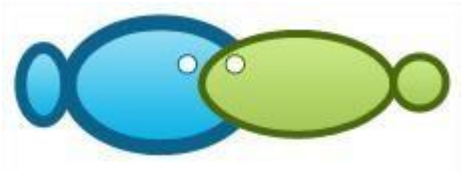

Analysis of environmental management strategies in areas affected by coal pollution in West Aceh, Indonesia

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Abstract. This study employs a descriptive and survey-based approach, collecting primary data through interviews with stakeholders, including officials and local fishermen, as well as secondary data from various institutions. It aims to analyze the impact of coal mining on small-scale fishing communities by examining internal (strengths and weaknesses) and external (opportunities and threats) factors affecting their sustainability. Utilizing internal factor analysis (IFAS) and external factor analysis (EFAS), the study seeks to formulate strategies to mitigate the negative impacts of coal mining, supplemented by the analytic hierarchy process (AHP) to develop more effective action steps that enhance community welfare. The analysis results indicate that the total score for internal factor evaluation (IFE) is 2.913, reflecting strengths such as abundant natural resources (score 0.464) and strong government commitment (score 0.410). However, significant weaknesses, including budget constraints (score 0.410) and weak inter-agency coordination (score 0.436), present major challenges in management. Conversely, the total score for external factor evaluation (EFE) is 2.666, indicating opportunities for collaboration with non-governmental organizations and obtaining international funding support. Nonetheless, there are threats to address, such as inconsistent government policies (score 0.276) and negative stigma towards the coal industry (score 0.144). The AHP analysis shows that in West Aceh's environmental management, Strengths carry the highest weight at 40%, followed by Opportunities at 25%, Weaknesses at 20%, and Threats at 15%. The strategy emphasizes Community-Based Rehabilitation Programs (30%) to empower communities and raise environmental awareness, eco-friendly technology innovations (25%) for improved waste management, and fundraising from international donors (20%) for financial support.
Key Words: coal mining, small-scale fishing communities, environmental management, IFAS, EFAS, AHP.

Introduction. Coal pollution remains a significant global environmental issue, affecting air quality and public health and contributing to climate change. The following analysis provides a comprehensive overview of global coal pollution data, its environmental impacts, and recent studies highlighting the statistics associated with coal emissions (Brooks et al 2019; Machowski et al 2024). In 2023, global emissions from coal reached approximately 15.5 billion metric tons of CO_2, accounting for about 45% of total greenhouse gas emissions from fuel combustion (Friedlingstein et al 2023; Statista 2024). China is the largest emitter, responsible for 8,550 million metric tons of CO_2 from coal, followed by the United States with 1,200 million metric tons. Emissions from coal-fired power plants grew by over 2% in 2022, primarily driven by increases in emerging markets and developing countries (Cooke et al 2024). The coal mining sector in Indonesia plays a significant role in the national economy, with production exceeding 600 million tons in 2022 (Hia et al 2023; Sujai et al 2023). According to the World Energy Council (WEC, 2013), Indonesia ranks fifth among the largest coal producers in the world, following China, the United States, India, and Australia (Kitt & Yates 2020).

However, Indonesia is the second-largest exporter globally, after Australia. The domestic demand for coal in Indonesia remains relatively low, at around 20-25% of total national production (Alami 2017; Asif et al 2022; Ungureanu et al 2024). As one of the

major coal producers in the world, Indonesia is highly dependent on this commodity, which exposes the economy to fluctuations in global prices. This high dependence poses risks not only to economic stability but also to environmental sustainability. Coal mining activities contribute to carbon emissions and pollution, negatively impacting ecosystem quality and public health, especially in areas near the mines, where respiratory issues are increasingly common (Chattopadhyay & Chattopadhyay 2020; Finkelman et al 2021; Zerizghi et al 2022).

Aceh Barat is one of the regencies with coal mines. The coal mining activities in Aceh Barat are conducted using open-pit mining methods, which can lead to various problems, such as the formation of large holes that damage land, land subsidence or depressions from leftover excavation materials, and piles of mining waste that pose risks of landslides and contain toxic substances. Additionally, difficulties in revegetation arise due to the lack of organic material and nutrients that are carried downstream (Feld et al 2011; Gastauer et al 2022). Common pollution issues in the mining industry include dust and water quality problems (BIAN et al 2010a; Dehkordi et al 2024). The dust generated in mining areas and residential communities causes various effects, disrupting both mining activities and community life, as well as leading to health issues.

Environmental management in areas affected by coal pollution is crucial for maintaining the quality of life for local communities and ensuring ecosystem sustainability (BIAN et al 2010b; Mondal & Palit 2022). Although the impact of mining operations has been significantly felt by the community, local fishermen acknowledge that they have received Corporate Social Responsibility (CSR) programs from the coal mining industry. For instance, PT Mifa Bersaudara and PT Bara Energi Lestari (BEL), two subsidiaries of PT Media Djaya Bersama (MDB Group), were recognized by the governments of Aceh Barat and Nagan Raya in 2024 as the best CSR managers in their respective operational areas. In Aceh Barat, PT Mifa Bersaudara has received recognition as the best CSR manager from the local government from 2015 through 2024 (Tarigan et al 2023).

Pollution caused by mining activities, such as dust, waste, and water contamination, can lead to serious health problems. Therefore, an integrated approach is needed, which includes regular monitoring of air, water, and soil quality, as well as post-mining land rehabilitation programs through the planting of local vegetation. Collaboration among the government, mining companies, NGOs, and local communities should be encouraged to create sustainable policies and practices. This study aims to formulate effective environmental management strategies in areas affected by coal pollution in Aceh Barat, taking into account environmental factors, public health, and community participation.

Material and Method. This study employs a descriptive and survey-based approach, utilizing literature reviews and survey techniques to collect relevant data. The descriptive method aims to provide a detailed description of the research object through the collection and analysis of data from a representative sample without drawing general conclusions (Thuillier et al 2015). The data collected consists of two types: primary and secondary data. Primary data were collected through comprehensive direct interviews with a variety of respondents. This included officials from the provincial Marine and Fisheries Office, representatives from the county Fisheries Department, local government authorities, fishermen's groups, and village and district officials. These interviews aimed to capture a diverse range of perspectives regarding the impact of coal mining on small-scale fishing communities. Additionally, discussions were held with representatives from coal mining companies and local community members to enrich the understanding of the situation from various viewpoints. This methodological approach was specifically designed to gather in-depth information on how coal mining activities affect the livelihoods, practices, and overall well-being of small-scale fishermen. By directly involving various stakeholders, this research seeks to uncover nuanced insights into the socio-economic challenges faced by these communities, as well as their perceptions of the mining industry's influence on their traditional practices. Furthermore, secondary data were collected from various institutions and departments involved in marine and fisheries management in Aceh, along with relevant prior research reports. The collection of secondary data is crucial as it provides a broader context for the primary findings, helping to validate and support the insights obtained from

direct interviews. This dual approach not only enhances the robustness of the research but also facilitates a more comprehensive understanding of the interplay between coal mining and small-scale fishing communities in the region.

This method involves several steps, including identifying internal and external factors that affect the fishing community. Internal factors consist of positive contributions (strengths) and negative contributions (weaknesses) within the community. Meanwhile, external factors encompass positive aspects (opportunities) and negative aspects (threats) that can influence their sustainability. Internal factor analysis (IFAS) and external factor analysis (EFAS) are used to evaluate these factors in detail. The results of this analysis are expected to provide a clear picture of the fishing community's position in facing existing challenges (Ngurah et al 2024). Subsequently, analytic hierarchy process (AHP) analysis is conducted to help formulate more detailed and focused strategies, ensuring that the steps taken are more effective in addressing the negative impacts of coal mining and improving the welfare of small-scale fishing communities in West Aceh (Khazaii 2016).

Results and Discussions

Case of coal pollution. This study found that coal spills have contaminated the beaches of West Aceh Regency, Aceh Province, occurring repeatedly without serious action from the government. These spills, which involve materials used for power generation, have been happening since 2017, with three incidents recorded in just 2023. Despite the recurrence of these coal spills, there has been no significant response from local authorities, either at the level of West Aceh Regency or Aceh Province. The waters of Meureubo, which are home to coral reefs, sea turtles, and various fish species, have suffered serious damage due to this pollution. The coral reefs in the marine conservation area (KKL) have begun to show signs of deterioration since the coal contamination of the sea and beaches.

Source: Kompas Indonesia Source: Mongabay Indonesia.

Figure 1. Coal pollution on the coast of West Aceh.

Since the end of September 2023, coal spills have once again contaminated the beaches of Meureubo district. This is not the first occurrence, as it has happened multiple times. In 2023 alone, there have been three recorded incidents of coal spills. Meureubo is a marine conservation area and part of the traditional territory of Panglima Laot. Interviews with local

fishing groups reveal that coal spills have become an annual problem. Fishermen reported that coal is often seen scattered along the beach, carried by ocean currents, which complicates their efforts to catch fish. Forest Nature and Western Environment (AHAN) has noted that since 2023, coal spills on the beaches of Meureubo have occurred three times. However, there has been no significant action taken by the government, either at the level of West Aceh Regency or Aceh province. The waters of Meureubo are home to coral reefs, sea turtles, and various fish species. However, since the coal pollution, the coral reefs have begun to show signs of damage. Coral reefs play a crucial role as habitats for marine organisms to find food, shelter, and breed, and they house 25 percent of marine species. Additionally, coral reefs provide natural functions as wave breakers, minimizing the impact of large ocean waves. This helps protect coastal areas from threats that could endanger the safety of residents living and working along the shore. Healthy coral reefs also guarantee the livelihoods of fishermen, especially for the traditional fishermen in the Panglima Laot area. According to Rufa, the Special Committee on Mining, Mineral Resources, and Energy of the Aceh Provincial House of Representatives (DPRA) previously conducted an investigation into the coal spills that occurred in April 2023.

Figure 2. Location of Coal Exploitation.

Coal production trend. The West Aceh Regency government has granted mining concessions to PT MBA covering an area of 3,134 hectares, based on West Aceh Regent Decree Number 117 of 2011. PT MBA is a subsidiary of PT MDB, which holds exclusive mining rights over an area of more than 4,629 hectares in Aceh Province. The concession area of PT MDB is estimated to contain approximately 169 million tons of coal, with total coal resources reaching 455 million tons. Through ABM Investama, PT RMH has acquired a 70% stake in PT MDB, making PT RMH the majority owner of PT MBA. The concession area of PT MBA is estimated to have proven coal reserves of 7 million tons and inferred coal reserves of 209 million tons. Thus, the total coal reserves of PT MBA amount to 216 million tons. The projected overburden for this area is estimated to reach 1.15 billion Bank Cubic Meters (BCM) over 19 years, which translates to an average of approximately 4 million BCM per month. The stripping ratio (SR) for this area is 4.7 SR, indicating the volume of overburden that must be removed to obtain one ton of coal in the mining area.

Table 1

Realized and planned coal production

Year	*Cover Layer (million bcm)*	*Coal (million tons)*	*Strip Ratio*	*CV (Kcal/kg)*	*TM % (ar)*	*TS % (ar)*
2012	0.8	0.10	2.80	3,370	44.00	0.15
2013	8.6	2.50	3.30	3,200	44.00	0.15
2014	22.2	6.40	3.60	3,200	44.00	0.18
2015	37.9	10.50	3.90	3,270	45.00	0.16
2016	57.1	14.50	3.90	3,270	44.00	0.22
2017	55.4	14.50	3.80	3,280	44.00	0.17
2018	54.7	14.50	3.80	3,360	43.00	0.17
2019	64.2	14.50	4.40	3,330	44.00	0.19
2020	68.5	14.50	4.70	3,350	43.00	0.19
2021	68.9	14.50	4.80	3,380	42.00	0.24
2022	69.3	14.50	4.80	3,390	42.00	0.23
2023	69.3	12.90	5.40	3,380	42.00	0.17
2024	69.3	14.20	4.80	3,380	43.00	0.16
2025	69.3	13.30	5.20	3,380	43.00	0.16
2026	67.9	14.50	4.70	3,400	43.00	0.16
2027	69.3	11.70	5.90	3,370	43.00	0.16
2028	57.5	9.80	5.80	3,390	43.00	0.16
2029	54.8	10.00	5.40	3,430	42.00	0.17
2030	29.8	5.40	5.10	3,430	42.00	0.20
2031	20.3	4.00	4.70	3,490	41.00	0.20

Sumber: Source: PT MBA (2024).

Analysis of data from 2012 to 2031 shows an increasing trend in coal production, peaking at 14.50 million tons between 2018 and 2021. This was followed by a decline to 12.90 million tons in 2023, with a stabilization of around 14.20 million tons projected for 2024. The overburden increased consistently, reaching 69.3 million BCM, while the stripping ratio exhibited significant fluctuations, rising from 2.80 to 5.90, indicating a decrease in mining operational efficiency. The calorific value (CV) remained relatively stable, ranging from 3,200 to 3,490 Kcal/kg, while the total mineral (TM) content decreased from 44% to 41%, suggesting an improvement in the extraction efficiency of quality coal. The total sulfur (TS) content fluctuated, showing a decrease to 0.16% by 2026, which may reflect improvements in the mining process.

Analysis of environmental management factors in areas affected by coal pollution. This SWOT analysis focuses on the factors influencing environmental management in areas affected by coal pollution, based on interviews, questionnaires, and field observations. The results identify internal factors, such as strengths that include skilled human resources and supportive environmental policies, as well as weaknesses like funding limitations and a lack of community knowledge. Additionally, external factors encompass opportunities, such as increasing public awareness and institutional support, and challenges, including industry resistance and inconsistent regulatory changes. Understanding these elements enables more effective planning and implementation of environmental management to achieve sustainability.

Table 2

Internal factor evaluation (IFE) affecting environmental management in West Aceh

No.	*Internal Strategic Factors*	*Weight*	*Rating*	*Score*
	Strengths			
S1	Aceh Barat Regency has abundant natural resources.	0.116	4	0.464
S2	Strong commitment from the government in addressing pollution issues.	0.082	5	0.410
S3	High public awareness of environmental issues.	0.071	4	0.284
S4	The region's experience in handling environmental issues.	0.093	3	0.279
S5	Potential for collaboration with the private sector to support environmental rehabilitation programs.	0.076	3	0.228
	Subtotal Strengths		1.665	
	Weaknesses			
W1	Budget constraints hinder the implementation of environmental management.	0.082	5	0.410
W2	Inadequate infrastructure for waste management, leading to inefficiencies and public health concerns.	0.091	1	0.091
W3	Limited skills and knowledge among the community in environmental management.	0.110	2	0.220
W4	Weak coordination between government agencies, non-governmental organizations, and other stakeholders.	0.109	4	0.436
W5	Dependency on external assistance or donor support for environmental management program funding.	0.091	1	0.091
Subtotal			1.248	
	Total Score		2.913	

There are 10 internal factors (strengths and weaknesses) related to environmental management in areas affected by coal pollution in West Aceh. The sustainability analysis of environmental management in West Aceh reveals significant strengths, such as abundant natural resources (0.464), which offer considerable potential for resource-based economic development. Additionally, the strong commitment of the government to address pollution issues (0.410) and the high level of public awareness regarding environmental issues (0.284) indicate solid public support for stricter environmental policies. The region's experience in managing environmental issues also serves as an important asset, scoring 0.279, along with the potential for collaboration with the private sector (0.228), which could expedite rehabilitation programs. However, there are also significant challenges, including budget constraints (0.410) that may hinder the implementation of environmental management. Weak coordination among government agencies and other stakeholders (0.436) presents a barrier to the effectiveness of programs. Furthermore, the lack of skills and knowledge among the community regarding environmental management (0.220) highlights the need for capacity building through education and training. Inadequate infrastructure for waste management (0.091) and reliance on external aid (0.091) further increase risks to sustainability. With a total score of 2.913, stakeholders need to leverage existing strengths while actively addressing these weaknesses to achieve better and more effective environmental sustainability in the future.

Table 3
External factor evaluation (EFE) affecting environmental management in West Aceh

No.	*External strategic factors*	*Weight*	*Rating*	*Score*
	Opportunities			
O1	Collaboration with non-governmental organizations strengthens rehabilitation programs.	0.121	3	0.363
O2	Availability of international donor funds supports environmental management projects.	0.096	4	0.384
O3	Environmentally friendly technological innovations increase waste management efficiency.	0.078	3	0.234
O4	Increased international attention to environmental issues attracts investment.	0.091	4	0.364
O5	Education and training programs enhance community knowledge.	0.072	3	0.216
	Subtotal opportunities			1.561
	Threats			
T1	Inconsistent government policies hinder strategy implementation.	0.092	3	0.276
T2	Conflict between industrial interests and community needs.	0.083	2	0.166
T3	Economic downturn due to pollution reduces public support for programs.	0.098	3	0.294
T4	Climate change threats can worsen environmental conditions and rehabilitation efforts.	0.075	3	0.225
T5	Negative stigma associated with the coal industry hinders investment and rehabilitation support.	0.072	2	0.144
	Subtotal threats			1.105
	Total Score		2.666	

There are ten external factors (opportunities and threats) that influence the sustainability of environmental management in areas affected by coal pollution in West Aceh. This analysis indicates that West Aceh has various significant opportunities that can be leveraged to enhance environmental management. One key opportunity is collaboration with non-governmental organizations (NGOs), which received a score of 0.363. Such partnerships can strengthen rehabilitation programs by utilizing local knowledge and community resources for more effective outcomes. Additionally, financial support from international donors, with a score of 0.384, is a critical factor that can assist in funding environmental management projects. This source of funding allows for the implementation of more ambitious and sustainable programs. Innovative eco-friendly technologies, scoring 0.234, also have the potential to improve waste management efficiency, thereby reducing pollution impacts from the coal industry.

Increased international attention to environmental issues, with a score of 0.364, presents another opportunity that could attract investment and support for local initiatives. Educational and training programs for the community, which received a score of 0.216, are essential for raising awareness and building community capacity in environmental management, enabling active participation in the rehabilitation process. However, alongside these opportunities, there are several challenges to confront. Inconsistent government policies, with a score of 0.276, can hinder the effective implementation of environmental management strategies. Policy uncertainty may create difficulties in executing planned programs. Additionally, conflicts of interest between industry and the community, scoring

0.166, could obstruct the collaboration necessary for sustainable resource management. The negative stigma associated with the coal industry, with a score of 0.144, also poses a challenge that must be addressed. Negative perceptions can impede investment and support for rehabilitation programs, making it crucial to shift public views toward the industry and emphasize improvement efforts. With a total score of 2.666, this analysis highlights the importance of capitalizing on available opportunities while actively addressing the threats faced. Success in environmental management in West Aceh will depend on the ability to build strong collaborations, secure necessary support, and engage the community in the management process, all while being mindful of existing challenges to achieve environmental sustainability.

Analysis of environmental management sustainability. This analysis examines the internal and external sustainability matrix of environmental management in areas affected by coal pollution in West Aceh. After calculating the total scores from the IFE and EFE matrices, the next step is to analyze the IE (internal-external) Matrix to determine the current position. The sustainability analysis of environmental management provides insights into how to face pressures and changes, particularly in the context of managing resources impacted by coal pollution in West Aceh.

Table 4

Sustainability analysis of environmental management in areas affected by coal pollution in West Aceh

		Total IFE score		
		High 3.0-4.0	*Moderate 2.0-2.99*	*Low 1.0-1.99*
Total EFE score	High 3.0-4.0	I	II	III
	Moderate 2.0-2.99	IV	V	VI
	Low 1.0-1.99	VII	VII	IX

The results of the IFE and EFE matrices provide a comprehensive overview of the environmental management conditions in areas affected by coal pollution. With a total IFAS score of 2.913, the analysis indicates that the internal conditions of environmental management are at a moderate level. This reflects the presence of various strengths and weaknesses in the existing management system. The positive IFAS value of 0.417 suggests that there is potential to leverage, such as diverse institutional capacities, to improve environmental conditions. Therefore, collaboration with various stakeholders—including local communities, non-governmental organizations, and government agencies—is crucial. Their involvement can strengthen the necessary rehabilitation and mitigation programs to more effectively address the impacts of coal pollution. On the other hand, the external analysis shows that the total EFAS score is 2.666, which also falls within the moderate category. The difference of 0.456 between opportunities and challenges in this analysis indicates that, despite significant challenges, there are considerable opportunities for improvement and further development. Better resource management, including the use of eco-friendly technologies and the implementation of sustainable approaches, can help mitigate the negative impacts of coal pollution. For example, adopting more inclusive and effective rehabilitation methods, along with developing policies that support sustainability, can yield better long-term results. Based on the IFE and EFE analyses, it is evident that environmental management in areas affected by coal pollution requires serious attention and coordinated action.

SWOT analysis. The SWOT analysis is a subsequent step following the IE matrix, resulting in four alternative strategies: S-O (strengths-opportunities), W-O (weaknesses-opportunities), S-T (strengths-threats), and W-T (weaknesses-threats). The SWOT matrix combines internal factors—strengths and weaknesses—with external factors—opportunities and threats—to develop effective strategies.

S-O strategies. This strategy aims to capitalize on external opportunities by leveraging existing internal strengths, such as abundant natural resources (S1) and strong government commitment to addressing pollution issues (S2). For instance, collaboration with non-governmental organizations (O1) can enhance environmental rehabilitation programs. Additionally, utilizing funds from international donors (O2) can support projects focused on eco-friendly technological innovations (O3), thereby improving waste management efficiency and positively impacting the community.

W-O strategies. This strategy focuses on reducing internal weaknesses by taking advantage of available opportunities. Budget constraints (W1) and inadequate infrastructure (W2) can be addressed by optimizing educational and training programs (O5) aimed at enhancing community knowledge. By increasing community capacity in environmental management, it is expected that individuals will contribute more actively to rehabilitation and pollution mitigation efforts. Community involvement can also help reduce dependence on external aid (W5).

S-T strategies. In this strategy, internal strengths are employed to confront external threats. Local experience in managing environmental issues (S4) can be utilized to tackle challenges such as inconsistent government policies (T1) and economic decline due to pollution (T3). Strengthening coordination between government agencies, non-governmental organizations, and other stakeholders is essential to ensure that implemented programs run smoothly and receive adequate support.

W-T strategies. This strategy aims to reduce internal weaknesses while avoiding external threats. For example, to address dependence on external aid (W5) and the risks posed by conflicts of interest between industry and community needs (T2), a review and improvement of funding mechanisms are necessary. Furthermore, enhancing coordination among various agencies can help mitigate the negative stigma associated with the coal industry (T5) and increase public support for rehabilitation programs.

AHP analysis. The results of the AHP (Analytic hierarchy process) analysis provide a clear overview of the priorities and focus areas needed for environmental management in regions affected by coal pollution in West Aceh. Below is a more in-depth explanation of the findings from this analysis.

Table 5

Results of AHP (Analytic hierarchy process)

Criteria	*Sub-factor*	*Comparison matrix*	*Weight*	*Description*
Strengths	Abundant natural resources (S1)	1, 2, 3, 2, 1	0.40	Significant potential for economic development
	Government commitment (S2)	0.5, 1, 2, 1, 1/3	0.25	Strong pro-environment policies
	Public awareness (S3)	1/3, 0.5, 1, 1/2, 1/4	0.15	Public support for environmental issues
	Local experience (S4)	0.5, 1, 2, 1, 1/3	0.15	Experience in addressing environmental issues
	Potential for private sector collaboration (S5)	1, 3, 4, 3, 1	0.05	Collaboration that can expedite rehabilitation
Weaknesses	Budget constraints (W1)	1, 2, 2, 3, 1	0.30	Hinders program implementation
	Inadequate infrastructure (W2)	0.5, 1, 1, 2, 1/3	0.20	Needs improvement for effective management
	Lack of community skills (W3)	0.5, 1, 1, 2, 1/4	0.15	Capacity building is necessary
	Poor coordination (W4)	1/3, 0.5, 0.5, 1, 1/5	0.25	Needed for program effectiveness
	Dependence on external aid (W5)	1, 3, 4, 5, 1	0.10	Long-term risk of dependency
Opportunities	Collaboration with NGOs (O1)	1, 3, 2, 2, 1	0.25	Strengthens rehabilitation programs
	Funding from international donors (O2)	1/3, 1, 1, 2, 1/4	0.30	Additional resources for projects
	Eco-friendly technology innovations (O3)	0.5, 1, 1, 3, 1/3	0.20	Enhances waste management efficiency
	International attention to environmental issues (O4)	0.5, 0.5, 1/3, 1, 1/5	0.15	Increases investment in the environmental sector
	Education and training programs (O5)	1, 4, 3, 5, 1	0.10	Enhances community knowledge
Threats	Inconsistent policies (T1)	1, 2, 3, 2, 1	0.30	Hinders strategy implementation
	Conflicts of interest (T2)	0.5, 1, 2, 1, 1/3	0.20	May reduce community support
	Economic decline (T3)	1/3, 0.5, 1, 1/2, 1/4	0.25	Reduces support for programs
	Climate change (T4)	0.5, 1, 2, 1, 1/3	0.15	Worsens environmental conditions
	Negative stigma of the coal industry (T5)	1, 3, 4, 3, 1	0.10	Hinders investment and rehabilitation support

The results of the AHP (analytic hierarchy process) analysis indicate that, in the environmental management of areas affected by coal pollution in West Aceh, the Strengths factor carries the highest weight (40%), followed by opportunities (25%), weaknesses (20%), and threats (15%). The primary focus of this management strategy is the development of community-based rehabilitation programs (30%) aimed at empowering the community in the rehabilitation process and raising environmental awareness. Furthermore, eco-friendly technology innovations (25%) are crucial for enhancing efficiency in waste management and rehabilitation, while Fundraising from International Donors (20%) is expected to provide significant financial support. This approach creates synergy between internal strengths and external opportunities while addressing weaknesses and threats, ultimately enhancing the effectiveness of rehabilitation efforts and community involvement in environmental protection. The findings of this research are corroborated by similar studies, which indicate that mining activities in Aceh have garnered

significant interest and participation from local communities. This trend is driven by several socio-economic factors, including poverty and limited job opportunities, which compel residents to engage in mining activities as a means of livelihood. Furthermore, there is a noticeable shift towards a more consumptive and hedonistic lifestyle, influenced by the economic benefits that mining can provide. This dynamic underscores the need for balanced approaches that not only address the negative environmental impacts of mining but also consider the socio-economic realities faced by the local population (Sriwahyuni 2022; Tjoetra 2024).

A study by Mardonova (2023) provides an in-depth examination of the environmental, hydrological, and social impacts of coal mining operations, addressing various stages of the mining life cycle and facility patterns. This research reveals that coal mining can lead to significant ecosystem damage, alterations to water resources, and pollution of both soil and air. Complementing this, Hobbs (2008) highlights the critical issue of acid mine drainage (AMD), which poses serious threats to water quality and public health, underscoring the necessity for robust environmental management strategies to mitigate negative impacts. Furthermore, Asif (2022) reviews air pollution control strategies for coal-fired power plants, focusing on technologies to manage emissions of pollutants like PM2.5, SO2, and NOx. This research also explores pathways to achieve net-zero emissions, aiming to alleviate the financial burdens associated with pollution control. Collectively, these studies underscore the urgent need for effective management practices in the coal industry to safeguard both the environment and public health.

Conclusion. The research findings can conclude that environmental management in West Aceh, affected by coal pollution, shows a moderate condition with an IFE score of 2.913 and an EFE score of 2.666. The key strengths identified include abundant natural resources (score 0.464), strong government commitment to addressing pollution issues (score 0.410), and high public awareness of environmental issues (score 0.284). However, there are significant weaknesses that need to be addressed, such as budget constraints (score 0.410) and weak coordination among government agencies (score 0.436), which hinder the implementation of effective programs. Based on the SWOT analysis, several alternative strategies have been identified to enhance environmental management in the region. S-O strategies (strengths-opportunities) emphasize leveraging natural resources and government commitment to improve rehabilitation programs through collaboration with non-governmental organizations and funding from international donors. W-O strategies (weaknesses-opportunities) focus on reducing budgetary weaknesses by optimizing educational and training programs to enhance community capacity in environmental management. Furthermore, S-T strategies (strengths-threats) utilize local experience to address challenges such as inconsistent government policies and the economic impacts of pollution, while W-T strategies (weaknesses-threats) aim to mitigate dependence on external aid by improving funding mechanisms and enhancing coordination among agencies.

The results of the analytic hierarchy process (AHP) analysis also indicate that in the environmental management of West Aceh, the Strengths factor carries the highest weight at 40%, followed by opportunities at 25%, weaknesses at 20%, and threats at 15%. The primary focus of this management strategy is the development of community-based rehabilitation programs (30%) aimed at empowering the community in the rehabilitation process and raising environmental awareness. Additionally, eco-friendly technology innovations (25%) are crucial for improving efficiency in waste management and rehabilitation, while fundraising from international donors (20%) is expected to provide significant financial support.

Recommendations. To enhance environmental management in West Aceh, strong collaboration among local communities, the government, and companies is essential. Communities should engage in environmental education through workshops and waste management initiatives, as well as participate in pollution monitoring. The government needs to strengthen policy frameworks with stricter regulations regarding coal pollution, improve inter-agency coordination through task forces, and facilitate public-private

partnerships to fund sustainable practices. Companies are encouraged to adopt eco-friendly technologies, implement corporate social responsibility (CSR) programs focused on sustainability, and maintain transparency by publishing environmental impact reports.

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