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Critical review of mine closure regulations and alignment with ecological restoration principles

Arief Adi Pradana[1,*]
[1] *School of Environmental Science, Universitas Indonesia, Central Jakarta, DKI Jakarta 10430, Indonesia.*
*Correspondence: arief.pradana@ymail.com

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ABSTRACT

Background: Indonesia, as one of the largest coal producers and exporters, faces negative impacts of mining such as water quality degradation, landscape changes, and social conflicts. Although the government has various regulations from MEMR and MoEF, the implementation of mine reclamation is often suboptimal, hampering ecological and biodiversity recovery. This study examines environmental regulations, especially related to mine closure issued by the two ministries. **Methods:** This study uses a literature study method by analyzing mining closure regulations in Indonesia, including the Decree of the Ministry of Energy and Mineral Resources No. 7/2014, the Decree of the Minister of Environment No. 3/2014, and the Decree of the Minister of Finance No. P.60/Menhut-II/2009, and their relation to ecological restoration. The analysis was conducted using the content analysis method to extract conclusions from related documents, focusing on the criteria for the success of reclamation and mine closure. **Findings:** There are differences in mine closure regulations with ecological restoration criteria, which show that the Minister of Energy and Mineral Resources Regulation No. 7/2014 has the highest suitability with a score of 54.55%. This analysis reveals that the Minister of Energy and Mineral Resources Regulation emphasizes stakeholder consultation, rehabilitation planning, and monitoring, while the Minister of Forestry Regulation No. 60/2009 focuses more on vegetation formation and erosion control, and the Minister of Environment Regulation No. 3/2014 provides guidelines for biodiversity management and fauna recolonization. **Conclusion:** This study shows that the current reclamation and post-mining regulations from the Ministry of Energy and Mineral Resources, Ministry of Forestry, and Ministry of Environment require coordination to create regulations that ensure sustainable mining in Indonesia. **Novelty/Originality of This Study:** The novelty of this study lies in its critical analysis of regulatory gaps, highlighting the need for synchronized policies to ensure effective ecological restoration in the mine closure phase.

KEYWORDS: ecological restoration; mine closure; regulation.

1. Introduction

Mining is a series of activities in exploration, excavation, processing, utilization and sale of minerals (minerals, coal, geothermal, oil and gas) (Dessai, 2023; Igogo et al., 2021; Michaux, 2021). Indonesia is one of the largest coal producers and exporters in the world. Since 2005, when it exceeded Australian production, Indonesia has become the leading exporter of thermal coal (Cornot-Gandolphe, 2017). The significant portion of the exported thermal coal is of medium quality (between 5100 to 6100 calories/gram) and low quality (under 5100 calories/gram), most of which come from China and India. Indonesia is currently ranked nine with approximately 2.2% of total global coal reserves, about 60% of Indonesia's total coal reserves consist of lower-quality sub-bituminous coal containing less

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than 6100 calories/gram. Indonesia also increased coal production from 114 million tons in 2016 to reach the highest value in 2013 of 279 million tons (CEIC, 2017).

According to Environmental Law Alliance Worldwide (2010), mining activities in addition to causing positive impacts can also have negative impacts on the environment, especially in terms of water quality degradation, air quality changes, flora and fauna habitats being damaged, reduced soil fertility, and social conflict. Considering the impacts of mining activities on the environment, ex-pit, facilities, waste dump or disposal should be rehabilitated by reclamation and revegetation (Hazarika et al., 2006). Lima et al. (2016) states that reclamation aimed at restoring ecosystem function and biogeochemistry is one of the best approaches to managing open pit mining. Each holders of mining permit either Coal Mining Concession Working Agreement/*Perjanjian Karya Pengusahaan Pertambangan Batubara* (PKP2B), Mine permit license/*Izin Usaha Pertambangan* (IUP) and Contract of Work/*Kontrak Kerja* (KK) are required to conduct reclamation and mine closure in accordance with the Ministry of Energy and Mineral Resources (MEMR) Decree No.7/2014 on the Implementation of Reclamation and Post-Mining on Mineral and Coal Mining Activities. There are more regulation that related to post mining or mine closure such as Government Regulation of Indonesia Decree No.27/2012 about environmental permit that provide Ministry of Environment (MoE) to launch Decree No.3/2014 about Program For Pollution Control, Evaluation and Rating (PROPER), Ministry of Forestry (MoF) Decree No. P.4/Menhut-II/2009 concerning forest reclamation guidelines and MoF Decree No. P.60/Menhut-II/2009 on guidelines on the success of forest reclamation.

Currently, Indonesia has examples of mining companies with gold commodities that have finished performing post-mining obligations, namely PT. KEM in East Kalimantan and PT. NMR in Sulawesi. According to G., Mcguire (2003), the status of production forest areas is limited to the area of PT. KEM after mine closure turned into a protected forest area to maintain the stability of civil structures waste dump/disposal that has been done rehabilitation. To support this, a community of sustainable business possibilities in the ex-mine area of 6.670 Ha is available such as fruit, rattan, fish, ecotourism and forest related research. Environmental Agency District Paser (2018) also states for coal mining commodities there is PT. BHP Kendilo Coal which has finished doing mine closure and there is difference of early area that is production forest become other usage area upon entering mine closure. After the void or mine hole from the mining activity has been used as a tourist park by the initiator of the activity and after doing some research related to ecological restoration by the university and the government, then in the area there is a change of area again from other use area into forest with forest park function (TAHURA/*Taman Hutan Raya*) in 2013 according to MoF No. SK.141/Menhut-II/2013. Two examples of mining companies above are examples of how mining land use as a result of mining activities can be used for other purposes that would require assessment and advice from stakeholders.

Fig. 1. Ex-mining pit area transformation to forest park (TAHURA) Lati Petangis (Environmental Agency District Paser, 2018)

Zhenqi et al. (2012) stated that ecosystem diversity, nutrient accumulation and nutrient cycle should be further studied to determine the main factor of system stability. In addition, research on ecological restoration in mining or mine reclamation areas with different types of minerals, differences in environmental degradation and different reclamation techniques in Indonesia need to be made of databases and model samples. Restoration ecology research was also conduct by many researcher such as Hobbs (1996) with the criteria such as restoration of physical and chemical characteristics of soil, restoration of vegetation cover, creation of heterogen condition of flora and fauna, re–creation of basic ecological processes between soil, water, nutrient cycles and regular monitoring and evaluation. Nichols et al. (2005) with criteria Curragh mine reclamation success with four stages such as planning, establishment, development and sign-off and monitoring and maintenance. If restoration ecology didn't made progress after mine closure, it can make heavy damage to environment surroundings such as flora, fauna, water quality and social impact (Sengupta, 2021; Tibbett, 2024; Wu et al., 2024).

This research aims to review mine closure regulation in Indonesia with the concept of restoration ecology. Research on the policy of post-mining reclamation success has been done by MMSD (2012) in Australia, United States, Papua New Guinea, Canada, Chile, South Africa, Philippines, Japan, Brazil, Bolivia, Ireland, Peru and Spain. Ardiyanto, W & Ishak, Y (2017) has completed the same research in Indonesia but only comparing three regulation MEMR Decree No.7/2014, MoF Decree No. P.4/Menhut-II/2011, MoF Decree No. P.60/Menhut-II/2009. The authors will add the MoE regulation and ecological restoration criteria according to Nichols et al. (2005). The objective to give recommendation of future mine closure regulation.

2. Methods

2.1 Data collection

This research will use desk study method with the regulation mine closure in Indonesia, which was MEMR Decree No.7/2014, MoE Decree No.3/2014, MoF Decree No. P.4/Menhut-II/2011, MoF Decree No.P.60/Menhut-II/2009 and linkages with ecological restoration. This research will use content analysis which according to Krippendorff (1980) as a research technique to make valid replication and conclusion from the data until the contents of a manuscript or document. Weber (1995) also defines content analysis as a research methodology that utilizes a set of procedures to make valid conclusions from a text or document. Prasad, BD (2008) also stated that this method can analyze letters, diaries, news stories, songs, short stories, radio broadcasts, television, documents, symbols and others.

2.2 Mine closure in MEMR regulation

Definition of reclamation according to MEMR Decree No.7/2014, shall be undertaken throughout the mining business stages to organize, restore and improve the quality of the ecosystem environment in order to function again. A mining company with a number of related regulations should undertake reclamation activities after exploration done, during exploitation and post-mining activities which include void management, infrastructure disassembly, environmental monitoring and continued empowerment of community programs undertaken after exploitation has been completed (Devrath et al., 2025; Pactwa et al., 2021; Turisno, 2022). The definition of post-mining activities or mine closure according to MEMR Decree No.7/2014 is a planned, systematic and continuous activities after the end of part or all of the mining activities to restore the function of natural environment and social functions according to local conditions throughout the mining area.

Regulated in MEMR Decree No.7/2014 that prior to the reclamation and mine closure, all holders of mining permits (IUP, PKP2B and KK), both exploration and exploitation stage, are required to place a guarantee fund for reclamation and mine closure. Reclamation and

mine closure guarantees are placed in a local bank or designated bank in the form of time deposits or bank guarantees. Holders of new mining permit may redeem the two guarantee funds regularly after the assessment of reclamation and mine closure assurance in accordance with criteria established by MEMR Decree No.7/2014. Depositing these funds do not eliminate the obligation to conduct reclamation and mine closure activities, if the reclamation and mine closure activities is not running, the government could use the guarantee funds through a third party to continue the activities (Listiyani et al., 2023; Lopes da Costa & Carlos, 2020; Wambwa et al., 2025). The Government of Indonesia through Government Regulation Number 78/2010 on reclamation and post-mining has also stated clearly for sanctions if not conducted activities are written warning, suspension of activities or revocation of mining permit. Certainly the commitment of the mining permit holder is tested.

Table 1. Mine closure success criteria

Activities	Monitoring Objects	Standards of Success
Ex-pit and disposal mine	a. Demolition of mining facilities	The mine facility has been completely disassembled as planned in the Mine Closure Plan document
	b. reclamation of mining facilities	Land has been fully reclaimed as planned in the Mine Closure
	c. Demolition and reclamation of mine roads	The mine road has been dismantled and reclaimed entirely as planned in the Mine Closure Plan document
	d. Surface mining reclamation (pit, waste dump)	Land has been fully reclaimed as planned in the Mine Closure Plan document
	e. Sediment ponds reclamation	Land has been fully reclaimed as planned in the Mine Closure Plan document
	f. Safeguarding all mining areas with underground mining systems that are potentially harmful to humans (shaft, raise, stope, adit, decline, tunned, etc.)	All openings have been secured in accordance with the plans in the Mine Closure Plan document
Processing and / or refining facilities	a. Dismantling of processing and / or purification facilities	The processing and / or refining facilities have been completely dismantled as planned in the Mine Closure Plan document
	b. Reclamation of former land of processing and / or refining facilities	The former land of processing facilities has been reclaimed completely as planned in the Mine Closure Plan document
	c. Reclamation of tailings pond and stabilization efforts	The former tailings pool has been completely reclaimed and its stabilization efforts have been successful
	d. Reclamation of former mining stockpile	The former land of stockpile has been reclaimed completely as planned in the Mine Closure Plan document
	e. Recovery (remediation) of soil contaminated with chemicals, oils, as well as hazardous and toxic materials and hazardous and toxic waste materials	The remediation program has been implemented and is successful
Supporting Facilities	a. Landfill land reclamation	Land of former landfill has been reclaimed completely in accordance with the plan in Mine Closure Plan documents
	b. Demolition of the remaining buildings, transmission of electricity, pipes, ports (air and water), and other facilities	Building facilities, electricity transmission, pipes, ports and other facilities have been completely dismantled as planned in the Mine Closure Plan documents

	c.	Reclamation of former land of buildings, transmission of electricity, pipes, ports (air and water), and other facilities	Ex-building land, electricity transmission, pipes, ports and other facilities have been reclaimed according to plan in the Mine Closure Plan documents
	d.	Disassembling of appliances, engines and fuel tanks of oil and lubricants	Fuel and lubricating equipment, machinery and tanks have been completely disassembled in accordance with the Mine Closure Plan documents
	e.	Handling the remaining fuel oil, lubricants, and chemicals	Handling programs for the remaining lubricants and chemicals are carried out as planned
	f.	Reclamation of used land transportation facilities	land used transportation facilities have been reclaimed according to plan in Mine Closure Plan documents
	g.	Land reclamation of former buildings and concrete foundations	the former land of buildings and concrete foundations have been reclaimed completely according to the Mine Closure Plan documents
	h.	Recovery (remediation) of soil contaminated with chemicals, oils, as well as hazardous and toxic materials and hazardous and toxic waste materials	The remediation program has been implemented and is successful
Social, cultural and economic development			Implemented in accordance with the program established in the plan in the Mine Closure Plan document
Maintenance			
Environment monitoring	a.	Surface water quality	Water quality has met the criteria of success in the Mine Closure Plan documents
	b.	Sea water quality	Water quality has met the criteria of success in the Mine Closure Plan documents
	c.	Ground water quality	The quality of surface water has met the criteria of success in the Mine Closure Plan documents
	d.	Air quality	Air quality meets the criteria of success in the Mine Closure Plan documents
	e.	Noise	The noise level meets the criteria of success in the Mine Closure Plan documents
	f.	Soil quality	Soil quality has met the criteria of success in the Mine Closure Plan documents

Table 1 describes the criteria for mine closure success criteria that includes six activities; the former mine site, processing and/or refining facilities, supporting facilities, social, cultural and economic development, environmental maintenance and monitoring. This criteria has no weight per activities and plans and realizations of each activity adjusted to the Mine Closure Plan document owned company which has been approved by the MEMR.

2.3 Mine closure in MoE regulation

The other obligations that the mining permit holder must have an environmental permit in accordance with the Indonesia Law No. 32/2009 on Environmental Protection and Management, which prior to obtaining environmental permit must prepare an Environmental Impact Assessment (EIA) document before starting exploration and exploitation. EIA contain terms of reference/*Kerangka Acuan Analisis Dampak Lingkungan Hidup* (KA ANDAL), environmental impact assessment/*Analisis Dampak Lingkungan Hidup* (ANDAL), environmental management plan/*Rencana Pengelolaan Lingkungan Hidup* (RKL) and environmental monitoring plan/*Rencana Pemantauan Lingkungan* (RPL) which require

the holder of a mining permit to undertake environmental management and monitoring efforts review the important impacts resulting from mining activity of both environmental and social aspects (Sikdar, 2021; Syafni et al., 2022; Wisnumurti, 2024). The results of the review in the EIA also serve to give consideration to the decision of the feasibility or impropriety of the proposed business plan. RKL & RPL document covers all stage of the mining permit holder operations, starts from pre-construction/exploration, construction, operational and post operational aspects. The post operational stage of the EIA usually the same aspect social, cultural and economic development, maintenance and environmental in Mine Closure Plan document.

The other tools to evaluate ecology restoration was Program For Pollution Control, Evaluation and Rating (PROPER). The history of PROPER began in 1990 which was once known as PROKASIH (Clean River Program/*Program Kali Bersih*), in its development in 1995 it changed into PROPER PROKASIH (specifically for water pollution control). In 2002 until now it became a PROPER which became wider as in Table 2. PROPER has several criteria assessment of which each assessment result is given a flag according to the results of its assessment. Evaluation Criteria PROPER is a form of evaluation on the effort of compliance environment regulation by every business activities.

Table 2. PROPER criteria

PROPER Criteria	PROPER Results
Compliance	Blue rank
1. Control of water pollution	
2. Air pollution control	
3. B3 waste control	
4. Control of land damage	
5. Document Summary of environmental management	Green & Gold rank
6. Environmental Management System	
7. Utilization of resources	
Beyond Compliance	
1.Energy efficiency	
2. Reduction of emissions and greenhouse gases	
3. Water efficiency	
4. Decrease and utilization of B3 waste	
5. 3R garbage	
6. Biodiversity	
7. Community development	

Table 2 explains that several aspects are categorized under the blue rating, which indicates that the company has implemented the required environmental management efforts in accordance with applicable regulations (fulfilling all requirements set by the Ministry of Environment). The gold rating signifies that the company has gone beyond the mandatory environmental management requirements and has carried out continuous community development initiatives. This rating is awarded to businesses and activities that have successfully implemented pollution control and environmental damage prevention measures.

Meanwhile, the green rating represents companies that have implemented environmental management practices exceeding the required standards and have established initiatives such as biodiversity conservation, environmental management systems, 3R (reduce, reuse, recycle) programs for both solid and hazardous waste, load reduction in water pollution, emission reduction, and energy efficiency measures.

2.4 Mine closure in mof regulation

Indonesia Law No. 41/1999 also stated that everyone is prohibited from exploring forests prior to obtaining permission from authorized officials, namely the Minister of Forestry (MoF). Nowdays it changes name to the Ministry of Forestry and the Environment

(MoFE) and reaffirmed by the MoFE Decree No. P.50/Menlhk/Setjen/Kum.1/6/2016 on Forest Land Use License Guidelines on various status of forest areas such as production forests and protected forests. In relation to the status of Forest License Use Permit (IPPKH) to be used for mining activities, various regulations related to the reclamation are issued such as MoF Decree No. P.4/Menhut-II/2011 on forest reclamation guidelines and MoF Decree No.P.60/Menhut-II/2009 concerining guidelines on the success of forest reclamation to encourage the obligations of mining permit holders to reclaim which, according to the two regulations, is defined as an attempt to repair or restore damaged land and vegetation in order to function optimally in accordance with its designation.

Table 3. Reclamation success criteria

Recontouring		Erosion and sedimentation control		Revegetation	
Activities	Weight	Activities	Weight	Activities	Weight
Backfilling of ex-pit area	7.5%	Soil conservation building		Area of planting area	10%
		1. Physical amount	5%		
		2. The benefits of building	5%		
Recountouring area	7.5%	Cover crop	5%	Percentage grows	10%
Land stability	7.5%	Erosion and sedimentation	5%	Number of plants	10%
Spreading top soil	7.5%			Composition of plant species (fast growing, local, exotic, MPTS)	10%
				Health plant	10%
Total	30%		20%		50%

3. Results and Discussion

Of the variety various government regulation that related to reclamation and mine closure. Table 4 is the result of descriptive analysis of each regulation that compare with ecology restoration criteria. It can be seen from Table 4 that the results of the descriptive analysis show that MEMR Decree No.7/2014 has value conformity above other regulation even though the score only reach 54,55%. MoF Decree No.60/2009 more focused on vegetation estabilishment and sustainability and MoE Decree No.3/2014 provide biodiversity management guidance.

Table 4. Matrix comparison mine closure regulation with ecology restoration

Ecology restoration criteria	Standard	MEMR Decree No.7/2014*	MoF Decree No. P.60/2009*	MoE Decree No. 3/2014*
		1. Planning		
The purpose of rehabilitation	Clear rehabilitation objectives have been developed in consultation with other stakeholders	V	V	V
The rehabilitation procedure is documented	Approved rehabilitation procedures have been developed and are being described in the relevant planning and management documents.	-	V	V
Monitoring and research	Rehabilitation monitoring and research programs designed to assess compliance with rehabilitation requirements	V	V	V

	and development, and enable continuous improvement, are undertaken and will continue, if necessary, during the life of the operation			
2. Establishment				
Rehabilitation has been done according to the standard	The Post Registration Monitoring Checklist has been completed as a quality control procedure, to confirm that all is required rehabilitation work has been done	V	V	V
Has the humus been restored?	Topsoil has been fixed with strips in rehabilitated areas, with increased proportions of humus as the slope increases, especially for outer boxcut is broken. If available and practical, the humus may contain viable original seeds that have been replaced directly to the rehabilitated area	-	V	-
3. Development				
3.1Vegetation establishment and sustainability				
The composition of tree species corresponds to the composition of other vegetation types in the lease, which include: - local species				
Plant health	Over 75% of the trees are healthy and grow as	-	V	-

	indicated by long-term monitoring			
Leaf analysis nutrition	Nutritional analysis performed on trees in the representative area showed no lack of key macro or micro nutrients	-	-	-
Tree density	Visual monitoring or estimation shows tree density> 2 m to height> 100 stems / ha, averaged over rehabilitated units	-	V	-
The presence of a treeless area	No areas without trees more than 1 ha are present	-	V	-
Evidence of tree regeneration	Second generation tree seedlings are present or possible, based on monitoring or research on comparable old sites	-	V	-
Erosion control	Visual monitoring and estimation indicate grass cover> 50% of these areas, or the site has sufficient rock cover to maintain erosion below the target standard	V	V	V
Tolerance of drought	Tree species, grasses, and grasses are able to withstand drought, as shown by recent monitoring and research results	-	-	-
3.2 fauna recolonisation				
Management of the fauna habitat in an area that is not mined	Where possible, the fauna habitat in the non-mined area will be protected from	-	-	V

	clearance and grazing as part of the overall Curragh lease management program, and since the area is a source of both fauna and flora recruitment for rehabilitation			
3.3 Stability of land				
The absence of flow erosion	No erosion gutter> 2m and / or 2m depth on the outer boxcut slope	V	V	V
Stability of drainage		V	V	V
3.4 Land suitability				
Soil fertility	The results of monitoring and research indicate that soil macro and micronutrient levels are likely to be sufficient to ensure that trees do not experience nutritional deficiencies (more specific values may be established after some monitoring year, as agreed with EPA)	V	-	-
The Elementary Cycle	Studies conducted on rehabilitated areas (ex decomposition waste and soil microbiology studies) show that the nutritional process of cycling becomes established	-	-	-
3.5 Land suitability				
Suitability for conservation	Areas of rehabilitation and sites not mined in the lease, including the remnant	V	-	V

	areas and the reconstruction of where grazing has been excluded, together have conservation values that are prescribed and manageable for the purpose of conserving various species of local flora and fauna and types of vegetation, including rare species of fauna			
Long-term management	Management requirements have been established and long-term management operations (eg maintenance of access points, fires) will not be greater than areas prior to mining, or where extra-action management may be required, mechanisms have been put in place to deal with this	V	-	V
4. Monitoring and maintenance				
Monitoring	A monitoring program has been developed that addresses post-closure and post-release monitoring requirements, and defines responsibilities for monitoring	V	-	-
Post-closure and post-release management requirements	A plan for dealing with post-closure management and post-exemption requirements has been developed with relevant stakeholders,	V	-	-

	and responsibility for performing tasks has been allocated			
Funding	Mechanisms to allocate the necessary funds for post-management release will be developed jointly with the authorities, and described in the Final Rehabilitation Report	V	-	-
Conformity with criteria Nichols, OG, *et al* .(2005)	54,55%	50%	45,45%	

*V: stated and -: not stated

At the planning stage, almost every regulation met the required criteria. According to MEMR Decree No. 7/2014, every mining permit holder must conduct public consultations with stakeholders to explain the rehabilitation plan after mine closure. This activity allows stakeholders to provide feedback to the permit holder, ensuring that their concerns and suggestions are incorporated into the planning process.

During the establishment stage, MEMR Decree No. 7/2014 mandates that mining permit holders implement the standards and reclamation success criteria outlined in the Mine Closure Plan document. Meanwhile, MoF Decree No. 60/2009 provides guidance on rehabilitation standards in forest areas, which are further detailed in MoF Decree No. 4/2011. These include revegetation plans, execution strategies, and erosion control methods. MoE Decree No. 3/2014, through the environmental management plan, also emphasizes that all activities, including rehabilitation, must follow a structured process—plan, do, check, and act—to fulfill regulatory requirements.

In the development stage, various aspects of ecological restoration are addressed. For vegetation establishment and sustainability, MoF Decree No. 60/2009 details almost all ecological restoration criteria except for leaf nutrient analysis and drought tolerance. MEMR Decree No. 7/2014 and MoE Decree No. 3/2014 provide general guidance within the framework of the environmental management plan or Mine Closure Plan, without detailed provisions for this stage. Regarding fauna recolonization, MoE Decree No. 3/2014 gives particular attention by including clauses on biodiversity program progress. Concerning land stability, all relevant regulations recognize it as a crucial factor to prevent gully erosion, sheet erosion, and landslides in rehabilitation areas. MoF Decree No. 60/2009 outlines detailed criteria requiring the implementation and monitoring of erosion control techniques to assess their effectiveness. For land suitability, MEMR Decree No. 7/2014 obliges mining permit holders to define the future use of rehabilitated land, ensuring it serves the needs of surrounding communities and provides meaningful post-mining functions.

In the monitoring and maintenance stage, only MEMR Decree No. 7/2014 explicitly includes the obligation to support social, economic, and cultural development in villages surrounding mining sites. It also requires the implementation of maintenance, environmental monitoring, and mandates the annual payment of a mine closure guarantee according to the mine's lifecycle.

4. Conclusions

From the result of the research, it can be seen that the regulation related to reclamation and pascatambang yang issued by the MEMR, MoF and MoE have not paid attention to aspects of ecological restoration. There needs to be a synchronization between the two government agencies to make regulations that can take account of aspects of ecological restoration on aspect vegetation estabilishment and sustainability, fauna recolonisation and elementary cycle in Indonesia for mining activities to be sustainable after completion of the activities.

However, despite these existing regulations, integration and coordination among ministries remain limited, and no single regulation fully meets all ecological restoration criteria as proposed by Nichols et al. (2005). Therefore, a more harmonized regulatory approach is required to strengthen post-mining rehabilitation, ensure long-term ecosystem recovery, and align Indonesia's mine closure practices with international standards of restoration ecology.

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Biography of Author

Arief Adi Pradana, School of Environmental Science, Universitas Indonesia, Central Jakarta, DKI Jakarta 10430, Indonesia.

- Email: arief.pradana@ymail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A