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Carbon Offset: A Sustainable Green Mining Industry from the Triple Bottom Line Perspective

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Abstract: This study aims to develop a sustainable green mining model based on the Triple Bottom Line (TBL) framework, emphasizing that coal mining companies must not only focus on economic efficiency but also on reducing carbon emissions through natural-based offsets and social-environmental contributions. By using a qualitative case study approach on coal mining companies in Indonesia, this research highlights the urgency of integrating green practices into mining operations to address ecological damage and improve corporate sustainability reporting. This study employed a qualitative case study approach on a coal mining company group in Indonesia, involving eight key informants across various departments, utilizing participant observation, in-depth interviews, and document analysis, with data analyzed through reduction, linkage to the triple bottom line theory, and triangulation to ensure validity. This study concludes that green mining, when viewed through the triple bottom line lens economic, environmental, and social is an urgent and essential strategy for sustainable mining operations. Carbon offset mechanisms, such as nature-based solutions and carbon trading, along with green accounting and sustainability reporting, play a crucial role in reducing environmental impact and increasing corporate accountability. Supported by government regulations, these practices not only mitigate climate change but also offer long-term economic benefits and social value. It is recommended that mining companies adopt comprehensive green mining practices by integrating carbon offset strategies into long-term business models, supported by refined government regulations, enhanced stakeholder competencies through academic and professional training, further research on carbon offset impacts, and strong public-private collaboration to accelerate the transition toward a sustainable green mining industry.

Keywords: Carbon Offset, Green Mining, Nature-Based Solutions, Sustainability Reporting, Triple Bottom Line.

INTRODUCTION

The Triple Bottom Line (TBL) theory is a sustainability framework that emphasizes that companies must consider three main aspects in managing company performance: Profit, People, and Planet. This concept states that the success of business performance is not only measured in terms of financial profit, but also from the social and environmental impacts it causes. The TBL framework in sustainable development has fundamentally changed the way organizations and policy makers understand and measure performance. TBL, which goes beyond traditional economic success, integrates economic, social, and environmental objectives, creating a tripartite framework for assessing the long-term impact of business decisions (Ionut et al., 2025).

Most companies in Indonesia still focus on disclosing financial reports related to financial performance, but now financial conditions alone are not enough to guarantee the sustainability of a company. Sustainability in the business world is becoming an increasingly interesting topic for investors, stakeholders, and companies to overcome uncertainty (Liu et al., 2024). Through sustainability is a way for a company to minimize damage caused by company activities to the environment, society and whether the company has good governance (Zyznarska, 2020). In addition, transparency in reporting can increase stakeholder trust and the company's reputation and sustainability reporting significantly improves company performance (Fitriyani, 2024).

The growing industry has a positive impact on the economy and the practicality of community life. Although it has a positive impact on humans, industrial activities have a negative impact on the environment, such as a significant increase in greenhouse gas (GHG) emissions (Onifade & Alola, 2022). An important factor contributing to economic development is energy consumption, which is provided through the combustion of natural gas and fossil fuels (Phong, 2019). According to a report by the Energy Institute think tank entitled Statistical Review of World Energy 2024, emissions from the energy sector in Indonesia in 2023 will reach 701.4 million tons of carbon dioxide equivalent.

Indonesia has a long history of coal mining, starting with the opening of its first mine in 1849. The 1960s brought liberalization of the country's investment and mining laws, leading to a significant increase in new mine openings in the late 1980s. This rapid growth made Indonesia the world's leading exporter of steam coal in 2005. In 2013, Indonesia supplied 38% of global steam coal exports, and 50% of Asia's demand. The coal industry sector in Indonesia is a major driver of economic growth in Asia (Afkarina et al., 2019). The current phenomenon is that the coal industry sector in its production process is related to environmental and social issues, for example carbon emissions from the use of fuel in the operation of heavy equipment and generators, land and forest clearing for mining areas, water waste, and others that need attention related to people and the environment.

Previous research conducted by Afkarina et al., showed that coal mining activities are a factor that influences economic development both locally and nationally. In addition to profitable coal mining, it also causes the growth of environmental damage in a region. Wu's research states that the coal mining industry has direct and indirect GHG emissions because the production process uses many energy sources that are not environmentally friendly, which have a major impact on the health of workers and the environment, so it requires ecological management as an effort to mitigate fuel emissions produced to absorb or eliminate emissions released (Wu, 2024). In this regard, it can be noted that reducing or eliminating ecological environmental damage caused by mining activities is a very hot issue (Prabandani et al., 2024). Previous research conducted by Qirem et al., 2023 and Wang et al., 2020, that professional organizations and government intervention are needed to regulate the preparation of a company's sustainability report and a sustainability committee is needed to regulate environmental, sociological and environmental impacts (Qirem et al., 2023). From the perspective of optimizing the coal mining industry, the authorities must create green mining

efficiency in coal mining companies and eliminate companies that have poor operations (Wang et al., 2020).

The novelty of this study is that a sustainable green mining model cannot be carried out only with process efficiency activities in reducing carbon emissions, but also reducing carbon emissions naturally (natural-based) through downstreaming business lines to offset excess carbon emissions in other business lines and implementing a green economy through company contributions to the environment and society. This study aims to provide a framework related to efforts to implement carbon emission reduction through natural carbon offsets carried out by coal mining companies from the perspective of the triple bottom line theory. This study uses an object in a Group of coal mining companies in Indonesia located in Jakarta, with the location of its mining area (jobsite) mostly on the island of Kalimantan, where researchers use qualitative methods based on case study analysis, interviews and documentation related to this study.

METHODS

This study uses a qualitative approach through a case study design. The object is a coal mining company group in Indonesia located in Jakarta, with the majority of its mining area (jobsite) located on the island of Kalimantan. This company group is the only coal mining company that has ever produced 1 billion Bcm in a period of 1 year. Of course, this company group contributes large carbon emissions in line with its large production results.

There are 8 informants, consisting of 1 person working in the environmental field, 3 people working in the operation field, 1 person working in the plant maintenance field, 1 person working in the CSR field and 2 people working in the finance field. The selection of these informants is a recommendation from the ESG team of the company that is the object of the study, and it can be ensured that the informants interviewed are persons in charge who know and are directly involved in the research problem. The following are the names of the selected key informants (not their real names):

Table 1. Key informant

No	Name	Age	Length of Service (Years)	Position
1	Febri	34	12 Thn	Environment Section
2	Irpan	53	30 Thn	CSR Manager
3	Aldi	37	14 Thn	Operation Section
4	Hidayat	49	24 Thn	Operation Section
5	Baliq	35	10 Thn	Operation Officer
6	Yanto	49	18 Thn	Plant Maintenance Expert
7	Seti	37	14 Thn	Finance Section
8	Ginan	32	10 Thn	Finance Section

The data collection technique uses the participant observation method, namely researchers who are involved in daily activities as a source of research data. In-depth interviews with key informants are considered capable of providing accurate information. Information is obtained by providing several questions asked to informants with question guidelines such as the concept of green mining in the mining sector, mining waste management and financial aspects related to the research objectives. Furthermore, document analysis such as sustainability reports and company financial reports. In conducting data analysis, researchers divide it into several stages, namely:

1. First, data grouping and reduction, namely grouping data into 3 main parts (economic, social and environmental), concluding, highlighting the main things, emphasizing crucial aspects, and removing unnecessary things.

2. Second, analyzing data that has been obtained from key informants and linking it to the triple bottom line theory (people, planet and profit).
3. Third, data triangulation to test the validity of the data. Triangulation is a multi-method approach when collecting and analyzing data. Examples are: a) method triangulation, which involves comparing information or data in various ways. b) Triangulation of data sources, conducted by investigating the truth of information (data credibility) by utilizing various techniques and sources of data collection. In this study, the researcher compared the answers of key informants with library documents such as sustainability reports and financial reports that have been prepared by the company.

The analytical framework diagram of thinking can be described as follows:

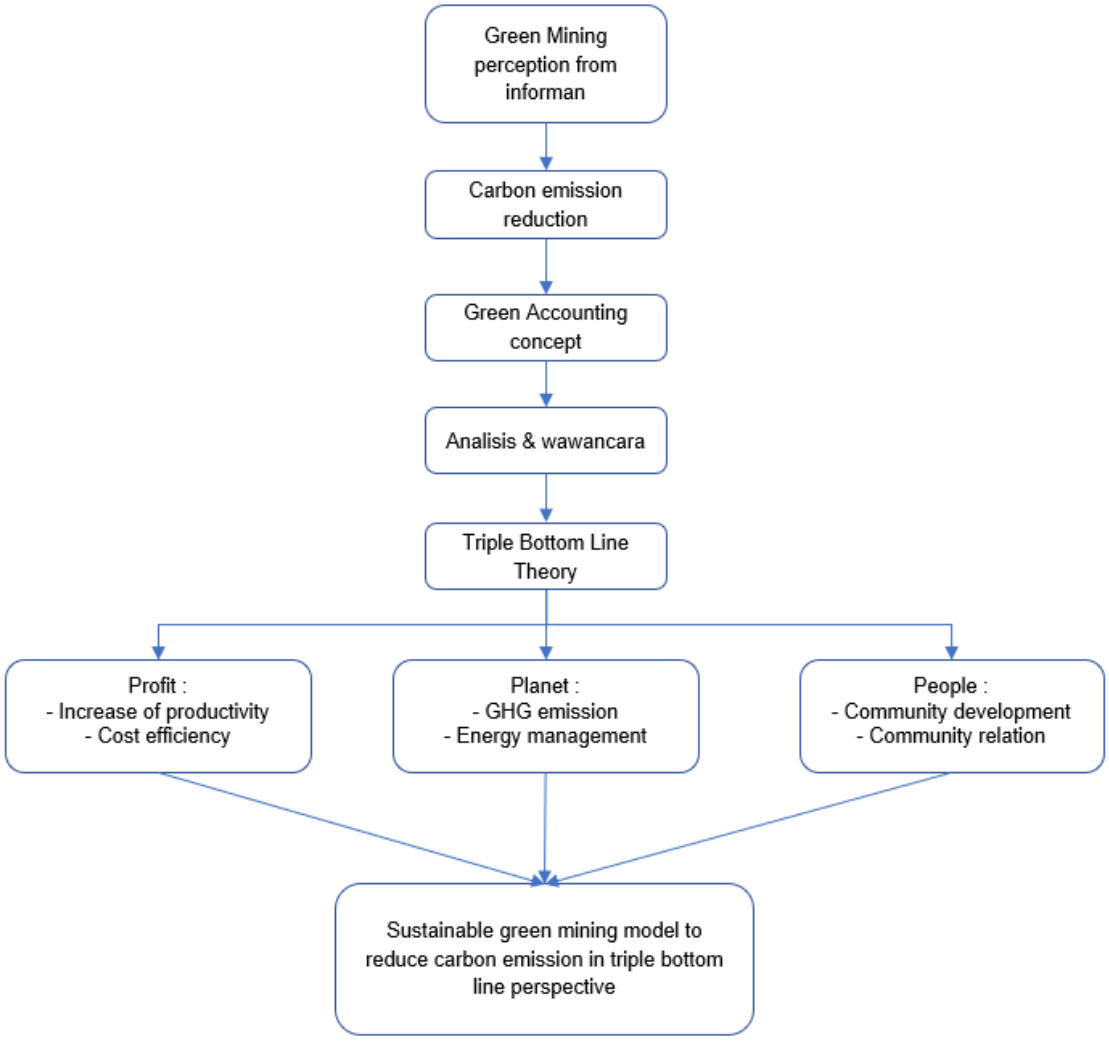


Figure 1. Analytical thinking framework diagram

RESULTS AND DISCUSSION

Green Mining and Corporate Sustainability: Profit and Planet Dimensions

Green mining refers to mining practices that minimize adverse impacts on the environment and society by emphasizing resource efficiency, responsible waste management, reduction of greenhouse gas (GHG) emissions, and biodiversity conservation. Several schemes have been developed to achieve green mining objectives through the lens of the triple bottom line (TBL) approach.

Based on a questionnaire response from Mr. Febri (34 years old, with 12 years of service), *"Green Mining is a term used to describe environmentally-oriented mining practices, both in terms of preventing environmental pollution and promoting efficient use of natural resources. This becomes crucial for mining companies as part of their responsibility to the environment and society. The company implements programs aimed at mitigating the impacts of climate change, including GHG emissions management, renewable energy mix increase, water and wastewater management, hazardous and toxic waste ("B3") handling, and maintaining natural balance through biodiversity management."*

The Profit Dimension and Its Impact on Mining Company Sustainability

According to the Ellen MacArthur Foundation, extending the lifespan of materials and products through design innovations to avoid waste and pollution, while utilizing regenerative natural processes, is a core principle of the circular economy. Through the adoption of circular economy practices such as product life extension, design innovation, maintenance, reuse, remanufacturing, recycling, and upcycling companies can reduce resource consumption, waste generation, emissions, and energy use.

From Mr. Yanto's (49 years old, with 18 years of service) questionnaire response, regarding corporate initiatives to extend product and material lifespan:

"The company is making efforts to extend the life of oil and major components within units (engines, transmissions, and cylinders) through midlife programs, remanufacturing, and tire retreading. Remanufacturing involves rejuvenating heavy equipment that should have been scrapped so it can be reused, thereby extending engine life. The company has successfully increased unit lifespan from zero to 40,000 operational hours. Instead of purchasing new equipment, the company reuses components through recycling processes to improve the efficiency of existing products and operational cost-effectiveness."

On the operational side, mining efficiency is also pursued through operator compliance in heavy equipment handling to ensure optimal fossil fuel use. According to Mr. Hidayat (49 years old, with 24 years of service):

"The company developed and implemented a system aimed at enhancing fossil fuel efficiency by providing real-time speed and gear selection recommendations to dump truck units. Operator adherence to these recommendations is also measured, with the current adherence level reaching 32%, leading to a reduction in fuel consumption by 0.76 liters per hour per unit."

Concerning fossil fuel efficiency, Mr. Baliq (35 years old, with 10 years of service) explained:

"Several factors influence carbon emissions in mining activities, particularly fuel consumption by operating units. To support green mining, the company has implemented programs such as fuel consumption reduction, unit productivity improvement, compliance with road standards to lower fuel consumption, operator competency checks to match skills with job areas, intelligent operator systems, and the use of simulator technology."

The Planet Dimension and Its Impact on Mining Company Sustainability

The mining industry plays a vital role in the global economy but also faces significant challenges due to climate change. Mining activities contribute to GHG emissions through fossil fuel combustion in heavy equipment operations, methane release from coal mines, and deforestation for land clearance.

According to Mr. Febri (34 years old, with 12 years of service):

"Carbon emissions are one of the most relevant ESG items related to mining operations. The largest source of carbon emissions is the combustion of fuel (Biodiesel 35) used in heavy equipment operations, accounting for 99%, while electricity usage in housing and office facilities contributes the remaining 1%. The company understands that the Indonesian government is committed to reducing GHG emissions by 31.9% by 2030, as previously regulated under Law No. 16 of 2016 regarding the 'Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change,' which sets a GHG reduction target of 29% from business-as-usual levels, or 41% with international assistance. The company is committed to supporting the Indonesian government in achieving its GHG emission reduction goals."

Likewise, Mr. Yanto (49 years old, with 18 years of service) emphasized the integration of employee behavior in realizing green mining initiatives:

"The company consistently ensures environmental management by minimizing the negative impacts of its operations through the integration of sustainable development principles. It must be recognized that environmental improvements contribute to climate change mitigation. Therefore, the company implements policies to reduce climate change impacts by fostering innovation and cultural shifts among employees that add value to stakeholders."

According to Mr. Seti (37 years old, with 14 years of service), key strategies to reduce GHG emissions include:

"Implementing energy management to reduce greenhouse gas emissions, developing renewable energy, substituting production and support equipment with cleaner alternatives (e.g., EV units), leveraging innovation and technology for more efficient operations, and preserving the environment by preventing deforestation."

To ensure safe, efficient, and productive operations, the company promotes a safe, healthy, clean, and environmentally friendly workplace while maintaining energy efficiency. Regarding carbon offset, Mr. Gina (32 years old, with 10 years of service) noted:

"Carbon offset is the process of balancing out emissions resulting from specific activities through the purchase of carbon credits in the emissions market or via forest management that generates oxygen. The carbon offset program is currently in place. The CO_2 emissions produced from mining activities are comprehensively calculated, and carbon offsets are carried out by purchasing carbon certificates from the carbon market."

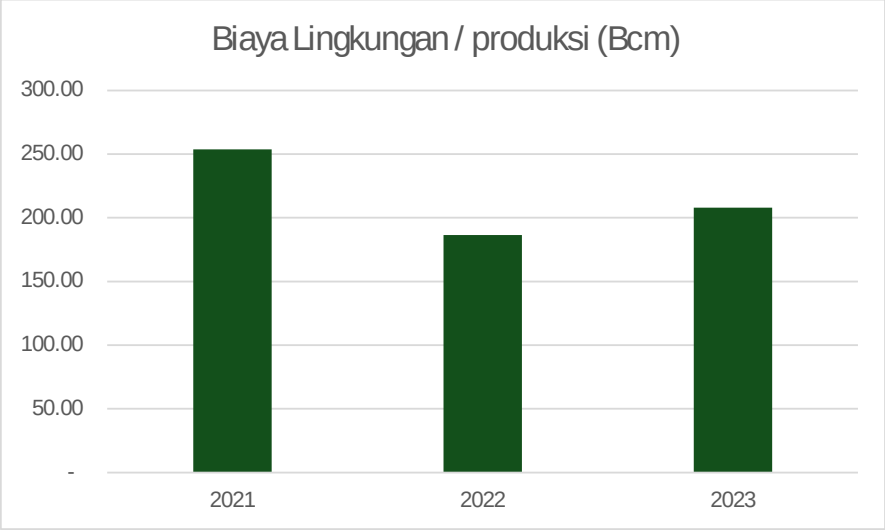


Figure 2. Environmental/Production Cost (Bcm)

The data above is the environmental costs (Planet) incurred by the company in order to provide optimal contribution to sustainability. Environmental costs in 2021 were the highest in the last 3 years in relation to the contribution to handling the covid outbreak, and the sustainability of environmental costs continues to grow under normal conditions along with increased production (sales). The company allocates a budget and provision for environmental cost contributions in monthly financial reporting which is presented as Cost of Revenue and Operating Expense in the Profit and Loss Statement.

The Impact of People (Social Programs for Local Communities) on the Sustainability of Mining Companies

The company has formulated policies and strategies grounded in its vision, mission, and corporate culture, which are implemented through various social responsibility programs. These programs aim to establish the company as a safe and stakeholder-friendly entity through the implementation of Corporate Social Responsibility (CSR). *CSR is recognized as a critical component of sustainable development, and the relationship between CSR and sustainable development has strengthened significantly in recent years*, with the mission of implementing programs that are aligned with the company's long-term business capabilities and capacities. These efforts are designed to foster positive stakeholder relationships and ensure the company's presence is perceived as beneficial by all parties involved.

The company routinely carries out CSR programs, allocating an annual budget recorded in its accounting system as a corporate contribution to the community. *The allocated amounts vary from year to year*, depending on the specific plans and programs to be executed.

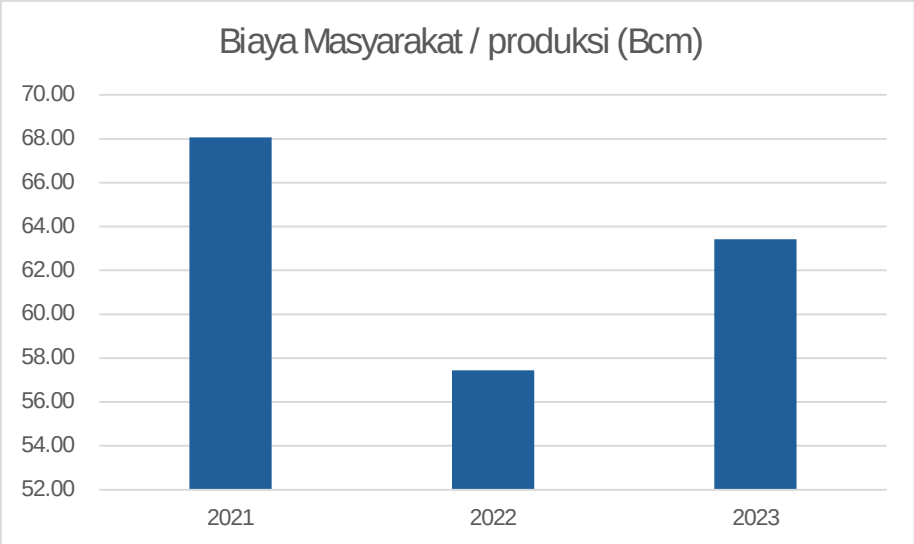
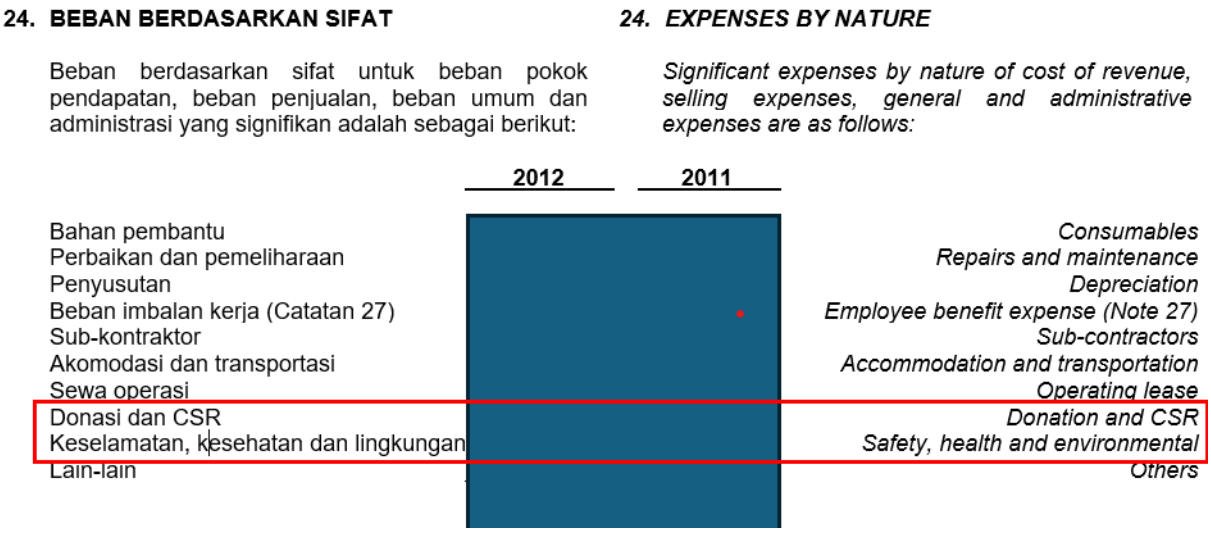


Figure 3. Community Cost/Production (Bcm)

The data above is the cost of society (People) incurred by the company in order to provide optimal contribution to sustainability. The cost of society in 2021 was the highest in the last 3 years in relation to the contribution to handling the Covid outbreak, and the sustainability of the cost of society continues to grow under normal conditions along with the increase in production (sales). The hope of the community for the future is that there will be more programs that help the economy of the surrounding community (people) and empower the surrounding community. The company's hope for the sustainability of the company is that in the future it can continue to collaborate in CSR programs efficiently and effectively, so that it gets support from the community and government while carrying out the company's operational activities in order to get rejection from the community and the surrounding government and the

community feels ownership of the company's presence in the community. The company allocates a budget and provision for the contribution of community costs in monthly financial reporting which is presented as Cost of Revenue and Operating Expense in the Profit and Loss Statement.



24. BEBAN BERDASARKAN SIFAT

Beban berdasarkan sifat untuk beban pokok pendapatan, beban penjualan, beban umum dan administrasi yang signifikan adalah sebagai berikut:

24. *EXPENSES BY NATURE*

Significant expenses by nature of cost of revenue, selling expenses, general and administrative expenses are as follows:

	2012	2011	
Bahan pembantu			*Consumables*
Perbaikan dan pemeliharaan			*Repairs and maintenance*
Penyusutan			*Depreciation*
Beban imbalan kerja (Catatan 27)			*Employee benefit expense (Note 27)*
Sub-kontraktor			*Sub-contractors*
Akomodasi dan transportasi			*Accommodation and transportation*
Sewa operasi			*Operating lease*
Donasi dan CSR			*Donation and CSR*
Keselamatan, kesehatan dan lingkungan			*Safety, health and environmental*
Lain-lain			*Others*

Figure 4. Cost of Revenue and Operating Expense in the Income Statement

The following is the concept of a sustainable green mining model in this study:

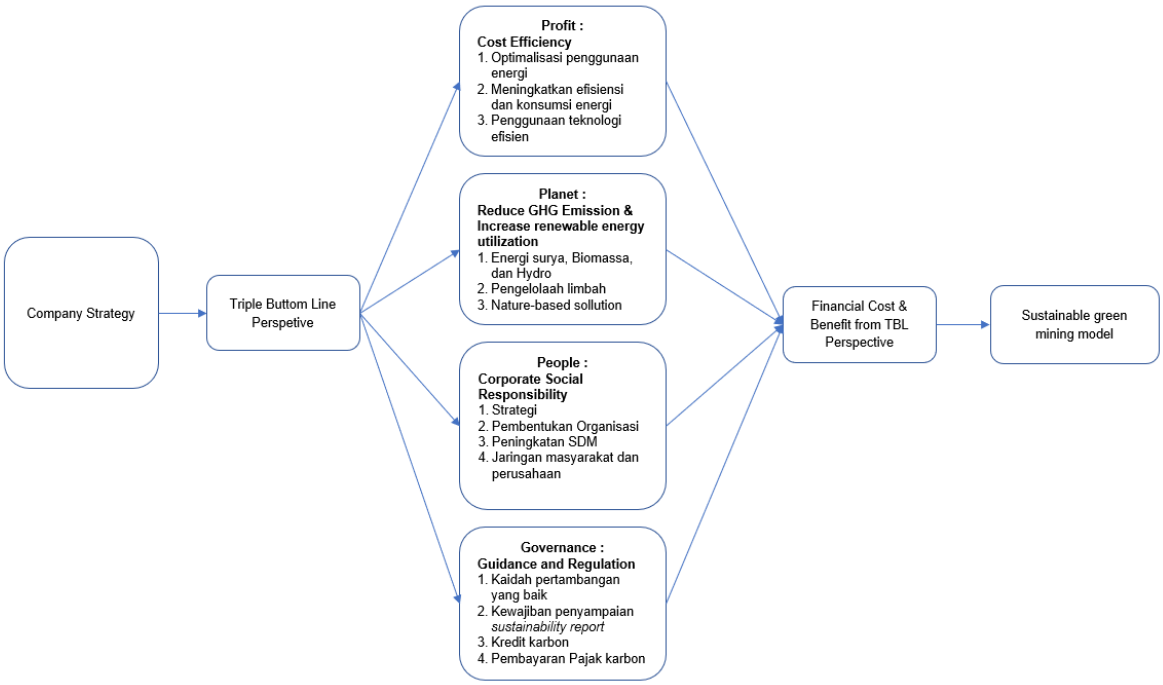


Figure 5. The concept of sustainable green mining model in this study

Discussion

This study reveals that the concept of green mining is a necessary and urgent approach to ensure that the mining industry can operate sustainably. *By minimizing environmental impacts, enhancing energy efficiency, empowering local communities, and aligning with government regulations, green mining offers significant long-term benefits to the economy, environment, and society.* Although implementation challenges persist, the commitment to greener mining practices is a crucial step toward a more sustainable and responsible future.

In Indonesia, carbon trading has become a critical component of national efforts to combat climate change, particularly through Presidential Regulation (Perpres) No. 98 of 2021 on Carbon Economic Value (NEK). The government has established an emission cap for specific sectors. Companies with emissions below this cap may sell their excess allowances to those exceeding the limit. By applying green mining principles, the mining industry can operate more responsibly and deliver broader benefits to surrounding communities and ecosystems. Green accounting or environmental accounting integrates environmental costs and benefits into various accounting practices and incorporates these environmental factors into business decision-making. *This fact also correlates with environmental and social fields* (Dwianika et al., 2023).

Nature-Based Solutions (NbS)

Nature-based solutions (NbS) offer a holistic approach to addressing carbon emissions. NbS leverages the power of nature to tackle environmental challenges, including climate change, through the protection, management, and restoration of ecosystems such as forests, wetlands, and coral reefs. Forests play a crucial role in climate change mitigation due to their function as natural carbon sinks. *Trees in forests absorb carbon dioxide (CO_2), with forests possessing a remarkable capacity to sequester and store carbon over the long term.*

Currently, the company is implementing a Nature-based Solutions (NbS) program through forest land acquisition and the establishment of a new business line focused on preventing deforestation and providing carbon offsets for its core mining operations. In the future, NbS represents a new business opportunity capable of generating revenue through carbon credit sales, profitability prospects, increased economic contributions to the government, and the promotion of a cleaner environment.

Carbon Trading (Carbon Offset)

Carbon offsetting is one of the adaptation strategies employed to reduce greenhouse gas emissions. In Indonesia, the mechanism for purchasing carbon certificates is regulated through the Indonesian Carbon Exchange. This practice serves as a last resort when internal efficiency measures are insufficient to meet carbon reduction targets. Carbon trading is a market mechanism that allows entities to buy and sell carbon emission allowances. *It serves as a key tool in the global effort to combat climate change by incentivizing the reduction of greenhouse gas emissions.*

The carbon trading concept is based on a simple principle: entities that can reduce emissions below the set cap can sell their unused allowances to those struggling to meet their emission limits. This creates an economic incentive to lower emissions, as companies can profit from selling surplus allowances or buy them to cover excess emissions. Currently, the company voluntarily purchases carbon certificates to offset carbon deficits in mining areas and put it as intangible asset at financial report. Government involvement is vital in establishing an effective carbon trading framework. *The success of carbon trading implementation relies heavily on strong government commitment and support.* With appropriate policies, the government can drive significant greenhouse gas reductions, foster innovation, and stimulate sustainable economic growth.

Accounting Implication

The sustainable green mining model is an approach within the mining sector that aims to minimize environmental and social impacts while ensuring economic profitability. The Indonesian government, through Financial Services Authority Regulation (POJK) No. 51/POJK.03/2017 concerning the Implementation of Sustainable Finance for Financial Services Institutions, Issuers, and Public Companies, mandates that a Sustainability Report

must be publicly disclosed. This report should include the company's economic, financial, social, and environmental performance in conducting sustainable business practices. Furthermore, the regulation requires that issuers and public companies prepare Sustainability Reports either as separate documents or as an integral part of the Annual Report. Therefore, the presentation of sustainability reporting is crucial, and accountants play an essential role in delivering sustainability-related information that users can rely on for both business and non-business decision-making purposes *(Mavlutova et al., 2023).*

CONCLUSION

This study concludes that green mining, approached from the triple bottom line perspective economic, environmental, and social is not only necessary but also urgent for the sustainability of the mining industry. Through carbon offset mechanisms, including nature-based solutions and carbon trading, mining operations can mitigate environmental degradation, enhance energy efficiency, empower local communities, and align with governmental regulations. These strategies collectively contribute to long-term benefits that address not only business sustainability but also environmental preservation and social responsibility. Although implementation challenges remain, the shift toward green mining is a vital step in shaping a more responsible and future-oriented industry.

The integration of green accounting and sustainability reporting further strengthens the accountability of mining companies in aligning with global environmental and financial standards. Government support, through regulations such as Perpres No. 98/2021 and POJK No. 51/2017, plays a crucial role in enabling the success of carbon trading and green finance. Carbon offset initiatives, including voluntary carbon certificate purchases and forest-based sequestration projects, highlight the mining sector's evolving commitment to climate change mitigation. Moreover, nature-based solutions offer a promising avenue for creating new revenue streams while contributing to ecological balance. Altogether, these findings underscore the strategic importance of embedding environmental and social considerations into core mining operations.

Based on the findings, it is recommended that mining companies adopt green mining practices more comprehensively by integrating carbon offset strategies into their long-term business models. Governments should continue to refine regulatory frameworks that support transparency, accountability, and incentives for sustainable practices. Academic and professional institutions are encouraged to develop capacity-building programs to enhance the competency of stakeholders in environmental accounting and sustainability reporting. Future research should explore the quantitative impact of carbon offset programs on mining company performance and community welfare. Lastly, collaboration between the public and private sectors is essential to accelerate the transition toward a sustainable green mining industry.

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