JPPIPA 9(11) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Post-Coal Mining Reclamation Land Sustainability Study in Tebo Regency

Hendriyanto[1]*, Dedi Hermon[1], Eri Barlian[1], Iswandi Umar[1], Nur Efendi[1]

[1] Environmental Science Study Program, Postgraduate School, Universitas Negeri Padang, Padang, Indonesia.

Received: September 9, 2023
Revised: October 3, 2023
Accepted: November 25, 2023
Published: November 30, 2023

Corresponding Author:
Hendriyanto
hendreehendree47@gmail.com

DOI: 10.29303/jppipa.v9i11.5553

Abstract: This research was conducted at one of the coal mines in Tebo Regency, namely PT. Asia Multi Investama. The technique for determining respondents was determined by purposive sampling with a sample size of 54 people. The data analysis techniques used are laboratory analysis (water and land), descriptive analysis (to determine the reclamation model) and sustainability index measurement using multidimensional scaling (MDS) from the three dimensions of sustainability analyzed, namely the social dimension and the economic dimension. and ecological dimensions. The results of soil and water laboratory analysis show a decline in soil and water quality. The results of observations of vegetation in the field also showed a decrease in plant growth. Management of post-mining reclamation land PT. The current Asia Muti Investama is quite sustainable with an Appraisal Post Coal Mining Sustainable (APCMS) score of 55.27 on a scale of 0 -100. The reclamation model that can be applied is the agroforestry reclamation model with the agrosilvofishery system. The leading tree commodities are rubber and palm oil. For fisheries, this is a place for fish breeding in former mining ponds (voids) with types of tilapia, goldfish and catfish. Sensitive factors as levers that influence the sustainability of PT's former coal mining land. Asia Multi Investama.

Keywords: Post-mining; Reclamation; Sustainable

Introduction

Efforts to restore the condition of the land so that it can be functional and efficient in accordance with its intended use require proper planning and implementation of reclamation activities by mining companies and require guidance and supervision efforts by the Government so that the management of mineral and coal resources can be carried out properly and correctly (Asr et al., 2019). Some of the physical obstacles faced in reclamation of ex-mining land are: too dense soil, unstable soil structure, poor soil aeration and drainage, and slow absorption of water (Adnyato, 2016). Apart from that, chemical constraints such as very acidic pH, high levels of salt, and low levels of soil fertility are one of the main problems in carrying out reclamation activities in ex-mining areas (Nugraha, 2019). The consequence is that relatively large inputs are required (such as: artificial fertilizer and organic fertilizer) (Wicaksono et al., 2020).

To improve the quality or revitalize the soil ecosystem so that it can support plant growth and development (Gouda et al., 2018). It would be a shame if post-coal mining land eventually becomes unproductive and actually brings disaster to humans. Reclamation is a mandatory program that must be implemented in every mining activity (Kurniawan & Surono, 2013). The function of reclamation activities is to convert critical land due to mining into productive land, by integrating environmental quality (Putra et al., 2015; Budiani et al., 2020).

Reclamation is needed to restore ex-mining land into land that is safe, stable and productive and well managed for sustainable use of ex-mining land (Tuheteru et al., 2018). Apart from improving the environment, reclamation activities bring great economic benefits to local residents and encourage transformation of regional development progress (Qiu et

How to Cite:
Hendriyanto, Hermon, D., Barlian, E., Umar, I., & Efendi, N. (2023). Post-Coal Mining Reclamation Land Sustainability Study in Tebo Regency. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10330–10337. https://doi.org/10.29303/jppipa.v9i11.5553

al., 2021) as well as social benefits to the community (Kodir et al., 2017; Aipassa et al., 2020).

Based on the results of the monitoring carried out, efforts are made to restore the condition of the land so that it can be functional and efficient according to its intended use through reclamation carried out by PT. Asia Multi Investama (AMI) was partly unsuccessful.

PT. AMI can be seen in some plants that fail to grow (die) in Pit 1 and in the presence of ex-mining holes that are not reclaimed (Pit 2 and Pit 4) due to problems regarding the allocation of reclaimed land for former coal mines between the company and the land owner. Whether or not the reclamation of ex-coal mining land is successful is not only the responsibility of the Mining Business Permit holder but also the responsibility of the regional government and central government as parties that provide guidance and supervision of the expected environmental conditions in an effort to realize good environmental management and management of mineral and coal resources correct and sustainable.

Method

The research method used in this research is quantitative descriptive and survey methods (Sugiono, 2018). This type of quantitative descriptive research method is a method used to describe, explain, or summarize various conditions, situations, phenomena, or various research variables according to events as they exist which can be photographed, interviewed, observed, and which can be expressed through other documentation materials (Bungin, 2015). The survey research method is a method used to obtain data from certain natural (not artificial) places, but researchers carry out treatments in collecting data, for example by distributing questionnaires, tests, structured interviews and so on.

Results and Discussion

Time and Place of Research

The research schedule will be carried out in the period March – October 2022 located at PT. Asia Multi Investama (AMI) in Tengah Ilir District which has an area of 466.20 km2 or 7.22% of the area of Tebo Regency.

Conditions of the Research Area
Ecological Conditions

PT. Mining Business License Area. AMI is mostly other use areas (APL) which are dominated by oil palm plantations and rubber plantations owned by companies and communities. Mining activities result in changes in vegetation components, especially rubber plantations and oil palm plantations. Changes in vegetation during the construction phase will result in a loss of the number of tree species, namely + 16 tree species, a loss of tree potential of 8.5 m 3 /ha, while the erosion of forest tree vegetation genes is estimated at 25.20%. For the cultivation area, there will be a loss of 500-700 rubber trees and 130 oil palm trees. The lost productivity of cultivated plants for rubber plants is 75-100 kg/ha/week while for oil palm plants it is estimated at 1-1.5 tons/ha.

Based on the analysis results, changes in vegetation due to mining activities are large, the direction of the impact is negative, the impact relationship is direct and the location of the impact occurs at the effective location of the mine opening, roads and utility construction.

Figure 1. Regional achievement location research location PT. Asia Multi Investama

Economic Conditions

The majority of Tebo Regency residents live in rural areas. The livelihoods of the population in 2021 are based on data from the Central Statistics Agency, generally in the agricultural sector, namely 57.54%, services at 29.20%, and the processing industry at 13.26%. The community's livelihood before coal mining activities was mostly as farmers.

When coal mining activities operate, many people become workers at coal mining companies. The job positions in coal mining companies that are obtained are not office employees who have positions, but rather technical workers such as laborers, drivers and security personnel. Conditions in the field show that after coal mining, most people will switch to other jobs such as opening trade and service businesses, but people will still return to their original jobs, most of which are farming.

Social Conditions

Before coal mining carried out by PT. The AMI population in the study area is 17,775 people. Without coal mining in the study area the population will increase naturally. With coal mining, it is estimated that population growth will be 2.76% per year (AMDAL PT.

AMI, 2012). The population of Tengah Ilir District, Tebo Regency in 2021 is 26,797 people. The male population is 13,977, and the female population is 12,820 with a sex ratio of 109.02%. The dependency ratio figure for the population of Tengah Ilir District, Tebo Regency in 2021 is 46.42%, meaning that every 100 people of productive age (15-64 years) have around 46 - 47 dependents who are not yet productive (0-14 years) and are considered unproductive. longer (65 years and over) (BPS Tebo Regency, 2022).

Post-Mining Reclamation Model

PT. AMI applies a reclamation model using the backfilling technique reclamation method, which is a method of backfilling overburden material in ex-mining openings where the excavated mining material has been removed. If backfilling has been carried out, it will be covered by spreading top soil on the top of the covering soil with a thickness ranging from 40-100 cm.

After the top soil has been leveled, an analysis of the soil quality will be carried out. If the soil quality is still good, revegetation or planting will be carried out immediately with sea sengon plants at a distance of 6 x 6 meters, while for landfill areas by planting these trees and on the terraces (benches) and slopes are planned to be planted with covercrop plants such as mucuna bracteata, so that sedimentation erosion can be anticipated which can occur during the rainy season.

Furthermore, after the stockpiling activities are completed, planting activities will continue with several types of plants so that it will reduce the risk of waterlogging and reduce the impact of landslides which can disrupt mining activities.

This method was chosen because this method is considered more cost and time efficient due to the relatively close distance to the overburden excavation area, besides that it will also make reclamation activities easier because the ex-mining hole has been refilled with excavated soil.

Post-Mining Reclamation Land Sustainability Index
Sustainability Index

Sustainability analysis of PT coal mining pass reclamation land. AMI in Muara Kilis Village, Tengah Ilir District, Tebo Regency produced a sustainability index for post-coal mining reclamation land, which obtained a multidimensional sustainability index value of 55.27 on a sustainable scale of 0 – 100, as seen in Figure 2.

The sustainability index value obtained is based on an assessment of 29 attributes covered in three dimensions, namely social, economic and ecological dimensions, which are included in the moderately sustainable category. The following is a description of 29 attributes from the social dimension, economic dimension and social dimension (Alemu, 2016).

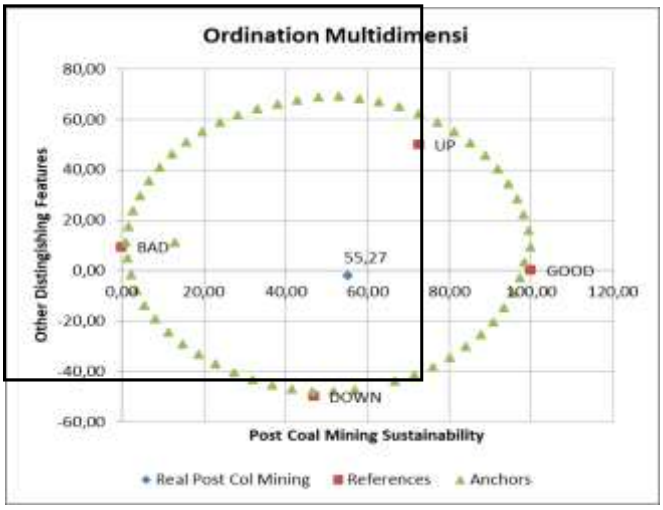

Figure 2. Multidimensional post-mining reclamation land sustainability index value PT. Asia Multi Investama Muara Kilis Village, Tengah Ilir District, Tebo Regency

Social Dimension

Level of employment, health of communities around the mine, frequency of inequality conflicts, relationship between communities around the mine and mining companies, community empowerment in coal mining activities, influence of mining and post-mining on community socio-cultural values, influence on improving education, community awareness for improving the environment and collaboration with the community in managing post-coal mining land.

Economic Dimensions

Creation of business opportunities, influence on community income, economic value of ex-mining land, post-mining economic activities, contribution of the mining sector to GDP, community development programs to encourage the people's economy, existence of economic facilities, costs of restoring environmental damage and benefits of CSR and village development programs for the community around the coal mining area.

Ecological Dimensions

Post-mining surface land degradation conditions, implementation of land reclamation and rehabilitation, vegetation growth on post-mining land, water availability and quality, level of ecosystem disturbance around the mine, frequency of flooding, conservation programs and disturbed land management, water pollution, soil pollution and impact on humans and animals.

The analysis results show that coal mining activities carried out by PT. AMI has so far paid little attention to

social, economic and ecological aspects in an integrated manner. To determine the sustainability index and determine the most sensitive attributes in the management of post-coal mining reclamation land PT. AMI then MDS analysis is carried out on each dimension. Kite diagram image of PT's sustainability index value. AMI shows that the three dimensions studied fall into the quite sustainable category. Kite diagram of PT's post-mining reclamation land sustainability index AMI can be seen in figure 3.

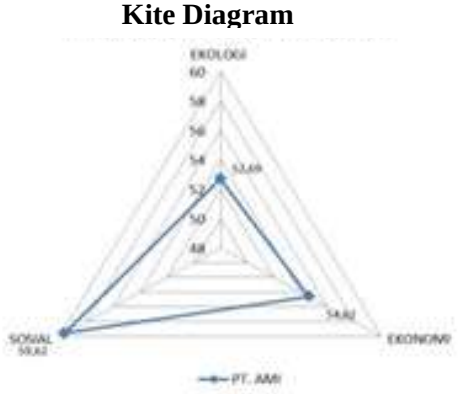

Figure 3. Kite diagram (kite diagram) sustainability index value of post-mining relamation land PT. Asia Multi Investama

The results of the statistical parameter analysis of the stress value (S) and the R-Square coefficient of determination (R2) show that the MDS method has good quality. This can be seen from the stress value in the multidimensional results and each dimension (ecological, economic and social) which has a value below 20%. Likewise, the value of the R-Square coefficient of determination (R 2) is close to 1. The results of the sustainability analysis for several statistical parameters can be seen in Table 1.

Table 1. Sustainability Analysis Results for Several Statistical Parameters

Statistical Value	Multi Dimensions	Social	Economy	Ecology
Mark Stress (S)	0.1342	0.146	0.147	0.151
R-Square (R2)	0.9525	0.947	0.947	0.945

The results of the Monte Carlo analysis in this study did not contain many errors in changing the total index value for each dimension. This also supports the good quality of the results of the analysis that has been carried out. The results of the Monte Carlo analysis for the multidimensional sustainability index values and each dimension in detail can be seen in Table 2. Table 2. Monte Carlo Analysis Results for the Multidimensional Sustainability Values and Each Dimension at 95% Confidence Interval.

Table 2. Results of Monte Carlo Analysis for Multi-Dimensional Sustainability Values and Each Dimension at 95% Confidence Interval

Index Status Continuity	MOS results	Carlo Method Results	Difference
Multi Dimensions	55.27	55.30	0.03
Ecological Dimensions	52.69	52.55	0.14
Economic Dimensions	54.62	54.24	0.38
Social Dimension	59.62	58.96	0.66

Based on table 2, it can be seen that the sustainability index status value of post-coal mining reclamation land of PT. AMI in Muara Kilis Village, Tengah Ilir District, Tebo Regency at a 95% confidence interval gave results that did not differ much from the results of the MDS analysis. The small differences in sustainability index values between the results of the MDS method analysis and Monte Carlo analysis indicate things such as relatively small errors in scoring each attribute, variations in scoring due to differences in opinion are relatively small, the analysis process carried out repeatedly is stable and errors in entering data and data loss can be avoided.

The small differences in the results of the analysis as seen in Table 2 indicate that the analysis uses the MDS method in determining the sustainability of post-coal mining reclamation land at PT. AMI, has a high level of trust, and the method developed in this research can be used as an evaluation tool to systematically, quickly, objectively and measurably assess post-coal mining reclamation land management in an area.

Post-Mining Reclamation Land Sustainability Index from the Social Dimension

The sustainability index value for the social dimension is 59.62 on a scale of 0 – 100. It is included in the quite sustainable category. The sustainability index value of the social dimension of post-mining reclamation land of PT. AMI can be seen in Figure 4.

There are four attributes that most sensitively influence the sustainability value of the social dimension, namely the influence of mining on socio-cultural values, the influence on education level, the health of the community around the mine and community awareness of the environment on the post-coal mining reclamation land of PT. AMI. The value of each social dimension attribute can be seen in Figure 5. The results of the multidimensional analysis of each dimension, namely the social, economic and ecological dimensions, show that of the three dimensions analyzed, the social dimension has the highest sustainability index.

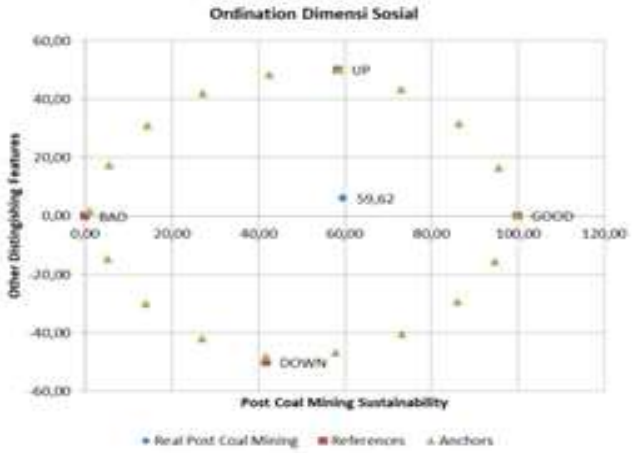

Figure 4. Social dimension sustainability index value of post-mining reclamation land PT. AMI

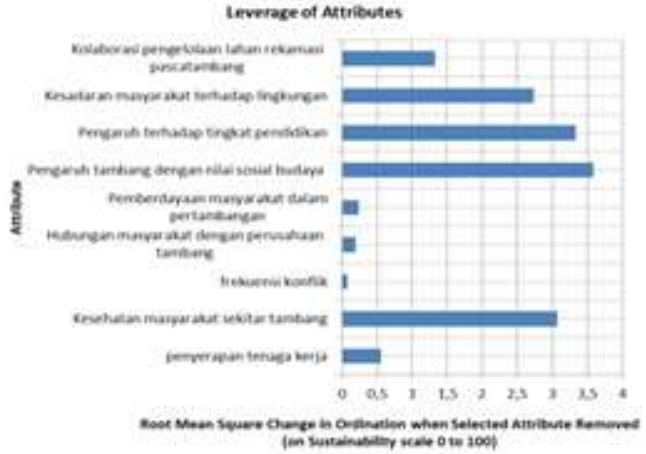

Figure 5. Analysis of social dimension leveraging factors on the sustainability of PT's Post-mining Land Reclamation. AMI

Post-Mining Reclamation Land Sustainability Index from Economic Dimensions

The sustainability index value for the economic dimension is 54.62 on a scale of 0 –100. Included in the quite sustainable category. The sustainability index value of the economic dimension of PT's post-mining reclamation land. AMI can be seen in figure 6.

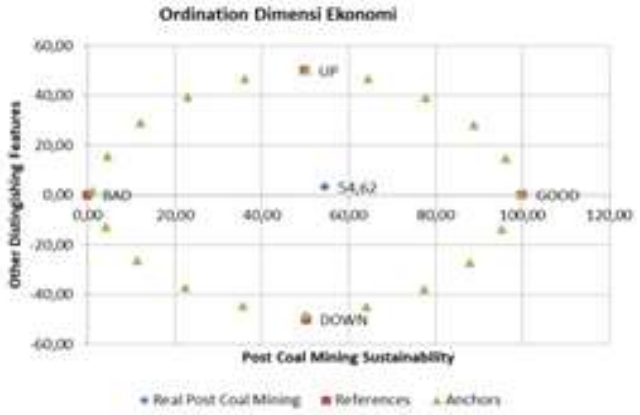

Figure 6. Sustainability index Value of the economic dimension of PT's Post-mining Reclamation Land. AMI

Based on the results of the sensitivity analysis, there are 3 attributes from the economic dimension that most influence the sustainability of PT's post-mining land reclamation AMI is the effect on income company and kmining contribution to GDP and economic value of ex-mining land. This can be seen in figure 7.

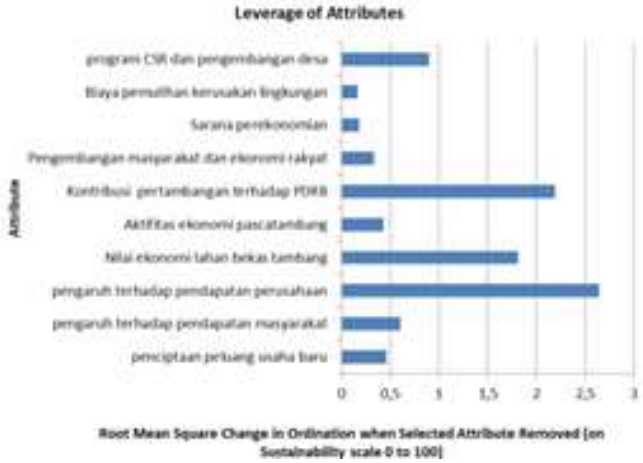

Figure 7. Analysis of economic dimension leveraging factors on the sustainability of PT's Post-Mining Land Reclamation. AMI

Post-Mining Reclamation Land Sustainability Index PT. AMI

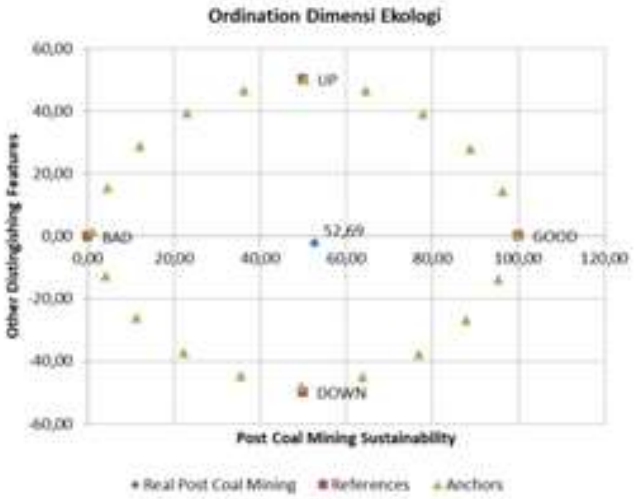

Figure 8. Sustainability index value of the ecological dimension of PT's Post-mining Reclamation Land. AMI

The sustainability index value for the economic dimension is 52.69 on a scale of 0 – 100, including the quite sustainable category. The sustainability index value of the ecological dimension of PT's post-mining reclamation land. AMI can be seen in figure 8. Based on the results of the sensitivity analysis, the RMS value for each ecological dimension attribute is obtained, as presented in Figure 9. Of the 10 attributes analyzed, there are 4 main attributes that have high leverage and are sensitive, namely disturbance to the ecosystem

around the mine, reclamation and land rehabilitation, frequency of floods and disturbed land conservation and management. The RMS value shows the level of influence of the attribute on the sustainability index value. This means that in an effort to improve the sustainability status of the ecological dimension, it is necessary to pay attention to and consider these four attributes (Setyowati et al., 2017).

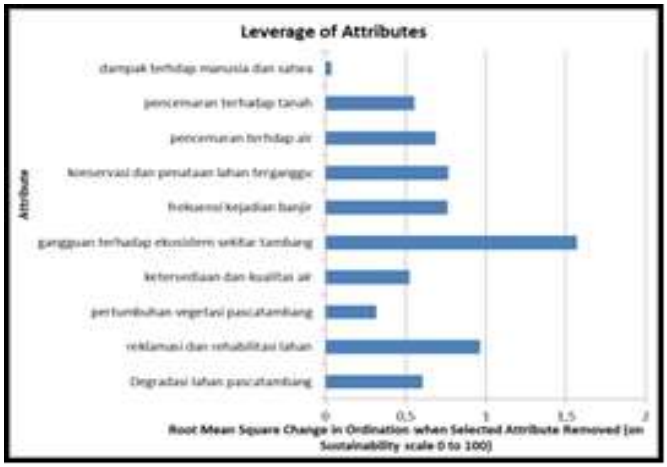

Figure 9. Analysis of ecological dimension leveraging factors on the sustainability of PT's Post-mining Land Reclamation. AMI

Discussion

Implementation of reclamation carried out by PT. AMI is not yet appropriate in its implementation. The ideal condition is that by carrying out reclamation there will be improvements in the physical properties, chemical properties of the soil, and improvement in vegetation (revegetation). Reclamation is expected to reduce flooding and erosion (Nurcahyani, 2011; Zolnierz et al., 2016).

The conditions that occurred in the field were not close to ideal conditions and were not as expected. This is due to the reclamation implementation carried out by PT. AMI is not in accordance with reclamation regulations or rules. These discrepancies include no fertilization, no addition of organic material, no lime and no leveling of the land. Therefore, good and sustainable reclamation modeling is needed. To overcome erosion that occurs on ex-mining land of PT. AMI can be done with alley or fence plants planted in rows parallel to the contour of the land, this is done as a soil and water conservation measure. Hedge plants are a type of legume plant that grows quickly (fast growing leguminous trees), for example Gliricidia (Gliricidiasepium), Lamtoro (Leucaena leucocephala), Kaliandra (Calliandra calothyrsus) and Flemingia (Flemingiacongesta) (Yuan & Li-Kun, 2014; Coder et al., 2017).

In preparing sustainable land reclamation arrangements, apart from the biophysical characteristics of the environment, what is really needed is the contribution of stakeholders, especially the government in providing guidance and supervision in the implementation of reclamation of ex-coal mining land. Results of laboratory tests, field observations, preferences of stakeholders, the company and preferences of the community in the study area through interviews on reclamation models that can be applied to restore land function and sustain PT. AMI is an agroforestry reclamation model. Besides being able to provide services to the environment by observing biodiversity, agroforestry is also able to improve community welfare through harvests (Maryati, 2013; Arif, 2021).

The background of the people in the study area which is based on agriculture and plantations is considered suitable for this reclamation model. Agroforestry is also considered suitable for companies that are environmentally conscious and committed to community development. Agroforestry practices that can be applied for a sustainable reclamation model on former PT coal mining land. AMI is an agrosilvofishery system, combining agricultural crops, various types of wood and fish farming which is considered capable of accommodating the preferences of stakeholders and the community (Sujiman, 2017; Lestari et al., 2019).

Sustainability analysis of land reclamation of PT coal mine bundles. AMI research results show that the sustainability index for the social, economic and ecological dimensions of the sustainability status of PT's post-mining land. AMI is quite sustainable, but among the three dimensions the ecological dimension has a low sustainability index value, namely 52.69 when compared with the social dimension index value of 59.62 and the economic dimension sustainability index value of 54.62. Something you need to pay attention to is the main attribute which is high leverage and sensitivity (Fauzi, 2019; Supriatna, 2021).

In the results of the analysis of the success index for the ecological dimension, there are two leverages that are leveraged and sensitive, namely disruption of the ecosystem around the mine with land reclamation and rehabilitation. By looking at these two attributes, it is true that the implementation of the reclamation model on post-mining land that has been carried out by PT is inaccurate. AMI and reclamation carried out by PT. AMI is not in accordance with good mining technical principles (Prasodjo et al., 2015; Agustian et al., 2021).

Efforts to restore ex-mining land are not just filling in ex-mining holes and replanting (revegetation), but are an effort to restore the condition of the land has been physically degraded and the ecosystem disturbed. The

factor of improving water and soil quality, care and maintenance is one of the benchmarks for achieving efforts to restore disturbed land (Pratiwi et al., 2021; Mahfud et al., 2022). Apart from aiming to prevent erosion or reduce the speed of runoff, reclamation is carried out to keep the land from becoming unstable and more productive (Stavi et al, 2020). Ultimately, reclamation is expected to produce added value for the environment and create a much better situation compared to the previous situation (Bradshaw, 2000).

Conclusion

The results of soil and water laboratory analysis show a decline in soil and water quality. The results of observations of vegetation in the field also showed a decrease in plant growth. Management of post-mining reclamation land PT. The current Asia Muti Investama is quite sustainable with an Appraisal Post Coal Mining Sustainable (APCMS) score of 55.27 on a scale of 0 -100. The reclamation model that can be applied is the agroforestry reclamation model with the agrosilvofishery system. The leading tree commodities are rubber and palm oil. For fisheries, this is a place for fish breeding in former mining ponds (voids) with types of tilapia, goldfish and catfish. Sensitive factors as levers that influence the sustainability of PT's former coal mining land. Asia Multi Investama.

Acknowledgments
During the research, the author received a lot of support, guidance, direction and input from various parties, for this reason the author would like to take this opportunity to thank colleagues and lecturers at Padang State University.

Auhor Contribution
H: preparation of original draft, results, discussion, methodology, conclusions; D. H, E. B, I. U and N. E: analysis, review, proofreading and editing. H, D. H, E. B, I. U and N. E: Visualization, and T. R.and R. A. E. All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interst
The authors declare that there is no conflict of interest regarding the publication of this paper.

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