

The Paradox of Economic Development : Environmental Sustainability and Economic Growth of the Mining Industry in Indonesia

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ABSTRACT

The mining industry in Indonesia plays an important role in national economic development. However, mining activities often result in significant environmental impacts. This creates a paradox between the need for economic growth and environmental sustainability. This study aims to explore the relationship between economic growth generated by the mining sector and its environmental impacts in Indonesia. The study uses qualitative methods with secondary data analysis from government reports, scientific journals and other relevant sources. The results showed a significant conflict of interest between natural resource exploitation and environmental preservation. The study concludes that sustainability-based policies should be integrated in the management of the mining industry to achieve a balance between economic and environmental development.

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INTRODUCTION

The mining industry is one of the main contributors to Indonesia's Gross Domestic Product (GDP). With abundant reserves of mineral resources, the sector provides substantial foreign exchange, creates jobs, and drives regional economic growth. This phenomenon makes the mining sector the main pillar of national economic development. However, on the other hand, the exploitation of mining resources often causes significant environmental damage. For example, coal mining activities in East Kalimantan have caused massive deforestation, river pollution and disruption of local ecosystems. This raises critical questions about how to manage mining resources sustainably (Razi, 2021; Reno Fitriyanti, 2016).

Globally, sustainability issues are a major concern in the management of extractive industries. Indonesia, as one of the countries with the largest mining reserves in the world, faces great challenges to balance economic benefits and environmental protection. Several cases of environmental pollution due to mining have triggered protests from local communities and criticism from the international community. In addition, existing

environmental regulations are often considered weak in enforcement, opening up space for destructive mining practices (Gunawan, 2023; Maulida & Purwanti, 2023).

Environmental issues caused by mining in Indonesia have been in the international spotlight. More than 500,000 hectares of forest have been lost to mining activities in the last decade. In addition, around 70 percent of mines in Indonesia do not have adequate environmental impact assessment permits. These facts point to weak government oversight and the need for stronger policy intervention (Darc et al., 2009; Kalangi, 2018). On the other hand, the economic and social needs of communities are often the main reason for the sustainability of the mining industry. Regions such as Papua and Kalimantan have a very high economic dependence on this sector. The mining industry is a major source of regional income, creating jobs and improving infrastructure. However, the balance between economic benefits and environmental damage remains an unresolved challenge (Nahriyah, 2024; Ramiadani, 2015).

This paradox in Indonesia's mining sector reflects a complex dilemma. On the one hand, the country needs mining resources to finance development, while on the other hand, the environmental damage caused can threaten the sustainability of the ecosystem. This paradox becomes more apparent when looking at the impact of mining on local communities. Land conflicts, water pollution and loss of traditional livelihoods are often the direct impacts felt by local communities (Amalia, 2023; Siregar et al., 2021). Based on this phenomenon, a holistic approach to managing the mining sector is needed. With increasing global pressure to adopt sustainability principles, Indonesia must urgently formulate policies that integrate economic, social and environmental aspects. This research makes a novel contribution by exploring the paradoxical relationship between economic growth and environmental sustainability, and offering relevant policy recommendations. Another urgency in this research is seen in the increasing global demands for socially and environmentally responsible business practices. Indonesia, as a member of the G20, faces international pressure to meet climate commitments and protect biodiversity. Therefore, this research is relevant in providing practical solutions to address these challenges.

This research provides novelty in emphasizing the importance of environmentally friendly technology as a strategic solution in overcoming the negative impacts of the mining industry. It also highlights the need for local community involvement in monitoring mining activities as part of transparency and accountability efforts. Thus, this research not only adds to the academic literature, but also provides practical guidance for policy makers and industry players. In addition, this research emphasizes a multidisciplinary approach to understanding the impacts of the mining industry. It explores not only economic and environmental dimensions, but also social and cultural dimensions that are often overlooked. Thus, this research is expected to provide comprehensive insights to overcome the paradox of the mining sector in Indonesia. Another contribution of this research is the development of literature on sustainable natural resource governance. By integrating technological, social and policy approaches, this research offers a new outlook on how to create a balance between economic development and environmental protection.

METHODS

This research uses a qualitative approach with descriptive analysis. The qualitative approach was used to understand complex phenomena related to the paradox between economic development and environmental sustainability in the context of the mining industry. This research is exploratory in nature, with the aim of exploring relationships, patterns and conflicts that are not identified through quantitative approaches. The data in this study is secondary data sourced from annual reports and official documents of the Ministry of Energy and Mineral Resources (ESDM), relevant case studies from scientific journals, and news articles documenting mining-related environmental issues. The data analysis technique in this research uses a literature study review with the stages of data organization (data is classified based on the main themes, such as economic impact, environmental impact, and sustainability policy), and Data Interpretation (Data is interpreted to understand the relationship between the main variables).

RESULTS AND DISCUSSION

Economic Contribution

The mining industry contributes significantly to Indonesia's GDP, reaching an average of 7% per year over the past decade. This includes increased foreign exchange from the export of minerals such as nickel, copper and gold. Foreign investment has also increased, accelerating infrastructure development in mining areas such as roads and ports. However, reliance on this sector can create economic risks, especially when global commodity prices experience a downturn (Badan Pusat Statistik Indonesia, 2024). In addition to its positive macroeconomic impact, the mining sector also creates significant employment opportunities, particularly in remote areas where access to other economic opportunities is difficult. For example, nickel mining projects in Sulawesi have created more than 10,000 new jobs for local people. However, most of these jobs are contract, which can create long-term economic instability (Aljauhar et al., 2016).

In a regional context, regions such as Papua and East Kalimantan experienced significant increases in GRDP thanks to the contribution of the mining sector. However, the disparity between mining and non-mining regions is widening, creating inequalities in economic development in Indonesia (Lung, 2020; Saleh & Suseno, 2017). Mining's contribution to state revenue is also evident from tax and royalty revenues, which account for up to 15% of total national revenue by 2022 (Badan Pusat Statistik Indonesia 2023). On the other hand, the economic impacts are not always positive. Economic dependence on the mining sector can lead to a "resource curse", where resource-rich regions fail to achieve economic diversification and long-term stability. Therefore, sustainable development strategies need to be integrated to address these challenges.

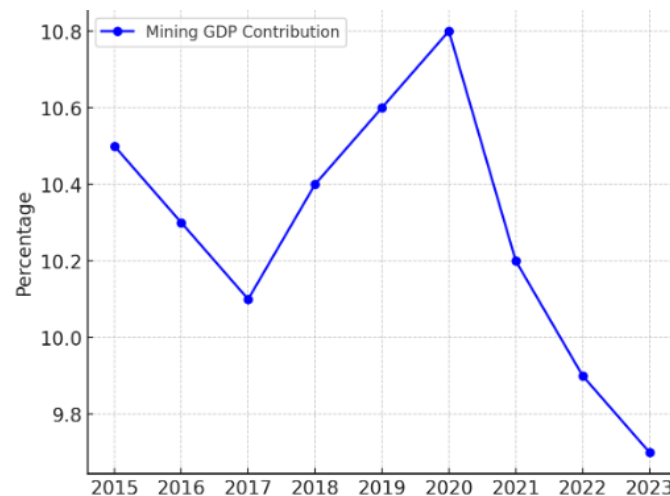


Figure 1. sector's contribution to Indonesia's GDP from 2015 to 2023

The graph illustrates the trend of the mining sector's contribution to Indonesia's GDP from 2015 to 2023. Over this period, the mining sector's share has shown a slight decline, fluctuating between 10.5% in 2015 and 9.7% in 2023. Despite temporary increases in certain years, such as in 2018 and 2020, the overall trend indicates a gradual decrease. Several factors may contribute to this decline, including the Indonesian government's policies promoting economic diversification, the global transition to renewable energy, and increasing environmental regulations that restrict mining activities. Additionally, fluctuations in global commodity prices, particularly for coal and minerals, may have influenced the sector's economic performance. While the mining industry remains a crucial pillar of Indonesia's economy, the declining contribution suggests a growing emphasis on sustainable economic growth strategies, including investments in manufacturing, services, and renewable energy sectors. This trend highlights the need for a balanced approach to resource management that ensures both economic benefits and environmental sustainability.

Environmental Impact

Coal mining activities in East Kalimantan have reduced the area of primary forest by 20% in the last two decades. In addition, pollution of the Mahakam river from mine waste threatens biodiversity and the health of local communities. Despite reclamation efforts, implementation is often slow and inconsistent, causing irreversible damage (et al., 2018). In addition, damage to marine ecosystems due to mine tailings disposal in Sulawesi waters has damaged coral reefs and reduced fish stocks, which has a direct impact on local fishermen (Syarifuddin, 2022). In addition, greenhouse gas emissions from mining activities, especially coal mining, contribute to global climate change (Arifiyanto & Sindu, 2020). In addition, public health risks are also increased due to air and water pollution from mining activities. due to higher levels of exposure to heavy metals, such as mercury and arsenic, which can lead to chronic diseases (Laksono et al., 2020).

Environmental impact mitigation policies are often ineffective due to weak government oversight and conflicts of interest with mining companies. This points to the need for more comprehensive policy reforms to ensure environmental sustainability. Nevertheless, some mining companies have begun to adopt sustainable mining practices, such as post-mining land rehabilitation and the use of environmentally friendly technologies. However, the implementation of these practices is still limited and often inconsistent. (Rizki & Firmansyah, 2021).

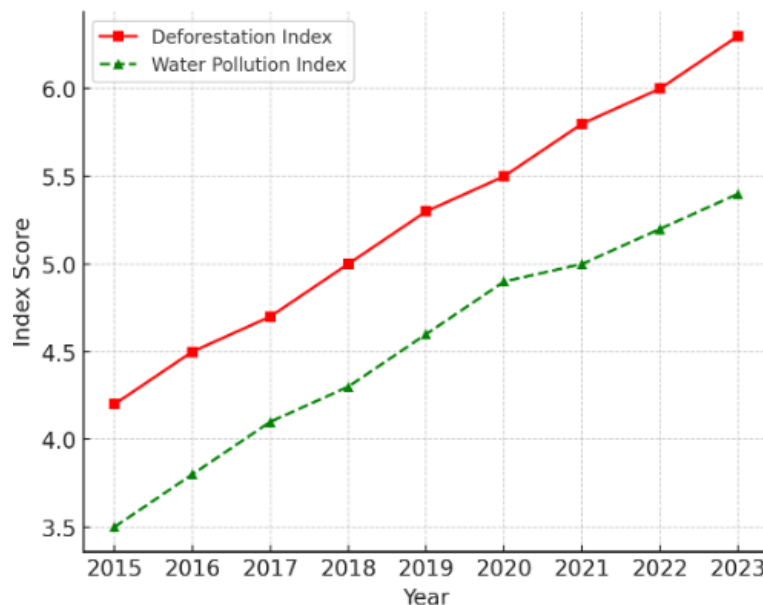


Figure 2. environmental impact of mining in Indonesia from 2015 to 2023

The graph illustrates the environmental impact of mining in Indonesia from 2015 to 2023, measured through the deforestation index and water pollution index on a scale of 1 to 10. Both indicators show an increasing trend, indicating worsening environmental conditions associated with mining activities. The deforestation index has risen steadily from 4.2 in 2015 to 6.3 in 2023. This suggests that mining operations have significantly contributed to forest loss, particularly in resource-rich areas such as Kalimantan and Sumatra. The expansion of open-pit mining and inadequate land rehabilitation are likely key drivers of this trend.

Similarly, the water pollution index has increased from 3.5 in 2015 to 5.4 in 2023. This rise reflects the growing contamination of water sources due to mining-related activities, such as the discharge of heavy metals, acid mine drainage, and improper waste disposal. The degradation of water quality poses serious threats to biodiversity and local communities that rely on these water sources. The increasing environmental impact underscores the urgent need for stricter environmental policies, improved monitoring, and the adoption of sustainable mining practices. Without intervention, the long-term ecological damage could outweigh the economic benefits derived from the sector.

Indonesian Government Policy and Implementation

Land reclamation policies are regulated in Law No. 4/2009, but implementation faces many obstacles. Lack of supervision and incentives for mining companies are major challenges. In contrast, some companies such as PT Freeport Indonesia have demonstrated success in reclamation programs through partnerships with local communities. In addition, government policies in managing the mining sector play an important role in balancing economic contributions and environmental impacts. The Indonesian government has issued various regulations to improve the sustainability of the mining sector, such as Law No. 4/2009 on Mineral and Coal Mining, as well as derivative regulations governing post-mining land reclamation (Nefi et al., 2018).

The implementation of these policies still faces various challenges. One of them is weak law enforcement, which is often caused by corruption and conflicts of interest between regulators and mining companies. Studies show that more than 40% of mining companies in Indonesia do not fully comply with land reclamation regulations. On the other hand, the government also faces pressure from the international community to improve transparency and accountability in the management of mining resources. Programs such as the Extractive Industries Transparency Initiative (EITI) have been adopted to improve reporting and monitoring of mining revenues. Mining zoning policies are also an important issue in the context of sustainability. Many mining areas that should be protected as conservation areas continue to be exploited due to weak oversight (Tampanguma, 2022).

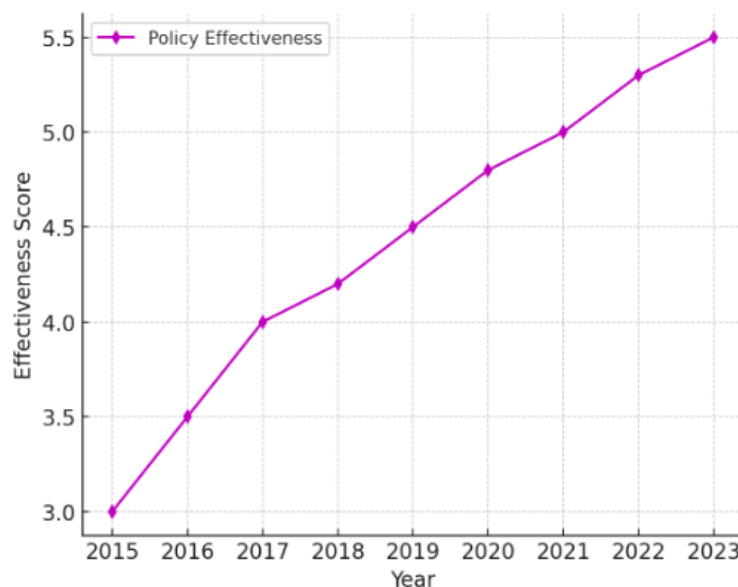


Figure 3. environmental policies in Indonesia's mining sector from 2015 to 2023

The graph illustrates the trend in the effectiveness of environmental policies in Indonesia's mining sector from 2015 to 2023, measured on a scale of 1 to 10. Over this period, the effectiveness score has shown a gradual improvement, rising from 3.0 in 2015 to

5.5 in 2023. While this indicates progress in policy implementation, the effectiveness remains moderate, suggesting that further improvements are needed.

The increase in effectiveness can be attributed to stricter environmental regulations, such as the enforcement of the *polluter pays* principle, mandatory environmental impact assessments (AMDAL), and the introduction of sustainability certification programs. Additionally, government-led initiatives, such as land rehabilitation programs and stricter monitoring of mining operations, have contributed to improved compliance. However, despite these advancements, several challenges persist. Weak enforcement mechanisms, lack of transparency in policy implementation, and limited coordination between government agencies and mining companies hinder optimal policy effectiveness. Additionally, small-scale and illegal mining operations continue to pose significant environmental risks, often operating outside regulatory frameworks. To further enhance the effectiveness of environmental policies, stronger law enforcement, increased funding for monitoring programs, and incentives for sustainable mining practices are essential. Strengthening collaboration between stakeholders—including the government, private sector, and local communities—will also be crucial in ensuring long-term environmental sustainability in Indonesia's mining industry.

Eco-friendly Technology

Green technology has become a key focus in the management of the modern mining industry. These technologies include innovations designed to reduce the negative impact of mining activities on the environment, such as more efficient tailings treatment systems and the use of safer chemicals. One example of the application of green technology is the use of “dry tailings” technology, which reduces the risk of water and soil pollution from mine waste. Although expensive to implement, this technology is starting to be considered a long-term investment that provides great benefits for environmental sustainability (Wati et al., 2024). In addition to waste management technology, innovations in mining exploration have also made significant progress. Sensor-based technology and artificial intelligence (AI) have enabled mining companies to map mineral reserves with high accuracy without the need for environmentally damaging physical exploration. This technology not only reduces environmental impact, but also increases the efficiency of mining operations, which in turn reduces production costs (Wulandari et al., 2025).

Technologies such as the use of tailings filters and bioleaching processes have begun to be implemented to reduce the impact of nickel mine pollution in Southeast Sulawesi (Kompas, 2023). However, the adoption of these technologies is still limited to large companies, while smaller companies often ignore sustainability aspects. In addition, the use of renewable energy at mine sites is another promising step in reducing the carbon footprint. Several mining companies in Indonesia have started adopting solar and wind power plants for their operational energy needs. This step not only helps reduce greenhouse gas emissions, but is also part of the global commitment to achieve net-zero emissions targets (Nugroho et al., 2023). Although various environmentally friendly technologies have been

introduced, their implementation often faces obstacles, especially in developing countries such as Indonesia. The main hindering factor is the high cost of adopting these technologies, which is often considered uneconomical by small and medium-sized mining companies. In addition, the lack of incentives from the government to encourage the use of sustainable technologies is another challenge that needs to be addressed. Expanding the use of environmentally friendly technologies in Indonesia's mining industry requires stronger support from various stakeholders. The government can play a role by providing tax incentives or subsidies to mining companies that adopt sustainable technologies. On the other hand, collaboration between mining companies and research institutions can also accelerate the innovation of more affordable and efficient technologies. With this approach, the mining sector will not only be a pillar of the economy, but also part of the solution to preserve the environment (Harjanti, 2006).

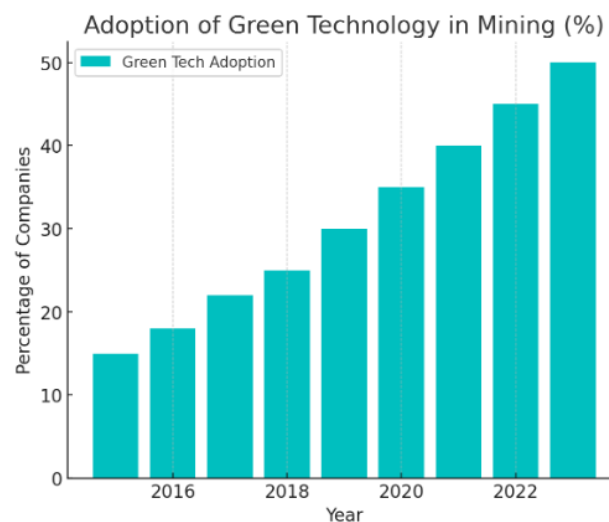


Figure 4. trend of green technology adoption in Indonesia's mining sector from 2015 to 2023

The graph shows the increasing trend of green technology adoption in Indonesia's mining sector from 2015 to 2023. The percentage of mining companies implementing environmentally friendly technologies has grown significantly, from 15% in 2015 to 50% in 2023. This upward trend indicates a growing awareness and commitment within the industry to reduce its environmental footprint. Several factors have contributed to this progress. Government regulations and policies promoting sustainable mining practices, such as tax incentives for green investments and stricter environmental compliance requirements, have encouraged companies to adopt cleaner technologies. Additionally, advancements in mining innovation—such as wastewater treatment systems, energy-efficient equipment, and post-mining land rehabilitation techniques—have become more accessible and cost-effective.

Despite this positive development, challenges remain. High implementation costs, limited technical expertise, and resistance from traditional mining operators slow down the widespread adoption of green technology. To accelerate this transition, continued

government support, financial incentives, and industry collaboration are crucial. If this adoption trend continues, the mining sector can achieve a more sustainable balance between economic benefits and environmental conservation.

CONCLUSION

This study shows that the mining industry in Indonesia is a major pillar of the national economy, contributing to commodity exports, state revenue, and job creation. However, the negative environmental impacts, such as ecosystem destruction, pollution, and loss of biodiversity, present a serious dilemma. Although policies and regulations exist to address environmental impacts, their implementation remains weak due to ineffective supervision, inconsistencies between central and local policies, and a lack of commitment from mining companies. Green technologies, such as post-mining land recovery systems and the use of renewable energy, could be crucial in mitigating these impacts, but they require significant investment and supportive policies for technological innovation. Therefore, Indonesia needs to adopt sustainability-oriented development policies by strengthening regulations, encouraging green technology innovation, and fostering collaboration between the government, private sector, and communities. This approach will create a new paradigm that integrates the economy with environmental conservation, providing long-term benefits for the country's sustainability.

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