



Sustainability Status and Factor Analyses to Improve Post-mining Land Use Sustainability Level with Pepper and Rice Plants

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Abstract. This study aimed to: (1) Determine the sustainability status and factors that can be used to improve the post-mining land use with the Multidimensional-Scaling (MDS) method based on the ecological, economical, social, law, infrastructure, and technological dimensions, (2) Calculate the business investment eligibility in post-mining land with pepper and rice plants using the Cost-Benefit Analysis (CBA) method. The MDS-RAPs analysis results obtained ecological sustainability index at 56.73, economical sustainability index at 63.72, social sustainability index at 67.09, law sustainability index at 58.18, infrastructure and technological sustainability index at 89.74. Based on the Investment Eligibility Analysis in Pepper Seedlings, the Net Present Value (NPV) was obtained at Rp 291,770,337.19, Net Benefit Cost Ratio (Net B/C) at 8.95, Internal Rate of Return (IRR) at 13.8%, and Gross BC at 32.6. Meanwhile, the Investment Eligibility Analysis in Rice Plant Cultivation obtained the NPV at Rp 178,372,549.80, Net B/C at 3.89, IRR at 23.63%, and Gross BC at 23.2. From these results, it can be concluded that the open coal post-mining land use as pepper and rice plant cultivations is eligible to conduct based on the sustainability and business investment eligibility analyses, following the proper environmental organization and restoration with the respective post-mining land characteristics.

Keywords: Sustainability · post-mining · investment · pepper · rice plant

1 Introduction

Various economical activities in coal post-mining land can become a new productive economical source and an opportunity in the future as economical basics and sustainable infrastructure development [1]. Open-pit coal mining is an unrenewable resource utilization activity, that provides ecosystem alteration or damage impact, which can no longer perform its function optimally and decrease the land quality, such as land form (nature),

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T. D. Larasati et al. (Eds.): ICTROPS 2022, ABSR 31, pp. 365–377, 2023.

https://doi.org/10.2991/978-94-6463-180-7_38

capillary pipe and soil permeability damages, lack of water storage capability, and soil quality decrease occurrence, therefore a proper post-mining reclamation land becomes more strategic for productive land utilization [2]. Generally, open-pit coal mining can have a sustainable development impact. There are five dimensions that should be noticed in post-mining land utilization, namely; 1) Environmental dimension, 2). Economical dimension, and 3). Social dimension that can be accepted widely, 4). Safety dimension, and 5). Resource efficiency dimension. By confirming these five dimensions, sustainable issues related to post-mining phase or mine closure receive an attention [3]. Unoperated post-mining land or covered-mining is a unique mining site potential owned by each different country [4, 5]. Mining impact requires a careful evaluation from contaminations, such as Fe and Mn wastes [6]. The study results indicate that the coal character, based on the organic geochemical approach with pyrolysis method of chromatographic gas, presents various hydrocarbon gas components in coal, that are dominated by methane (C1), formed in a land environment [7]. A sustainable post-mining land use needs a careful supervision due to contamination potential, in addition to noticing the mining site limitation and other dangers [8]. From the technical aspect, post-mining land that has been fixed its land condition can be used for agriculture cultivation. From the soil quality aspect, the main problem in land rehabilitation is low nutrients and organic materials, certain toxic matters, soil capability in nutrient and water absorption, soil pH, poor or very low soil physical condition, low water surface tension, salinity, rough texture, soil solidification, insufficient nutrient supply for plants, erosion, and acidic-promoting materials [9, 10]. Appropriate plants for post-mining land have high adaptability level in marginal lands [11]. Identification of land feasibility for sago and palm oil cultivations in coal post-mining land of Sangatta Kutai Timur, East Borneo, presents that the coal post-mining land can be developed as an agriculture land for sago cultivation by balanced-fertilization, while palm oil cultivation becomes the most convergent (appropriate) sector to replace the mining sector in post-mining period [12, 13]. Post-mining land use can also be performed by noticing the matched-land feasibility on growing-planting and planting requirements, after improving the post-mining land use management [14].

2 Methods

2.1 Research Location

This study was performed in PT. Multi Sarana Avindo (PT. MSA) and PT. Anugerah Bara Kaltim (PT. ABK) concessions, Loa Janan Sub-district, Kutai Kartanegara District, East Borneo on November, 2021 with the purposive-sampling method. The study location map can be seen in Fig. 1.

2.2 Research Procedures

1. Multi-Dimensional Scaling (MDS) Analysis Method

The multi-dimensional scaling (MDS) analysis method was used to identify the post-mining land sustainability level in this study. Sustainability assessment method with MDS has three steps, namely: The first step determined the attributes from the

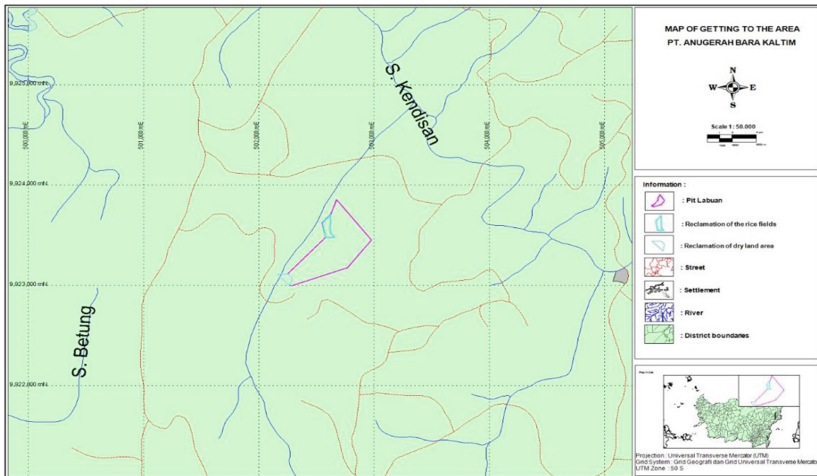


Fig. 1. Research location

studied objects on sustainability status from each dimension (ecology, economy, socio-culture, institution, and technology). To determine the attributes, the amount of ranking in each attribute and score assignment is observed following the literature availability. The second step described each attribute assessment in ordinal scales based on the sustainability criteria in each factor and MDS-based analysis. Each attribute from each dimension will provide scores that reflects on the sustainability condition from each dimension. The weighting, grades, scores are based on empirical and field observations, supported with several literatures that are commonly used in the impact of open-pit coal mining activities and their relationship with the study topic. The third step identified which dimension that mostly affects on the studied object based on the index value, after being analyzed with selected software's developed from the modified software called Rafish as the MDS development software.

2. Business Feasibility Analysis with Benefit Cost Analysis

To analyze the business feasibility in post-mining land, investment criteria were used, containing:

a. Net Present Value (NPV)

The NPV formula is:

$$NPV = \sum_t^n \frac{Bt - Ct}{(1 + i)^t}$$

Note:

Bt = benefit in t-th year (Rp)

Ct = cost in t-th year (Rp)

t = business activity year (t = 1, 2, 3, ..., n)

i = interest rate (%)

n = project age (year)

b. Gross B/C Ratio

The Gross B/C is

$$\text{Gross B/C} = \frac{\sum_t^n \frac{B_t}{(1+i)^t}}{\sum_t^n \frac{C_t}{(1+i)^t}}$$

iii. Net B/C Ratio

The Net B/C is

$$\text{Net B/C} = \frac{\sum_t^n \frac{B_t - C_t}{(1+i)^t} > 0}{\sum_t^n \frac{B_t - C_t}{(1+i)^t} < 0}$$

iv. Internal Rate of Return (IRR)

The IRR formula is

$$\text{IRR} = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)} \times (i_2 - i_1)$$

Note:

i_1 = interest rate that produces a positive NPV (%)

i_2 = interest rate that produces a negative NPV (%)

NPV_1 = positive NPV (Rp)

NPV_2 = negative NPV (Rp)

3 Result and Discussion

Ansahar et al [14] concluded that the initial planting period in 2020 with a six-year simulation period at coal post-mining land of PT. MSA and PT. ABK concessions was suitable for pepper and rice plant cultivations, based on the economical indicators, namely NPV, B/C, Net B/C, and IRR. However, these locations are included in a less-fertile category, based on the average value of soil chemical conditions and soil fertility category. A less-fertile soil in post-mining land is affected by soil quality, low nutrients and organic matters, certain toxic matters, soil capability in nutrient and water absorption, soil pH, poor or very low soil physical characteristics, low water surface tension, salinity, rough texture, soil solidification, insufficient nutrient supply for plants, erosion, and acidic-promoting materials. Appropriate plants for post-mining land are highly-adaptable plants in marginal lands due to mining impact trend with Fe and Mn exposure in various countries. The coal characteristics based on the organic geochemical approach uses a pyrolysis method with gas chromatography presents that coal has a highly variative hydrocarbon gas dominated by methane (C1) formed in land environment. According to Sitorus [14], soil function as mentioned above is a unique land resource, which can be used as a composite resource, either a renewable resource and an unrennewable resource. Soil as a renewable resource in terms of the management

provides a fertilizer addition regularly, thus the land damage can be fixed. In contrast, soil as an unrenueable resource is unable to fix, after the damage occurs, as the sub-soil loss requires a longer time to naturally recover. Regarding the post-mining land that has been left behind, there are no rehabilitation actions without any principles of sustainable development during the exploitation process, thus the condition is permanently damaged. This condition occurs due to erosion process and continuous washing, which causes soil function loss. Therefore, soil as explained above is categorized in an unrenueable resource.

3.1 Multidimensional Scaling Analasys-1

1. Ecological Sustainability Dimension

Figure 2 presents the post-mining land ecological dimension analysis results performed as a reclamation or land management. The ecological sustainability index value is 56.73. Based on the sustainable assessment value with MDS-RAPs analysis method, the ordination/sustainability index is shown Fig. 2.

To determine the most sensitive attributes in detail, which contribute to the sustainability index from ecological dimension, a leverage analysis was performed. Sustainability of coal post-mining land ecological dimension is closely affected by 15 factors as a sustainability triggering-factor. Conservation and land management are terminated due to the most triggering factor with 2.27 presented in Fig. 3. Conservation and land management disruption are in accordance with land as a renewable resource, when provided by additional fertilizer regularly basis, which can fix the land damage. This shows that each closed mine is unique, thus the sustainable post-mining land use requires careful evaluation of its potential, limitations of contamination, and other hazards.

2. Economical Sustainability Dimension

For post-mining land, that are highly adaptable on marginal land Sustainability of economical dimension uses 19 sustainable attributes. The analysis results of MDS-RAPs need an ordination/sustainability index at 63.71, which can be seen in Fig. 4.

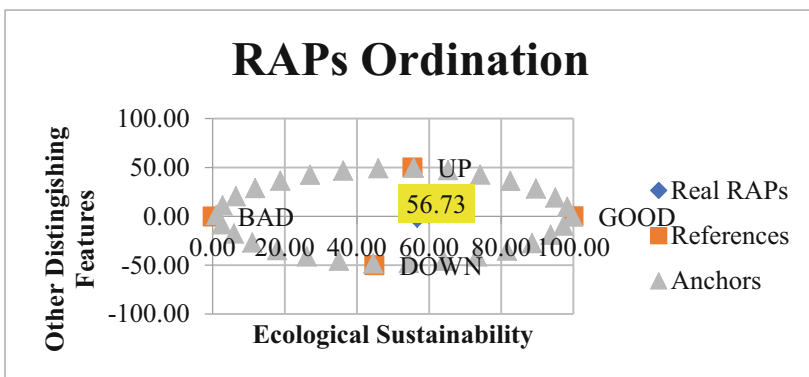


Fig. 2. Ordination/Ecological Sustainability Dimension

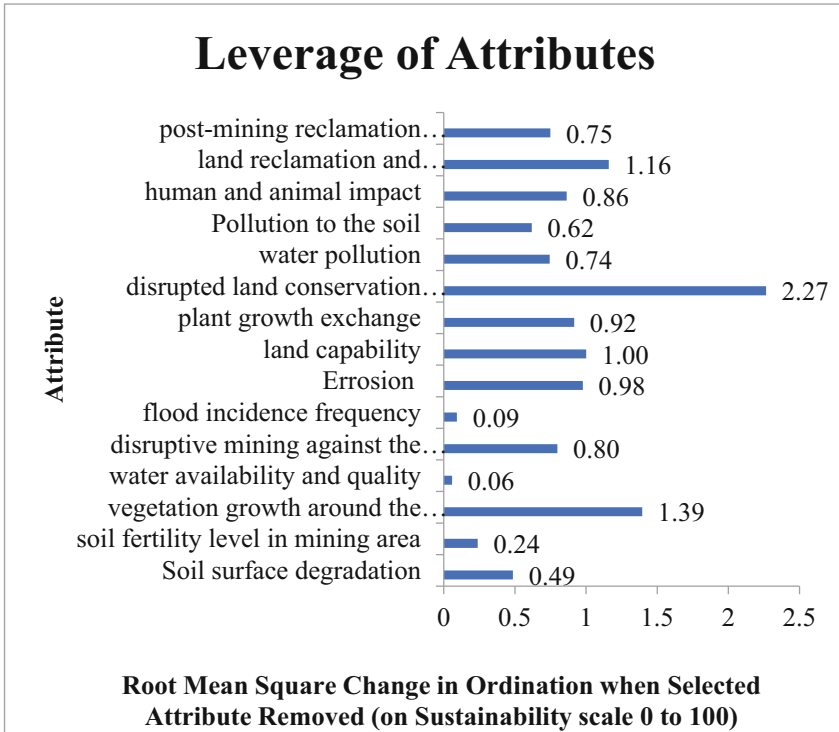


Fig. 3. Sustainability Factors based on Ecological Dimension

The economical sustainability dimension of coal post-mining land is closely affected by the triggering-factors, namely community income around the coal post-mining region and local community increase. This is consistent with the community income increase around the post-mining area, which has more attention to the matched land between growing crops, planting requirements, and suitable plants.

Leverage of attributes with the value of 2.70 can be seen in Fig. 5. The post-mining land use can also provide an economical basis and a sustainable infrastructure development, which become an opportunity in the future based on land characteristics and condition.

3. Social Sustainability Dimension

The analysis results of MDS-RAPs obtain that the ordination/social sustainability index at 67.09. The social sustainability dimension can be seen in Fig. 6.

The social sustainability dimension of coal post-mining land is closely related to various triggering factors with 17 sustainability attributes. The highest leverage of attributes is community awareness on the environmental repairment at 3.08, as seen in Fig. 7. Community awareness attribute on the environmental repairment is conformed with the CSR (*corporate social responsibility*) program from the company.

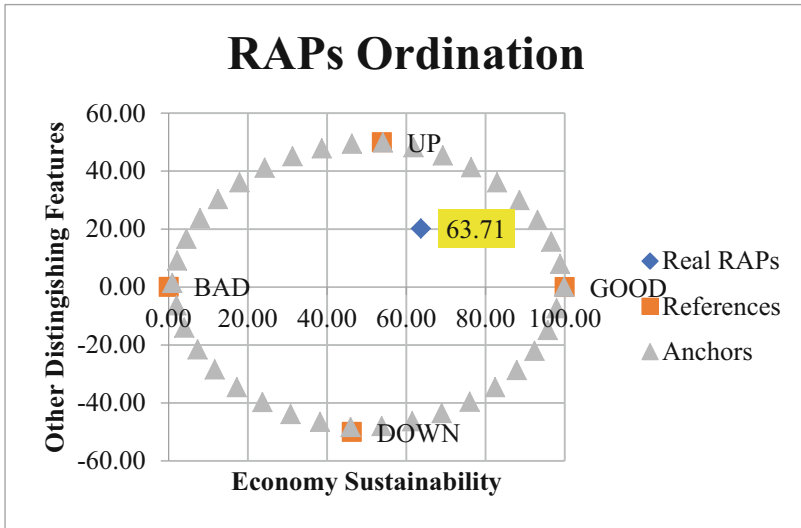


Fig. 4. Ordination/Economical Sustainability Dimension Index

4. Law Sustainability Dimension

The MDS-RAPs analysis results obtain the ordination/law sustainability dimension index at 58.08. The law sustainability dimension can be seen in Fig. 8.

The law sustainability dimension of post-mining land is highly affected by 15 sustainability factor attributes. From these attributes, the most influential factor is cross-sectoral cooperation in environmentally friendly mining with the value of 2.47. The sustainability triggering-factor from law dimension can be seen in Fig. 9 which follows the Good Mining Practice.

5. Infrastructure and Technological Sustainability Dimension

The analysis results of MDS-RAPs obtain ordination/infrastructure and technological sustainability index at 89.74. The infrastructure and technological sustainability dimension can be seen in Fig. 10.

The infrastructure and technological dimension of coal post-mining land is highly affected by the triggering factors that have 22 sustainability attributes. Resource and backup calculations are the most influential attributes at 89.74. The infrastructure and technological sustainability dimension can be seen in Fig. 11, which conforms with the mining period to produce coal carefully.

Feasibility Analysis of Pepper Breeding Investment-2

The investment feasibility analysis was performed with various assumptions. The interest rate used for investment analysis is 3.5%, based on the average loan interest rates of commercial banks in Indonesia (BPS, 2020). The investment feasibility test is presented in Table 1.

Based on the analysis results, the NPV is > 0 , precisely at 291,770,337.19 for 15 years. Furthermore, the Net B/C is > 1 , precisely at 8.95, which means that each cost

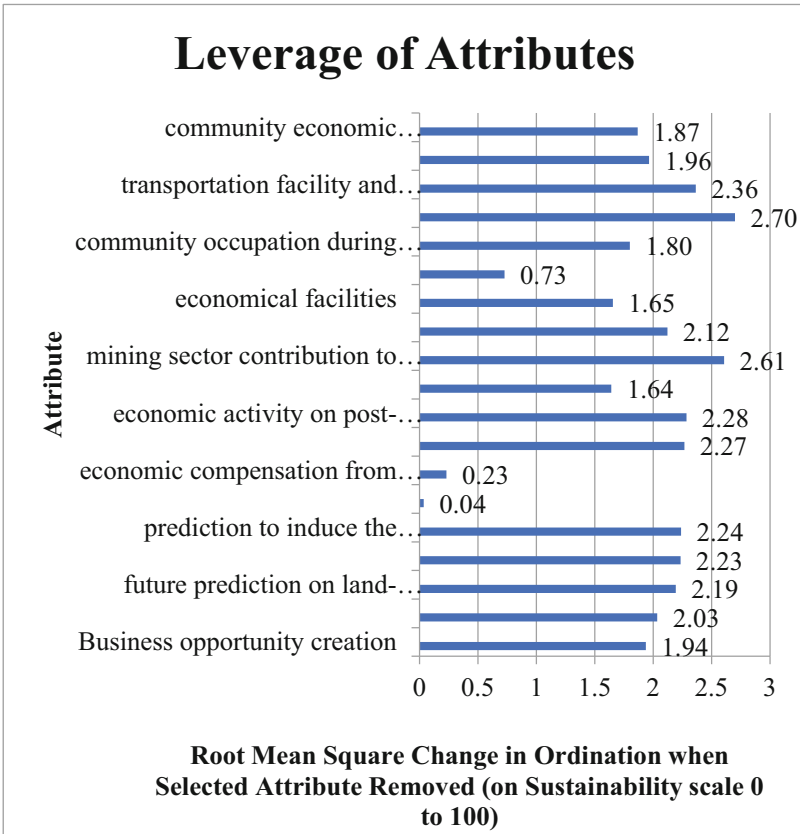


Fig. 5. Sustainability Factors based on Economical Dimension

exposed in the investment will gain a net acceptance around 8.95 units. The IRR value is 13.8%, which is much greater than current interest rate at 3.5%. The Gross B/C is > 1 in pepper investment is 22.6. Based on the investment criteria, the pepper cultivation investment in post-mining land at Tabuhan Pit and Purwajaya Pit of PT. ABK, Kutai Kartanegara, East Borneo, is financially feasible.

Feasibility Analysis of Rice Plant Investment-3

Investment feasibility analysis in this study was performed by various assumptions. The interest rate used in this investment analysis is 3.5%, based on the average loan interest rates of commercial banks in Indonesia (BPS, 2020). The analysis results of investment feasibility are presented in Table 2.

Based on the analysis results, the NPV is > 0, precisely at 178,372,549.80 for 15 years. Furthermore, the Net B/C is > 1, precisely at 3.89, which means that each cost exposed in the investment will gain a net acceptance around 3.89 units. The IRR value is 23.63%, which is much greater than current interest rate at 3.5%. The Gross B/C is > 1 in pepper investment is 23.2. Based on the investment criteria, the rice plant cultivation

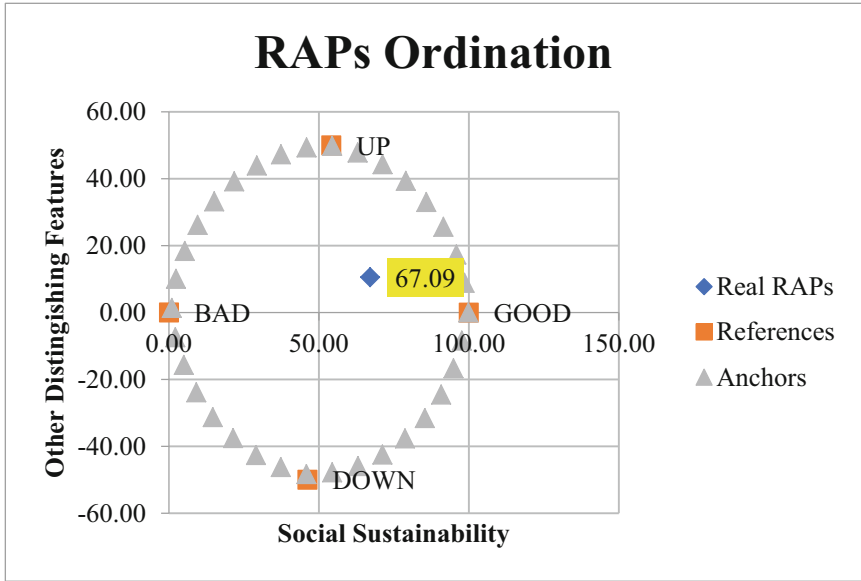


Fig. 6. Ordination/Index of Social Sustainability Dimension

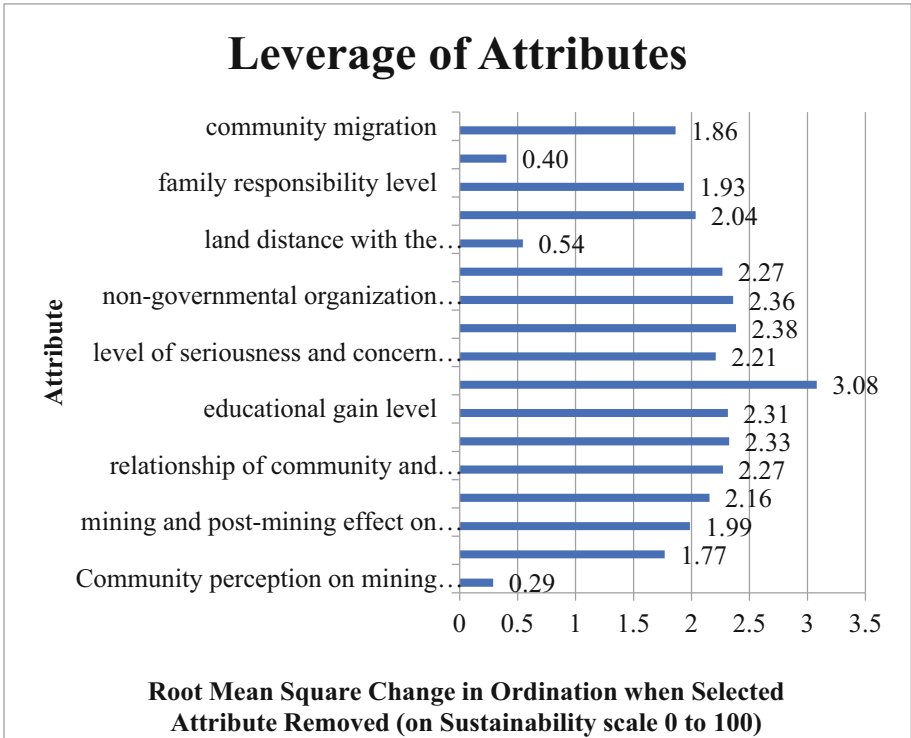


Fig. 7. Sustainability Factors based on Social Dimension

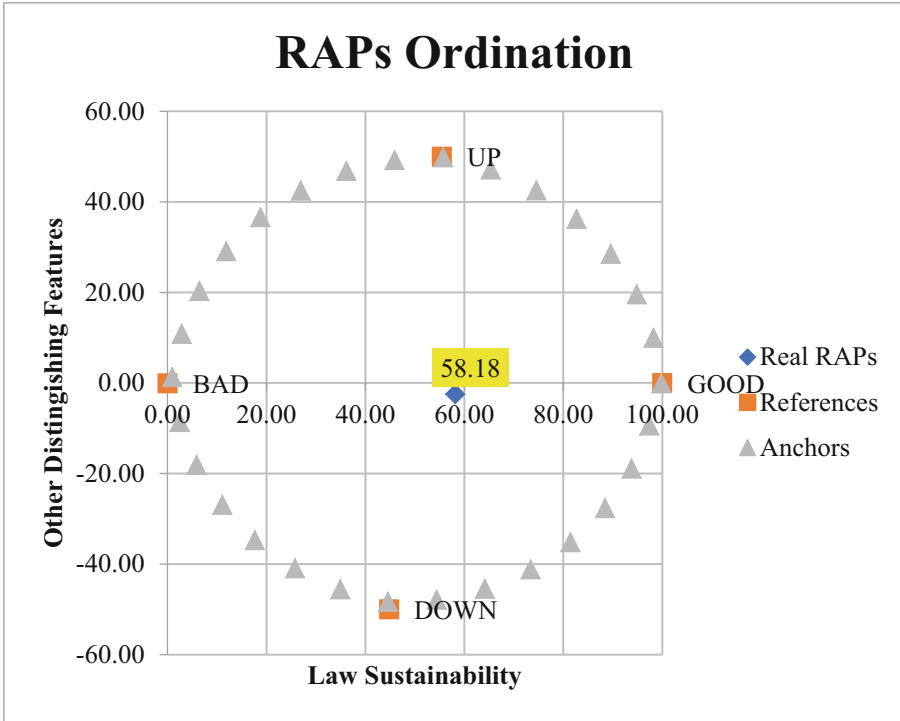


Fig. 8. Ordination/Indeks Keberlanjutan Dimensi hukum

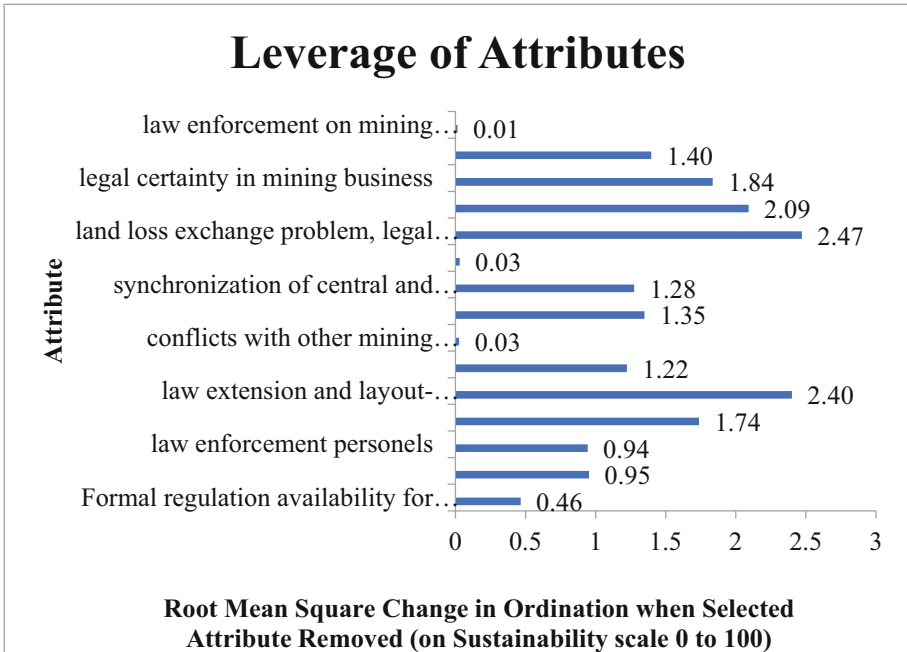


Fig. 9. Sustainability Factors based on Law Dimension

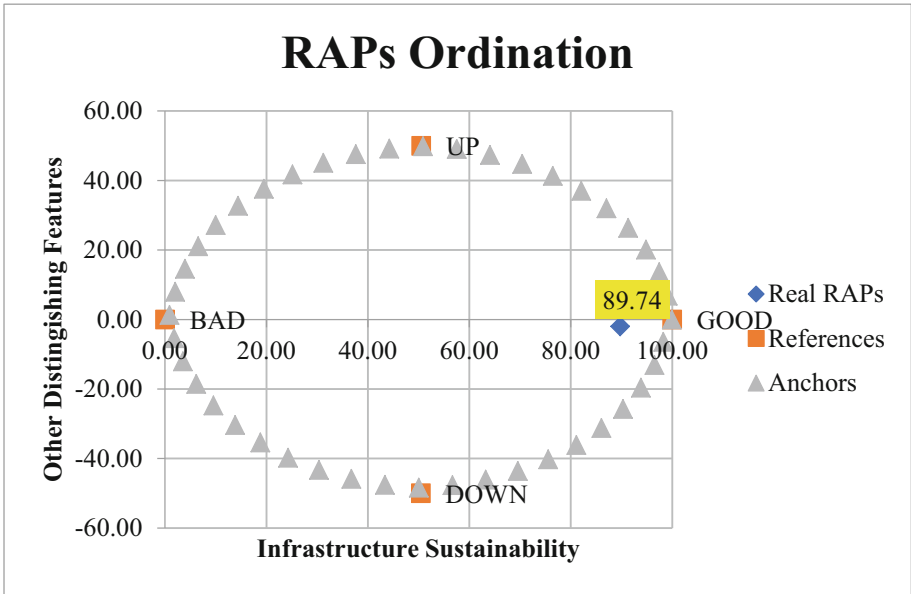


Fig. 10. Ordination/Infrastructure and Technological Sustainability Dimension

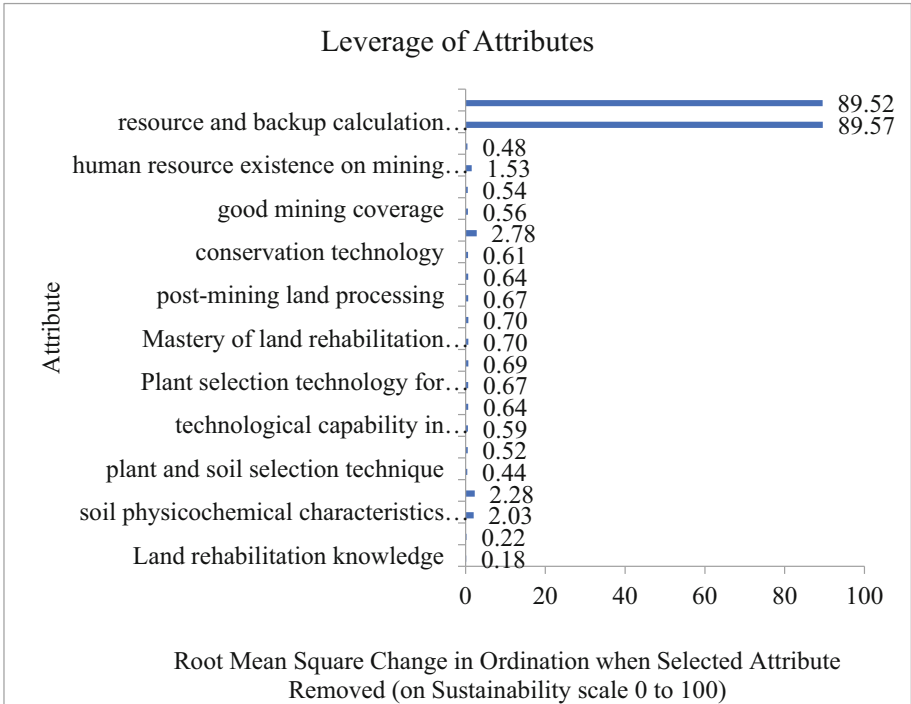


Fig. 11. Sustainability Factors based on Infrastructure and Technology Dimension

Table 1. Pepper Breeding Investment Feasibility Analysis

No	Feasibility Criteria	Standard	Result	Note
1	Net Present value (NPV)	> 0	291,770,337.19	Feasible
2	Net Benefit Cost Ratio (Net B/C)	≥ 1	8.95	Feasible
3	Internal Rate of Return (IRR)	> 3,5%	13.8%	Feasible
4	Gross BC	> 1	32.6	Feasible
Source: Primary-processing data (2022)				

Table 2 Rice Plant Investment Feasibility Analysis

No	Feasibility Criteria	Standard	Result	Note
1	Net Present value (NPV)	> 0	178,372,549.80	Feasible
2	Net Benefit Cost Ratio (Net B/C)	≥ 1	3.89	Feasible
3	Internal Rate of Return (IRR)	> 3,5%	23.63%	Feasible
4	Gross BC	> 1	23.2	Feasible
Source: Primary-processing data (2022)				

investment in post-mining land at Tabuhan Pit and Purwajaya Pit of PT. ABK, Kutai Kartanegara, East Borneo, is financially feasible.

4 Conclusion

Based on the results of multi-dimensional scaling analysis, the index obtained and the factors that influence it, it can be concluded that post-mining land can be used for sustainable rice and pepper economic activities. From these results, it can be concluded that the open coal post-mining land use as pepper and rice plant cultivations is eligible to conduct based on the sustainability and business investment eligibility analyses, following the proper environmental organization and restoration with the respective post-mining land characteristics.

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