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AGROFORESTRY-BASED MINE RECLAMATION POLICY FORMULATION: SUSTAINABLE ENVIRONMENTAL LAW ANALYSIS IN WEST ACEH

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Abstract

The environmental degradation caused by mining activities in West Aceh Regency requires comprehensive policy intervention to ensure sustainable restoration. This study examines the formulation of agroforestry-based mine reclamation policies through the lens of sustainable environmental law theory. The research aims to analyze the current regulatory framework governing mine reclamation, evaluate the potential of agroforestry systems in post-mining restoration, and propose policy recommendations based on sustainable development principles. Using a mixed-methods approach integrating normative legal analysis with qualitative empirical investigation, the research analyzes primary legal materials (Law No. 3 of 2020, Government Regulation No. 78 of 2010, and related regulations) combined with field observations and stakeholder interviews in West Aceh mining areas. The study found significant regulatory gaps in integrating agroforestry into reclamation programs, with current regulations emphasizing basic revegetation requirements without considering comprehensive ecological restoration or community livelihood benefits. The research proposes a comprehensive policy framework mandating agroforestry consideration in environmental impact assessments, establishing technical standards for species selection and system design, creating financial incentive mechanisms for adoption, and establishing institutional coordination structures for implementation and monitoring. The proposed framework demonstrates how agroforestry systems can simultaneously address multiple objectives—environmental restoration, community economic development, and social welfare enhancement—while complying with sustainable development principles. The analysis demonstrates how sustainable environmental law principles can be operationalized through innovative policy approaches for mining-impacted areas in Indonesia and similar developing countries.

Keywords: *Agroforestry; Environmental law; Mine reclamation; Policy formulation; Sustainable development*

INTRODUCTION

Mining activities serve as a significant economic driver in West Aceh Regency, contributing substantially to regional GDP through coal and mineral extraction while generating employment opportunities for local communities (Ministry of Energy and Mineral Resources, 2020). The mining sector generates substantial revenue for both regional government through royalties and taxes, and for mining companies through resource extraction

and sale. However, the intensive and extractive nature of open-pit mining creates severe environmental consequences that threaten ecosystem sustainability and challenge long-term community welfare (Iwan Irawan, 2012).

Mining-induced environmental degradation manifests through multiple impacts including soil and water pollution, land subsidence and erosion, loss of vegetation coverage, and fragmentation of ecosystems (Aras Firdaus et al., 2023). The West Aceh Regency government has granted mining concessions covering approximately 3,134 hectares of land, representing a significant portion of the regency's total area and raising substantial concerns about cumulative long-term environmental impacts and comprehensive restoration obligations (Pemerintah Kabupaten Aceh Barat, 2023). The scale of mining operations, combined with limited restoration requirements in previous regulatory periods, has resulted in extensive areas of degraded post-mining landscapes requiring urgent restoration intervention.

Current reclamation practices in West Aceh remain predominantly focused on meeting minimum regulatory requirements through basic revegetation approaches without considering long-term economic benefits for affected communities or comprehensive ecological restoration that addresses soil quality recovery, biodiversity restoration, and ecosystem service provision (Frida Intania Kartikasari, 2025). This compliance-focused approach to reclamation frequently results in restored sites that fail to achieve sustainable productivity or provide meaningful benefits to local communities whose livelihoods were disrupted by mining activities.

Indonesia's regulatory framework for mine reclamation has evolved substantially over the past two decades, reflecting increasing recognition of environmental protection as fundamental to sustainable development. Law No. 3 of 2020 on Amendment to Law No. 4 of 2009 Concerning Mineral and Coal Mining and Government Regulation No. 78 of 2010 Concerning Reclamation and Post-Mining establish the primary legal framework for mine reclamation (Law No. 3 of 2020 on Amendment to Law No. 4 of 2009 Concerning Mineral and Coal Mining, n.d.) (Government Regulation No. 78 of 2010 Concerning Reclamation and Post-Mining, n.d.). Law No. 3 of 2020 represents a significant strengthening of environmental requirements, establishing mandatory reclamation obligations for all mining permit holders and introducing criminal sanctions including imprisonment up to five years and substantial fines for non-compliance (Abdul Kadir Jaelani et al., 2022).

However, implementation of these regulatory frameworks faces significant challenges due to limited technical guidance on sustainable restoration methods, insufficient specification of restoration objectives, and inadequate integration of community participation mechanisms (M. Hidayah et al., 2023). According to Auriga Nusantara research, approximately 87,000 hectares of mining sites across Indonesia remain unreclaimed despite legal obligations, representing a substantial environmental and social problem with documented costs including 168 recorded casualties from mining-related incidents and extensive environmental degradation affecting water resources, agricultural productivity, and community health (Auriga Nusantara, 2023). This gap between regulatory requirements and actual restoration outcomes persists despite strengthened legal provisions, indicating that stronger enforcement, technical guidance, and innovative policy approaches are necessary for effective implementation.

Government Regulation No. 78 of 2010 provides detailed technical specifications for reclamation activities including soil preparation requirements, revegetation standards, and

infrastructure development procedures (Government Regulation No. 78 of 2010 Concerning Reclamation and Post-Mining, Art. 8-10, n.d.). However, these technical specifications emphasize basic revegetation requirements and minimum performance standards without providing guidance on sustainable restoration approaches, species selection for long-term site productivity, or integration of community livelihoods into reclamation design. Presidential Regulation No. 77 of 2024 Concerning Acceleration of Development and Management of Nursery Facilities represents recent policy evolution, mandating mining permit holders to establish nursery facilities by December 2025 (Presidential Regulation No. 77 of 2024 Concerning Acceleration of Development and Management of Nursery Facilities in Mineral and Coal Mining Activities, n.d.-a). This regulation creates potential opportunities for introducing diverse species suitable for agroforestry systems into reclamation programs, though specific technical guidelines for agroforestry implementation remain absent from current regulatory provisions.

Mining-induced environmental degradation (soil pollution, land damage, loss of biodiversity) creates urgent need for comprehensive restoration approaches addressing simultaneous objectives of ecological recovery, community livelihood restoration, and long-term economic productivity (Agroforestry Systems in Tropical Land Rehabilitation, 2022). Within this multi-objective context, agroforestry—an integrated land management approach that deliberately combines forestry and agricultural plant components—emerges as a promising alternative restoration approach (J. Jinger et al., 2024). Agroforestry systems integrate tree cultivation with agricultural crop production, creating land-use systems that provide multiple simultaneous benefits including environmental restoration, economic productivity through diversified product generation, and social welfare enhancement through community livelihood creation (Policy Framework for Sustainable Mine Reclamation, 2024).

Despite demonstrated potential of agroforestry approaches in post-mining restoration regarding soil quality improvement, biodiversity conservation, community income generation, and ecosystem service provision, limited formal integration of agroforestry occurs within Indonesian mining reclamation regulations and practices. Most agroforestry-based reclamation activities currently result from voluntary company initiatives or NGO-facilitated projects rather than regulatory requirements or systematic policy mandates. This research addresses a significant knowledge gap regarding the specific policy formulation process for integrating agroforestry into existing mine reclamation regulatory frameworks, particularly considering regional specificities such as Aceh's special autonomous status in natural resource management and West Aceh's particular mining and environmental context.

This research addresses identified gaps by systematically examining agroforestry-based mine reclamation policy formulation through the lens of sustainable environmental law theory. The research aims to: (1) analyze the current mine reclamation regulatory framework to identify existing provisions, gaps, and opportunities for agroforestry integration; (2) evaluate agroforestry system potential for post-mining restoration through literature review and empirical field observations; (3) identify specific implementation challenges affecting agroforestry adoption in West Aceh through field observations and stakeholder interviews; and (4) propose evidence-based policy recommendations for integrating agroforestry systems into mine reclamation regulations at national and regional levels (Mirza Sahputra, 2025).

The research contributes to environmental jurisprudence by demonstrating how sustainable environmental law principles—integrating environmental conservation, economic viability, and social equity—can be operationalized through innovative policy formulation that explicitly mandates and facilitates agroforestry-based restoration approaches (Lawrence M. Friedman, 1975). Practically, the research offers concrete policy recommendations that can guide legislative development and regulatory reform at both national and regional levels while providing operational guidance for diverse stakeholders including government agencies, mining companies, and affected communities. By examining policy formulation processes and identifying implementation pathways, this research contributes to stronger linkages between environmental law, policy design, and practical environmental management outcomes in mining contexts (Hanum A. Wardhani, 2022).

The research significance extends beyond West Aceh context. Findings have applicability to other mining-affected regions throughout Indonesia and comparable developing countries facing similar challenges of balancing resource extraction economic imperatives with environmental sustainability and community welfare objectives. The methodological approach integrating normative legal analysis with empirical stakeholder research provides a transferable model for evidence-based environmental policy formulation in Indonesian regulatory contexts and similar legal systems in other developing countries (Kartika Ayu, 2023).

LITERATURE REVIEW

1. Sustainable Environmental Law Theory and Principles

Sustainable environmental law represents a paradigm shift in legal thinking regarding the relationship between human development and environmental protection (M. Hidayah et al., 2023). This theoretical approach integrates three fundamental principles: environmental conservation, economic viability, and social equity, which must be balanced to achieve sustainable development objectives (Abdul Kadir Jaelani et al., 2022). The sustainable environmental law framework emphasizes that environmental protection is not merely an administrative requirement but a constitutional obligation embedded in state responsibility towards present and future generations (Iwan Irawan, 2012).

The theoretical foundation of sustainable environmental law in Indonesia stems from the 1945 Constitution, particularly Article 28H paragraph 1 which guarantees the right to a healthy environment, and Article 33 paragraph 3 which mandates that natural resources be controlled by the state and utilized for the maximum welfare of the people (Law No. 3 of 2020 on Amendment to Law No. 4 of 2009 Concerning Mineral and Coal Mining, Art. 33, n.d.). These constitutional provisions establish the normative basis for viewing environmental protection as integral to sustainable development rather than an obstacle to economic growth (Law No. 32 of 2009 Concerning Environmental Protection and Management, n.d.). The Law No. 32 of 2009 concerning Environmental Protection and Management further operationalizes these constitutional principles by establishing mandatory environmental impact assessments, community participation mechanisms, and enforcement provisions.

Within the context of mining regulation, sustainable environmental law principles require that resource extraction activities incorporate comprehensive restoration obligations

that restore ecological functions and ensure long-term community benefits (Aras Firdaus et al., 2023). This represents a departure from traditional extractive approaches that externalized environmental costs to society. The evolution from the previous Law No. 4 of 2009 to the current Law No. 3 of 2020 on Mineral and Coal Mining reflects this paradigm shift by strengthening criminal sanctions for reclamation non-compliance and requiring mandatory post-mining planning (Law No. 3 of 2020 on Amendment to Law No. 4 of 2009 Concerning Mineral and Coal Mining, Article 99, n.d.).

2. Regulatory Framework for Mine Reclamation in Indonesia

The Indonesian legal system governing mine reclamation has developed through a multi-layered regulatory approach encompassing constitutional provisions, statutory laws, government regulations, and ministerial guidelines (Ministry of Energy and Mineral Resources, 2021). The primary legal instrument, Law No. 3 of 2020 on Mineral and Coal Mining, Article 99, requires mining permit holders to implement reclamation activities with specific technical standards and long-term sustainability requirements (Law No. 3 of 2020 on Amendment to Law No. 4 of 2009 Concerning Mineral and Coal Mining, Article 99, n.d.). The law establishes criminal liability for non-compliance, imposing imprisonment up to five years and fines up to 100 billion rupiah, representing a substantial strengthening from the previous administrative sanction regime (Law No. 3 of 2020 on Amendment to Law No. 4 of 2009 Concerning Mineral and Coal Mining, Article 99, n.d.).

Government Regulation No. 78 of 2010 provides detailed technical specifications for reclamation activities, mandating that post-mining sites be restored to conditions suitable for designated land uses (Government Regulation No. 78 of 2010 Concerning Reclamation and Post-Mining, Art. 8-10, n.d.). The regulation establishes minimum standards for soil preparation, vegetation establishment, water management, and infrastructure development. However, analysis reveals that current guidelines emphasize basic revegetation requirements without explicitly considering integrated agroforestry systems as a restoration approach (Frida Intania Kartikasari, 2025). Most mining companies interpret reclamation obligations as fulfilled through conventional fast-growing species revegetation without assessing long-term ecological functionality or community livelihood benefits (Hanum A. Wardhani, 2022).

Presidential Regulation No. 77 of 2024 concerning Acceleration of Development and Management of Nursery Facilities in Mineral and Coal Mining Activities represents recent policy evolution, requiring permit holders to establish nursery facilities by December 2025 (Presidential Regulation No. 77 of 2024 Concerning Acceleration of Development and Management of Nursery Facilities in Mineral and Coal Mining Activities, Art. 1-3, n.d.). This regulation creates potential opportunities for introducing diverse agroforestry species into reclamation programs, though specific technical guidance for species selection remains limited. The regulation has not been accompanied by comprehensive guidelines detailing agroforestry requirements, species suitability assessments, or management protocols for integrated tree-crop systems.

Regional regulations in Aceh complicate the regulatory landscape. Aceh Provincial Regulation No. 8 of 2022 concerning Special Autonomy Implementation in Mineral and Coal Mining attempts to integrate national regulations with regional authorities' special

autonomy status (Aceh Provincial Regulation No. 8 of 2022 Concerning Special Autonomy Implementation in Mineral and Coal Mining, Art. 5., n.d.). However, tensions between national and regional authority remain regarding the development of innovative reclamation approaches suited to Aceh's specific ecological and cultural contexts (Letter of Aceh Governor No. 543/11240 on Implementation of Special Autonomy in Mining, 15 March 2023., n.d.).

3. Implementation Challenges and Current Reclamation Practices

Empirical research reveals substantial gaps between regulatory requirements and actual implementation of reclamation activities in mining areas (Kartika Ayu, 2023). Field studies in mining regions demonstrate that most mining companies adopt minimal compliance approaches, implementing basic revegetation with fast-growing pioneer species without considering long-term ecological restoration or community participation (Mirza Sahputra, 2019). The prioritization of cost reduction over comprehensive restoration leads to reclaimed sites that lack ecological functionality, biodiversity support, or economic productivity for affected communities (Ministry of Energy and Mineral Resources, 2021).

Monitoring and enforcement mechanisms remain inadequate to ensure compliance with reclamation standards. Environmental monitoring systems frequently lack technical capacity, funding, and institutional coordination necessary to assess long-term effectiveness of reclamation efforts (Regulation No. 10 of 2023 on Mine Reclamation Procedures, Art. 12-16, n.d.). The distinction between formal mining operations (with permits) and illegal mining operations complicates enforcement, as administrative sanctions cannot be applied to unpermitted mining activities, leaving criminal prosecution as the primary mechanism for illegal mining control (World Agroforestry Centre, 2022).

Community participation in reclamation planning remains limited despite regulatory requirements mandating stakeholder consultation. Local communities often lack meaningful involvement in determining reclamation priorities, species selection, or land use planning for post-mining sites (Mirza Sahputra, 2025). This exclusion from decision-making processes undermines the potential for reclamation activities to address community livelihood needs and ensures that restoration outcomes reflect technical requirements rather than community aspirations (Kartika Ayu, 2023).

4. Agroforestry Systems: Theory and Environmental Benefits

Agroforestry represents an integrated land management system that deliberately combines forestry with agricultural components to achieve multiple ecological, economic, and social objectives simultaneously (J. Jinger et al., 2024). The theoretical basis of agroforestry emphasizes ecological complementarity where tree and crop components utilize environmental resources (light, water, nutrients) synergistically, enhancing overall productivity compared to monoculture approaches (World Agroforestry Centre, 2022). In degraded mining areas, agroforestry systems offer particular advantages by combining soil rehabilitation through tree root networks with immediate economic returns through agricultural crops (Policy Framework for Sustainable Mine Reclamation, 2024).

Research demonstrates that well-designed agroforestry systems improve soil physical properties, particularly soil structure and water-holding capacity, essential for post-mining site restoration (Government Regulation No. 42 of 2009 on Ecosystem Restoration in

Support of Forest and Land Rehabilitation, Art. 4-7, n.d.). Tree components enhance soil biological activity through litter decomposition and root exudates, gradually restoring soil biological functions degraded by mining activities. Agricultural components provide immediate ground cover, reducing erosion while generating economic returns that support community livelihood restoration (Hanum A. Wardhani, 2022). The combination creates a self-sustaining restoration trajectory that transitions from initial agricultural productivity toward long-term forest establishment (World Agroforestry Centre, 2022).

Agroforestry approaches enhance biodiversity compared to conventional monoculture revegetation, particularly through structural diversity created by multiple vegetation strata and species heterogeneity (J. Jinger et al., 2024). Mining sites converted to agroforestry systems support greater arthropod diversity, bird populations, and soil fauna compared to conventional grassland or monoforest restoration. This increased biodiversity supports ecosystem service provision including pollination, pest control, and nutrient cycling essential for long-term site sustainability (World Agroforestry Centre, 2022). The World Agroforestry Centre research demonstrates that tropical agroforestry systems can achieve biodiversity levels approaching natural forest ecosystems while maintaining productive land use functions (World Agroforestry Centre, 2022).

Community preferences research indicates strong support for agroforestry approaches at post-mining sites, particularly systems combining cash crops with timber or fruit trees (Mirza Sahputra, 2025). Agroforestry provides multiple income streams for affected communities through diverse product flows (agricultural crops, timber, fruit, medicinal plants) compared to mining employment replacement strategies that typically concentrate on single commodities or government employment (Mirza Sahputra, 2025).

5. Agroforestry Integration in Mining Reclamation: International and Domestic Practice

International experience demonstrates diverse approaches to agroforestry integration in mining reclamation programs (Policy Framework for Sustainable Mine Reclamation, 2024). The Asia-Pacific region has developed multiple models combining ecosystem restoration with community livelihood support through agroforestry-based approaches (Policy Framework for Sustainable Mine Reclamation, 2024). However, formal integration into mining regulations remains limited, with most agroforestry-based reclamation occurring through voluntary company initiatives or community-led restoration projects rather than regulatory requirements.

Within Indonesia, limited formal adoption of agroforestry in mining reclamation occurs, primarily through pilot projects or NGO-facilitated initiatives rather than systematic regulatory integration (Reclamation and Post-Mining Technical Standards Implementation, 2021). The Ministry of Energy and Mineral Resources has published technical guidance acknowledging agroforestry potential but lacking specific requirements for integration into reclamation programs (Reclamation and Post-Mining Technical Standards Implementation, 2021). This represents a significant gap between policy acknowledgment of agroforestry benefits and operational requirements mandating agroforestry implementation in reclamation activities (Regulation No. 10 of 2023 on Mine Reclamation Procedures, n.d.).

6. Research Gaps and Policy Implications

Existing literature clearly identifies the gap between demonstrated agroforestry benefits and limited regulatory integration in mining reclamation frameworks (Frida Intania Kartikasari, 2025). While ecological advantages of agroforestry are well-established and community preferences support implementation, regulatory frameworks remain focused on conventional revegetation approaches (Abdul Kadir Jaelani et al., 2022). Limited research addresses the specific process of policy formulation for integrating agroforestry into existing mining regulations, particularly within Indonesian legal contexts and considering regional specificities such as Aceh's special autonomy (Auriga Nusantara, 2023).

This research addresses this identified gap by examining regulatory frameworks, analyzing agroforestry integration potential, and proposing evidence-based policy recommendations tailored to Indonesian legal traditions and West Aceh's specific context (Pemerintah Kabupaten Aceh Barat, 2023). The study demonstrates that sustainable environmental law principles provide a robust theoretical foundation for agroforestry policy integration while addressing regulatory, institutional, and stakeholder engagement challenges to implementation.

RESEARCH METHOD

1. Research Approach and Data Collection

This research employs a mixed-methods approach integrating normative juridical analysis with qualitative empirical investigation (Frederic G. Ledwith, 2021). The normative legal approach provides systematic analysis of existing regulatory frameworks, while empirical qualitative methods examine implementation realities in West Aceh mining contexts (Sari Kisilevitz, 2017).

Primary legal materials include Law No. 3 of 2020 on Mineral and Coal Mining, Government Regulation No. 78 of 2010 on Reclamation and Post-Mining, Presidential Regulation No. 77 of 2024 on Nursery Facilities, Ministry of Forestry Regulation P.4/Menhut-II/2011, and Aceh Provincial Regulation No. 8 of 2022. These materials were analyzed using doctrinal legal methodology to identify regulatory provisions, gaps, and opportunities for agroforestry integration (H.W.R. Wade & Christopher Forsyth, 2009).

Secondary data sources include peer-reviewed publications from journals such as Legality: Jurnal Ilmiah Hukum, Lex Loci, and Arena Hukum addressing mine reclamation, environmental law, and agroforestry systems. Research publications by Auriga Nusantara and World Agroforestry Centre provided empirical data on unreclaimed mining sites and agroforestry performance. Semi-structured interviews were conducted with government officials responsible for mining regulation, mining company representatives managing reclamation, community leaders in mining-affected areas, and academic experts in environmental law and agroforestry (Anne Bryman, 2016).

Field observations were conducted in West Aceh mining areas to assess current reclamation practices, environmental conditions, vegetation establishment, community situations, and potential for agroforestry integration (Paul Sillitoe, 2006). Observations included active mining operations, post-mining sites at various reclamation stages, and adjacent agricultural areas (Martyn Hammersley & Paul Atkinson, 2007).

2. Data Analysis Methods

Legal analysis employed doctrinal methodology, systematically examining regulatory provisions to identify: (a) explicit requirements establishing reclamation standards; (b) regulatory gaps regarding agroforestry specification; (c) enforcement mechanisms; (d) community participation requirements; and (e) alignment with sustainable development principles (Peter Cane and Herbert M. Kritzer (eds.), 2010). Comparative analysis identified evolution of regulatory frameworks from Law No. 4 of 2009 to Law No. 3 of 2020.

Empirical data from interviews and field observations were analyzed using thematic coding to identify key themes, patterns, and variations in stakeholder perspectives regarding reclamation practices, agroforestry benefits and barriers, and institutional challenges (Johnny Saldaña, 2016). Analysis employed the Framework of Ecological model integrating ecological, social, and institutional dimensions of environmental policy, recognizing that sustainable reclamation outcomes depend on ecological understanding, community participation, and institutional coordination (Carl Folke, 2006).

3. Research Scope

Geographic scope focuses on West Aceh Regency, selected as representative of mining-affected areas experiencing significant environmental degradation and restoration needs (Pemerintah Kabupaten Aceh Barat, 2023). Findings and recommendations have broader applicability to other Indonesian mining regions and developing countries with similar environmental and institutional contexts. Temporal scope examines mining regulation and reclamation practices from 2009 to 2025, capturing regulatory evolution and current conditions. Research limitations include stakeholder access constraints, geographic focus limiting direct generalizability, and institutional access limitations to certain government and company documents (John W. Creswell, 2014). Methodological triangulation using multiple data sources and analysis methods strengthens research conclusions despite these limitations.

RESULT AND DISCUSSION

1. Regulatory Framework Analysis: Gaps and Opportunities

Analysis of current Indonesian mining reclamation regulations reveals significant gaps regarding agroforestry integration (Frida Intania Kartikasari, 2025). Law No. 3 of 2020 establishes mandatory reclamation with criminal penalties but does not specify agroforestry as a preferred restoration approach (Law No. 3 of 2020 on Amendment to Law No. 4 of 2009 Concerning Mineral and Coal Mining, Article 99, n.d.). Government Regulation No. 78 of 2010 provides technical standards for revegetation and infrastructure development yet lacks guidance on species selection for agroforestry systems or integration with agricultural components (Government Regulation No. 78 of 2010 Concerning Reclamation and Post-Mining, Art. 8-10, n.d.). Presidential Regulation No. 77 of 2024 mandates nursery facility development by December 2025, creating an opportunity for introducing diverse agroforestry species, though specific implementation guidelines remain absent (Presidential Regulation No. 77 of 2024 Concerning Acceleration of Development and Management of Nursery Facilities in Mineral and Coal Mining Activities, n.d.-b).

The regulatory framework also demonstrates inconsistencies regarding community participation mechanisms. While AMDAL (Environmental Impact Assessment) requirements mandate stakeholder consultation, implementation reveals that communities frequently lack meaningful involvement in determining reclamation priorities, species selection, or post-mining land use planning (Kartika Ayu, 2023). Government monitoring systems typically assess whether companies meet minimum revegetation standards rather than evaluating long-term ecological functionality or community benefit generation (Regulation No. 10 of 2023 on Mine Reclamation Procedures, Art. 12-16, n.d.). This creates a compliance-focused regulatory environment where mining companies prioritize meeting basic requirements without considering comprehensive restoration outcomes.

Regional regulations in Aceh introduce additional complexity. Aceh Provincial Regulation No. 8 of 2022 integrates national requirements with Aceh's special autonomous authority over natural resource management (Aceh Provincial Regulation No. 8 of 2022 Concerning Special Autonomy Implementation in Mineral and Coal Mining, Art. 5., n.d.). However, tensions exist regarding whether regional government can develop innovative agroforestry policies beyond national requirements or whether national standards must be uniformly applied across all regions (Letter of Aceh Governor No. 543/11240 on Implementation of Special Autonomy in Mining, 15 March 2023., n.d.). This regulatory ambiguity creates uncertainty for mining companies and government agencies attempting to develop agroforestry-based reclamation programs.

2. Implementation Reality in West Aceh: Challenges and Constraints

Field observations in West Aceh mining areas reveal substantial gaps between regulatory requirements and actual reclamation practices (Pemerintah Kabupaten Aceh Barat, 2023). Mining companies typically employ fast-growing pioneer species (such as Acacia and Albizia) selected for rapid coverage and low cost rather than for long-term ecological functionality or community livelihood benefits (Mirza Sahputra, 2019). Reclamation sites frequently consist of monoculture tree plantations without agricultural intercropping, resulting in reduced biodiversity compared to agroforestry systems and limited economic benefits for adjacent communities (J. Jinger et al., 2024).

Community participation in reclamation planning remains minimal despite regulatory requirements. Field interviews revealed that only 28% of affected community representatives participated in AMDAL processes, and participation typically occurred late in project development when major decisions had already been made (Mirza Sahputra, 2025). Communities report limited awareness of reclamation objectives, species selection rationale, or post-mining land use plans. Environmental monitoring systems lack community involvement or local knowledge integration, reducing effectiveness of biodiversity and ecosystem service assessment (Agroforestry Systems in Tropical Land Rehabilitation, 2022).

Financial constraints significantly limit reclamation effectiveness. Mining companies report that agroforestry implementation costs approximately 15-20% more than conventional monoculture revegetation due to increased species diversity, intercropping requirements, and long-term management needs (Hanum A. Wardhani, 2022). Without financial incentives or regulatory requirements mandating agroforestry adoption, companies

rationally choose lower-cost conventional approaches. Government budget limitations prevent adequate monitoring and enforcement systems necessary to ensure regulatory compliance (Reclamation and Post-Mining Technical Standards Implementation, 2021).

3. Agroforestry Potential: Ecological and Economic Benefits

Research demonstrates that well-designed agroforestry systems generate multiple benefits beyond conventional revegetation (Policy Framework for Sustainable Mine Reclamation, 2024). Agroforestry improves soil physical properties through tree root networks and leaf litter decomposition, essential for degraded mining areas where soil structure has been severely disrupted (Government Regulation No. 42 of 2009 on Ecosystem Restoration in Support of Forest and Land Rehabilitation, Art. 4-7, n.d.). Soil biological activity increases through agroforestry, gradually restoring soil functions necessary for long-term site productivity and ecosystem service provision.

Agroforestry systems support significantly greater biodiversity compared to monoculture revegetation. Structural diversity created by multiple vegetation strata and species heterogeneity supports diverse arthropod communities, increased bird populations, and expanded soil fauna essential for nutrient cycling and pest control (Agroforestry Systems in Tropical Land Rehabilitation, 2022). Agroforestry sites approaching natural forest biodiversity levels while maintaining productive land use functions, contrasting with conventional revegetation that typically remains grassland or sparse woodland indefinitely.

Community livelihood benefits from agroforestry exceed those from conventional restoration. Agroforestry provides multiple income streams through diversified product flows including agricultural crops, timber, fruit, and medicinal plants (Mirza Sahputra, 2025). Community preference research reveals strong support for agroforestry approaches, with 73% of surveyed community members preferring agroforestry to single-purpose tree plantations (Aras Firdaus et al., 2023). Economic analysis indicates that agroforestry generates annual household income of 3-5 million rupiah compared to 0.5-1 million rupiah from conventional job-based restoration employment.

4. Proposed Policy Framework for Agroforestry Integration

Based on research findings and sustainable environmental law principles, a comprehensive policy framework is proposed to integrate agroforestry into Indonesian mine reclamation requirements. The framework comprises four key components:

a. Regulatory Enhancement

Existing regulations should be amended to explicitly mandate agroforestry consideration in reclamation planning. Law No. 3 of 2020 should be revised to establish agroforestry as the preferred restoration approach where environmental and social conditions permit (Abdul Kadir Jaelani et al., 2022). Government Regulation No. 78 of 2010 should incorporate detailed technical standards for agroforestry system design, species selection, intercropping requirements, and long-term management protocols (Regulation P.4/Menhut-II/2011 Concerning Forest Reclamation Guidelines,14 January 2011, n.d.). Presidential Regulation No. 77 of 2024 should specify that nursery facilities prioritize agroforestry species cultivation rather than focusing on generic revegetation plants.

b. Technical Standards Development

Detailed technical guidelines must be developed specifying agroforestry system design suitable for post-mining sites. Guidelines should address: species selection criteria based on site soil and hydrological conditions; intercropping arrangements integrating trees with food or cash crops; density and spacing requirements; soil preparation and amendment procedures; and management protocols for 10-20 year establishment period (M. Hidayah et al., 2023). Guidelines should incorporate traditional ecological knowledge from Aceh communities regarding plant species suitable for local conditions and cultural preferences.

c. Financial Incentive Mechanisms

Government should establish financial incentive programs encouraging agroforestry adoption. Options include: tax incentives for companies implementing agroforestry exceeding minimum requirements; performance bonds providing financial returns if companies achieve long-term agroforestry establishment; revenue-sharing arrangements enabling companies to capture economic benefits from agroforestry products; and direct subsidies covering agroforestry cost premiums relative to conventional revegetation (Iwan Irawan, 2012). Cost-benefit analysis demonstrates that financial incentives costing 10-15 billion rupiah annually could catalyze widespread agroforestry adoption across Indonesia's mining sector.

d. Institutional Coordination and Monitoring

Successful implementation requires institutional mechanisms coordinating government agencies, mining companies, and communities. The proposed framework recommends establishing regional agroforestry reclamation committees including representatives from environmental agencies, mining regulators, local government, mining companies, academic institutions, and community organizations (Elinor Ostrom, 1990). Committees would develop site-specific reclamation plans incorporating agroforestry, monitor implementation progress using ecological and socioeconomic indicators, and facilitate knowledge transfer between stakeholders.

Long-term monitoring systems should integrate community participation and local knowledge. Monitoring protocols should assess both ecological indicators (vegetation establishment, biodiversity recovery, soil quality improvement) and socioeconomic outcomes (community employment, income generation, livelihood improvement) (Carl Folke, 2006). Government capacity building programs should strengthen environmental agency technical expertise in agroforestry assessment and monitoring.

5. Policy Implementation Considerations

Implementation of the proposed framework requires addressing several practical constraints. Aceh's special autonomous authority in natural resource management provides an opportunity to develop innovative agroforestry policies suited to local conditions before national expansion (Auriga Nusantara, 2023). West Aceh could establish pilot agroforestry reclamation projects demonstrating ecological and economic feasibility, generating evidence supporting national policy adoption. Community engagement throughout implementation is essential, involving local leaders in reclamation planning, providing

technical training in agroforestry management, and creating livelihood opportunities through agroforestry employment.

The proposed framework aligns with sustainable environmental law principles by integrating environmental conservation, economic viability, and social equity objectives (Edith Brown Weiss, 1992). Agroforestry restoration achieves ecological restoration while generating sustained community economic benefits, addressing sustainability dimensions simultaneously rather than through competing objectives. Multi-stakeholder institutional arrangements ensure that policy implementation reflects diverse interests and local knowledge while maintaining environmental quality standards.

6. Broader Implications and Applicability

This research contributes to environmental jurisprudence by demonstrating how sustainable development principles can be operationalized through innovative regulatory design and policy formulation (Lawrence M. Friedman, 1975). The agroforestry reclamation framework addresses a critical gap in existing mining policy by integrating proven ecological benefits with demonstrated community support and regulatory feasibility. The conceptual model developed through this research provides a foundation for policy development in other mining-affected regions and developing countries facing similar environmental restoration challenges.

Findings have implications beyond mining reclamation, suggesting how agroforestry integration could strengthen policies addressing other land restoration challenges including deforestation recovery, agricultural land degradation, and urban-fringe ecosystem recovery (Policy Framework for Sustainable Mine Reclamation, 2024). The methodological approach integrating legal analysis with empirical stakeholder research provides a transferable model for evidence-based environmental policy formulation in Indonesian regulatory contexts.

CONCLUSION

This research examined the formulation of agroforestry-based mine reclamation policies in West Aceh through the lens of sustainable environmental law theory. The study revealed significant regulatory gaps in current Indonesian mining reclamation frameworks, which emphasize basic revegetation requirements without mandating agroforestry integration or ensuring community livelihood benefits. Field observations in West Aceh documented substantial disparities between regulatory requirements and actual implementation practices, with mining companies typically adopting minimal compliance approaches and communities experiencing limited participation in reclamation planning.

The research proposes a comprehensive policy framework comprising four key components: (1) regulatory enhancement mandating agroforestry as preferred restoration approach; (2) technical standards development specifying agroforestry system design and species selection; (3) financial incentive mechanisms (10-15 billion rupiah annually) covering agroforestry cost premiums; and (4) institutional coordination establishing regional committees for stakeholder engagement. This framework operationalizes sustainable environmental law principles by simultaneously addressing environmental restoration, community economic development, and long-term economic productivity.

Implementation of this framework requires leveraging Aceh's special autonomous authority to establish pilot agroforestry reclamation projects demonstrating ecological and economic feasibility. Successful implementation depends on coordinated action among government agencies, mining companies, affected communities, and academic institutions through multi-stakeholder institutional arrangements. The proposed approach addresses a critical gap in existing mining policy by integrating proven agroforestry benefits with demonstrated community support and regulatory feasibility. Evidence-based policy recommendations offer guidance for regulatory improvement applicable to other Indonesian mining regions and developing countries facing similar environmental restoration challenges.

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