must be able to identify and utilize environmental potential, such as historical aspects, meaning, location uniqueness, and distinctive characteristics of a place, to create better and sustainable functions.

Source: Field Analysis, 2025

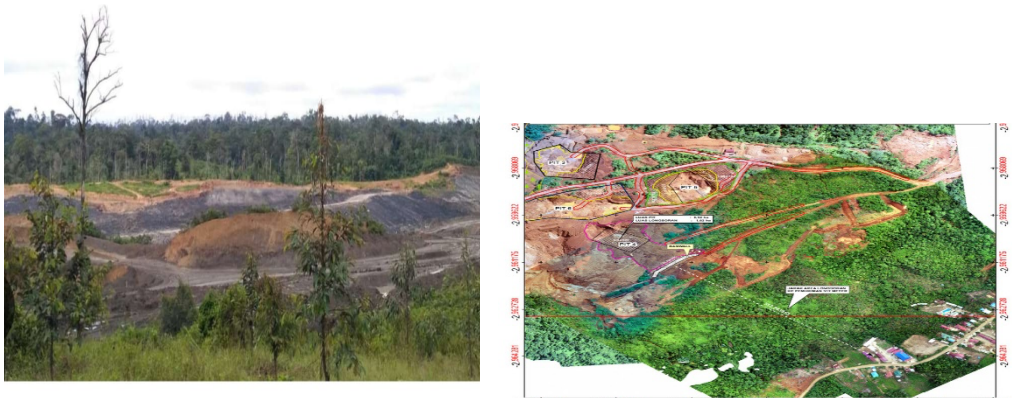
Image 2. Topography of Former Coal Mining Marginal Land Location

Former coal mining land is generally abandoned in critical condition, with damaged ecosystems and soil that has lost its fertility. This condition increases the risk

of natural disasters such as soil erosion, floods, and landslides. Additionally, water and soil contamination from mining waste exacerbates environmental damage. If not revitalized, these areas can become sources of environmental disasters affecting surrounding communities. In this context, revitalization aims to restore the ecological functions of damaged land, thereby reducing disaster risks that may impact surrounding communities. Mining activities significantly affect surface water quality in various regions in Indonesia (Faz et al., 2025). The revitalization process not only focuses on restoring soil and environmental quality but also considers social and economic factors that can improve community living conditions. One strategy used in revitalization is transforming former coal mining land into agricultural or forestry land that can function as an ecosystem buffer, reduce erosion, and increase water absorption. Revitalization of former mining land as a disaster rehabilitation measure requires several structured steps to ensure its success and sustainability. The following are revitalization steps that can be applied:

1. Land Condition Identification and Assessment

The first step is to identify and assess the condition of former coal mining land, including analysis of soil structure, organic matter content, pollution levels, and local ecosystem conditions. This assessment is crucial for determining suitable vegetation types and interventions needed to restore soil and environmental quality. A comprehensive assessment framework for mine reclamation success based on soil quality indices, vegetation, and ecological conditions can be adapted to assess the effectiveness of coal mine reclamation (Tang et al., 2025). Criteria and indicator frameworks are needed to assess the sustainability of legacy mining lands (Pan et al., 2025). At this stage, evaluations are also conducted regarding the extent of ecosystem damage and potential post-coal mining disasters that may occur due to such damage, such as erosion and flooding.



Source: Observation Results, 2025

Image 3. Coal Mining Location in Nagari Muaro Sopan

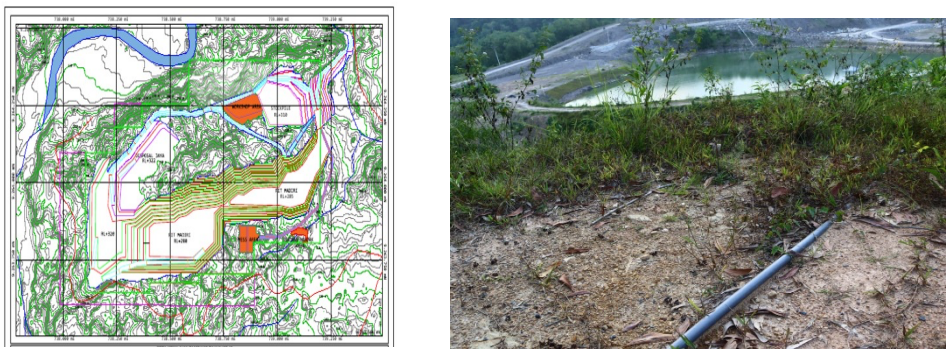
2. Soil Quality Restoration

Soil quality is the soil's ability to perform its various functions, whether in managed or natural soil. The function of soil in agriculture is to support plant and animal productivity and maintain quality (soil, water, air). Soil capability changes as a reflection of management or the influence of climate change. High soil fertility levels indicate high soil quality as well. Soil quality demonstrates the soil's ability to display its

functions in land use or ecosystems, to support biological productivity, maintain environmental quality, and improve plant, animal, and human health. After assessment, the next stage is soil quality restoration. Former mining land often has soil lacking organic matter and poor physical quality. To restore soil fertility, addition of organic materials such as compost, organic fertilizer, or soil rich in organic matter is necessary. Local organic resources are effective in improving physical and chemical properties of post-mining soil for agriculture (Hong et al., 2025). Agroforestry has been proven to improve physical, chemical, and biological soil properties, reduce erosion, and serve as a "climate-smart" practice relevant for restoring degraded land, including former mining land (Fahad et al., 2022). Additionally, liming is performed to adjust soil pH, which is generally acidic due to mining activities. In some cases, addition of soil microorganisms that can improve soil structure and increase its resistance to erosion is also necessary. The purpose of this stage is to prepare the soil to support the growth of plants to be planted in the next step.

3. Drainage Infrastructure Development and Water Management

Water management in coal mining operations is a fundamental operational need that intersects with technical complexity, economic imperatives, and environmental compliance requirements. Mining operations expose sulfide-containing minerals to oxidizing conditions, creating acid mine drainage characterized by pH values below 5 and high concentrations of dissolved metals including iron, manganese, aluminum, and copper. Nagari Muaro Sopan, Padang Laweh District, Dharmasraya Regency, conducts coal mining where tropical rainfall patterns intensify water management challenges. Water management is a crucial aspect of former coal mining land revitalization because degraded land tends to have poor drainage systems. Creating effective drainage channels is essential for regulating water flow, preventing waterlogging, and reducing flood risks often caused by soil erosion. Planning and management of former mining lakes need to consider technical and environmental aspects in an integrated manner (Von Döhren & Haase, 2023). Additionally, construction of infiltration wells or water absorption holes is crucial for increasing soil capacity to absorb rainwater. Proper water management will reduce the potential for landslides caused by high surface water flow on already degraded soil.



Source: Analysis Results, 2025

Image 4. Water Flow Construction in Former Coal Mining

4. Appropriate Vegetation Planting

Next, selection of vegetation suitable for local conditions becomes one of the key steps in former mining land revitalization. Selected plants must have the ability to grow in degraded soil and improve its quality. Green revegetation and remediation techniques at mining sites include species selection, soil improvement, and utilization of new technologies to accelerate soil quality recovery and biodiversity (Zine et al., 2024). Ground cover plants such as grasses and legumes can help reduce erosion, while deep-rooted trees such as acacia and albizia will improve soil structure and increase soil organic matter content. Soil depth is a major limiting factor for successful revegetation in former coal mining land (Sitorus et al., 2025). Reforestation of post-mining land in Indonesia requires science-based practices and long-term monitoring (Siahaan et al., 2025). Planting native trees is also crucial for restoring biodiversity and supporting overall ecosystem recovery. On formerly converted lands (e.g., ex oil palm concessions in Aceh), forest restoration is framed as necessary to achieve climate targets and biodiversity recovery, consistent with the idea that trees and forest vegetation sequester carbon while rebuilding ecosystem functions (Misbah et al., 2024).

Source: Analysis Results, 2025

Image 5. Planting Oil Palm Trees on Former Coal Mining Land

5. Ecosystem and Biodiversity Recovery

Revitalization of former coal mining land must also include broader ecosystem recovery by introducing various local plant and fauna species that support biodiversity. Vegetation diversity and arbuscular mycorrhizal fungi play important roles in post-mining land ecosystem recovery (Saputra et al., 2025). One main objective in revitalization is returning the ecosystem to a more stable and productive condition that can support local flora and fauna life. Therefore, planting ground cover plants, native trees, and plants that can improve soil quality and biodiversity becomes an important step in ecosystem recovery. Mine land restoration can be optimized by utilizing natural processes in ecosystem succession (Pratiwi et al., 2021). This step can also reduce further damage potential and increase water absorption capacity, which reduces flood risks in former coal mining areas.

Source: Observation Results, 2025

Image 6. Flora and Fauna in Former Coal Mining Land Revitalization Activities

6. Local Community Empowerment

Local community empowerment is also an inseparable part of the revitalization process. Communities living around former mining areas are often the most affected parties by environmental damage and have limited access to economic potential from these areas. Therefore, community participation in planning, implementation, and maintenance of revitalization is crucial. Community participation in developing countries has been proven to increase the success of post-mining land reclamation (Arifin et al., 2025). Training on sustainable agricultural techniques, environmentally friendly forestry, and land management will enhance community capacity to manage areas in environmentally friendly and sustainable ways. Through this empowerment, communities will also obtain economic benefits, such as increased income from agriculture or forestry sectors. Institutional integration and community-based initiatives are key to reframing post-mining landscape sustainability in Indonesia (Ballesteros et al., 2025).

Source: Analysis Results, 2025

Image 7. Local Community Development

7. Sustainable Economic Development

After revitalization, restored former coal mining areas can become income sources for communities through development of agriculture, forestry, or nature-based tourism sectors. Agroforestry has been proven to increase food security and livelihoods of smallholder farmers in Indonesia in the context of climate change (Yoom et al., 2025). Agroforestry in Indonesia contributes significantly to food security through increased food diversity, income, and environmental stability, with traditional and commercial home garden systems providing different combinations of income and food diversity benefits (Duffy et al., 2021). Agroforestry development provides positive socio-economic impacts for rural households and promotes sustainable land management (Kurniawan et al., 2024). Programs such as sustainable horticultural agriculture, agroforestry, or land management for timber production can create new employment and improve local community welfare. Agroforestry practices in production forest areas have been proven to increase income of surrounding communities (Pagouni et al., 2024). Area management based on sustainability principles not only provides economic benefits but also supports long-term environmental conservation. Sustainable post-mining land use requires long-term planning and integration of various land use options (Zhang et al., 2025).

Additionally, good coordination among stakeholders, including government, mining companies, and communities, is crucial for program success. Institutional integration and community-based initiatives are key to reframing post-mining landscape sustainability in Indonesia (Ballesteros et al., 2025). The government plays an important role in formulating policies supporting revitalization, such as providing incentives to mining companies conducting land reclamation or introducing regulations encouraging companies to be responsible for environmental impacts left behind. Overall, revitalization of former mining land as a disaster rehabilitation measure requires an integrated approach involving all relevant parties and focusing on sustainable environmental recovery. The concept of "post-mining ecosystem reconstruction" as a cross-disciplinary approach to convert mining land into safe, stable, and productive landscapes (e.g., for forestry, agroforestry, or agriculture) (Tibbett, 2024). Thus, former mining land revitalization can not only restore environmental conditions but also provide social and economic benefits to surrounding communities and reduce disaster risks that may arise from environmental damage. The success of this program depends heavily on synergy among all relevant parties and strong policy support from the government.

Source: Analysis Results, 2025

Image 7. Community Development in Former Coal Mining Land Revitalization Policy

Conclusion

This study establishes that systematic revitalization of marginal land from former coal mining in Nagari Muaro Sopan, Padang Laweh District, Dharmasraya Regency, requires a comprehensive seven-component strategic framework integrating environmental restoration with disaster risk reduction and socioeconomic development. Through synthesis of international scientific literature and field-based case study analysis, the research demonstrates that effective post-mining landscape transformation depends on coordinated implementation of: (1) thorough land condition assessment to characterize degradation extent and restoration potential; (2) soil quality restoration through organic amendment, pH correction, and microbial inoculation; (3) drainage infrastructure development and water management systems to prevent flooding and erosion; (4) appropriate native vegetation establishment to stabilize soils and restore biodiversity; (5) comprehensive ecosystem recovery targeting flora, fauna, and ecological processes; (6) local community empowerment through capacity building and participatory governance; and (7) sustainable economic development creating livelihood opportunities aligned with restored ecosystem services.

The findings confirm that integrated revitalization approaches transcending isolated technical interventions can substantially mitigate environmental degradation, enhance community resilience to natural disasters, and generate tangible economic benefits for affected populations. However, successful implementation fundamentally depends on three critical enablers: robust multi-stakeholder collaboration involving government agencies, mining corporations, and local communities; sustained policy support through clear regulatory frameworks and enforcement mechanisms; and adequate financial resources committed to long-term restoration and monitoring activities. This research contributes to the growing body of literature on post-mining landscape sustainability by demonstrating how global best practices in mine reclamation can be contextualized for tropical Indonesian settings while simultaneously addressing environmental, social, and economic dimensions of sustainability. The integrated framework developed through this study provides evidence-based guidance for policymakers, mining industry practitioners, and community organizations engaged in transforming degraded post-mining lands into productive, ecologically stable, and socially equitable landscapes. Ultimately, the revitalization of marginal lands from former coal mining represents not only an environmental imperative but also a significant opportunity for sustainable rural development in Indonesia's mining-affected regions.

Recommendation

1. Government and Regulatory Authorities

Local governments should develop integrated post-mining revitalization policies with clear standards, monitoring mechanisms, and cross-sectoral coordination. Zoning regulations and incentives are needed to guide environmentally appropriate and community-oriented land reuse.

2. Mining Corporations

Mining companies should adopt progressive reclamation approaches integrated from the early mining stages, supported by adequate financial guarantees, participatory planning with local communities, and long-term ecological and socioeconomic

monitoring.

3. Local Communities

Communities should be actively involved in revitalization planning and management through capacity building, utilization of indigenous knowledge, and establishment of community-based institutions to ensure equitable and sustainable land use outcomes.

4. Academic and Research Institutions

Universities should support post-mining revitalization through longitudinal and action-oriented research, focusing on ecological recovery, livelihood impacts, and capacity development for ecosystem restoration professionals.

5. Future Research

Further studies are needed on long-term revitalization effectiveness, comparative site analysis, economic valuation of revitalization options, climate adaptation strategies, and governance mechanisms influencing post-mining land management.

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