An Analysis of Coal Post-Mining Land for Agricultivation Uses (A Case Study on PT ABK in Kutai Kartanegara District, East Kalimantan Province)

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Abstract. The characteristics of coal surface mining activity are vulnerable to environmental degradation due to soil excavation, although only causing a lower risk in worker’s incidence and economically beneficial as requiring a lower cost than the underground mining method. This study aimed to analyze the types of post-mining land use worth developing for the local community’s livelihood around the post-mining land on the concession of PT Anugerah Bara Kaltim (ABK) in Kutai Kartanegara District, Kalimantan Timur Province. The method used was a cost-benefit analysis (CBA). The analysis results indicate that the pepper plant cultivation on the post-mining land within six years produces Net Present Value (NPV) at Rp 49,484,637.00, Benefit/Cost (B/C) Ratio at 1.347, Net B/C Ratio at 2.56, and Internal Rate Return (IRR) at 39.20%. Meanwhile, rice plant cultivation stimulated within six years produces NPV at Rp 8,653,754.00, B/C Ratio at 1.035, Net B/C ratio at 1.3871, IRR at 8.50%. The economic analysis results based on all indicators: NPV, B/C, net B/C, and IRR, demonstrate that the pepper and rice plant cultivation activities are feasible in the coal post-mining land.

1. Introduction

Indonesia is a country that has giant mining land with 161 billion tons of available resources and 31 billion tons of preserved coal across various islands, specifically Kalimantan (46.9%) and Sumatera (52.5%) [1]. The natural resource activity management in coal mining has contributed to national and regional income. The mining company was also providing a benefit for the community. Such as physical and infrastructural development, working field availability, education, local community wisdom, health, which can be utilized by the community around the mining land [2,3]. Some areas with coal deposits on Kalimantan Island are found around the forest and other lands, such as transmigrant settlements [4]. Utilization of resources without careful handling will cause a heavy impact on the environment and spend a pretty high cost for the development [5]. The coal mining activity in the forest removes the forest's ecological function that causes natural resource depletion (forest and coal) and forest ecosystem's environmental contribution loss. Kutai Timur district has lost significant environmental value to approximately 9.5 trillion rupiahs from coal mining activity [6].
The coal mining system in Indonesia, specifically in the Kutai Kertanegara District, East Kalimantan Province, is performed through the surface mining operation with a more significant environmental impact than the underground mining operation. Surface mining operation makes low organic soil material, low to very low pH, low water carrying capacity, salinity, rough texture, soil solidity, insufficient nutrients for plants, rapid erosion, and acidified materials formation [7,8,9]. This condition is marked as the soil becomes unfertilized due to surface soil loss, plant damage, and soil capability loss in carrying the water, which can cause environmental damage (land, vegetation, and depletion).

Coal mining leaves a post-mining hollow or void. Void is a coal post-mining hollow that remains uncovered based on the feasibility study as mandatory to be managed and reclaimed. According to the Ministry of Forestry Regulation P.4 in 2011 at article 33 point 1: The void refilling as stated in article 32, point a, on the surface mining activity, the void must be closed following the Environmental Impact Analysis document [10]. The number of voids in East Kalimantan until 2017 was 537 voids. The number of voids in the Kutai Kertanegara District was 264 voids [11].

Void management is a systematic and integrated effort to prevent pollution, environmental damage, and incidences. Void management includes planning, securing, recovering, controlling, utilizing, maintaining, and closing (if the other utilization effort is unable to fulfil, the feasibility study through the environmental document and post-mining plant document) [12, 13]. Post-mining land uses for agricultural land expansion is an opportunity based on the land typology and technical aspect after the land condition recovery [14,15,16]. Based on the soil quality aspect, the main obstacle of land rehabilitation is low nutrient and organic material contents, specific element toxicity, soil capability to absorb nutrients and water, soil pH, and low soil physical characteristics [17]. Reclaiming post-mining land into the re-fertility requires time and high cost, with high technological and complex land and water management [18].

A study to identify land suitability in PT Kaltim Prima Coal (KPC), Sangatta, Kutai Timur, East Kalimantan show that the coal post-mining land could be developed as agricultural land for sago plants [19]. The study recommended that the agricultural and oil palm cultivations become the most convergent sector to replace the mining sector after the post-mining period [20]. Pepper is the most significant of five commodities in East Kalimantan Province. The pepper plant area trend increased by 2.5% in 2020 compared to the previous year. In 2020, the pepper plant area in East Kalimantan was 9,146 ha. Kutai Kertanegara District is a region that has the widest pepper commodity in East Kalimantan at 46.01% of the total pepper cultivation business area in 2020 [21]. Recently, the pepper commodity business in Kutai Kertanegara District has been performed in conventional land, either in farmer's land and private company plantations.

Meanwhile, based on the study results, pepper development in post-mining land in Bangka-Belitung Province had a positive value. It was feasible to develop even in marginal lands with the land suitability class of (S3) [22]. Therefore, the pepper commodity can become an alternative for the agriculture business development in the post-mining land. The commodity development in the post-mining area can also use the rice plant. As a primary food material for the community, the rice plant is an essential commodity, mainly supporting food sovereignty and regional inflation control.

Mine-closing indicates sustainable benefits and mining values that are continuously perceived after mine-closing. There is a process to sustain the benefits when the mine-closing period arrives as a transformation of economic use-value for the community from mining [23]. The post-mining use transformation was also stated that mine-closing is a mine-closing that still contributes to the local social-economical sustainability [24]. Alternatives for post-mining land use besides land revegetation were utilised post-mining that no longer operated as an economic transformation to develop the sustainable economy in the community. Mine-closing is a process of changing the void to safe and stable lands that are unpolluted, serve habitat and ecosystem services, and support the economic activity of new land users [25]. Mine is closed when the resource is depleted, or mining is no longer economically profitable due to high mining cost and market low price [26]. Heikkinen et al. (2018) reported that mining is often left after the production phase without considering the risk potential in
human and environment or social dimension [27]. This condition means that sustainability cannot be obtained in the post-mining period, either in the economy or environment and society. In several conditions, a temporal closing can occur due to external factors, such as unprofitable commodity prices or through an ownership change.

The development of post-mining land use for agriculture, especially for pepper and rice plant commodities, needs further analysis to identify their technical and financial feasibility. This paper will attempt to conduct a prospective analysis in financial analysis and land suitability study to identify its technical feasibility.

2. Methodology

2.1. Period and Location
The study is located in a reclaimed coal post-mining land concession of PT Anugerah Bara Kaltim in Loa Janan Sub-district, Kutai Kartanegara District. Samples were taken through a purposive sampling due to the vast operational region of PT ABK in Kutai Kartanegara District, East Kalimantan Province. The study location map can be seen in Figure 1. Study preparation was performed in October 2020. All preparations and procedures were performed for 19 months (May 2020 – December 2021), including preparation, field observation, data sampling, data analysis, and paper writing.

Figure 1 Study location map.

2.2. Rice plant cultivation economic activity and land suitability analysis
The economic activity or business types were identified and analyzed from the coal post-mining land in Labuhan Pit and Purwajaya Pit of PT. ABK Kutai Kartanegara, East Kalimantan. The selected economic activity types were rice plant and pepper cultivations:
Rice plant and pepper are cultivated in the Labuan Pit Techno Part with a 50 ha land area. These commodities function as food ingredients and food security industry support as the leading staple food for significant Indonesian people. This location has been reclaimed for five years.

Water source found on the Labuan void is utilized to irrigate the 2.5-hectare field. Plants suggested in each group are high economic plants with highly marketable and profitable properties. Utilizing the post-mining land and the following management strategy is expected to alter the sequence on contributing to the national agricultural sector and economic activity value for the community around the post-mining land.

2.3. Rice field agricultural development
The rice field formed was 2.5 ha divided into 8 rice fields of 7 ha prepared land. The rice plant was started to cultivate on June 10, 2020 with three different varieties, namely, Ciherang, Mikongga, and Inpari located in the Agro Techno Park.

2.4. Procedures for rice field development in the post-mining land are:
- Pre-cultivation. Rice field formation by rice field design, land survey, irrigation system formation, recounturing, Top soil stocking, these activities spent two-month period (February – March, 2020).
- Pre-cultivation. Rice field maturity by irrigation maintenance, land immersion, field maintenance, soil plowing and clearing, limning. These activities spent two-month period (April – May, 2020).
- Cultivation. Rice plant Planting and maintenance by working partnership determination, rice plant variety selection, planting method determination, planting process, rice plant cultivation and maintenance, and harvesting process (June – September, 2020).
- Post-harvest, evaluation of harvest product and cultivation planning for the next period.

2.5. Data analysis
To analyze the financial feasibility of pepper and paddy plant cultivated in the post-mining land, investment criteria analysis was used containing [28]:

a. Net Present Value (NPV)
The NPV formula is:

\[ NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1 + i)^t} \]

Whereas:
- \( B_t \) = benefit at \( t \)-th year (Rp)
- \( C_t \) = cost at \( t \)-th year (Rp)
- \( t \) = business activity (year) (\( t = 1, 2, 3, \ldots, n \))
- \( i \) = interest rate (%)
- \( n \) = project age (year)

b. Gross B/C Ratio
The Gross B/C ratio is:

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

c. Net B/C Ratio
The Net B/C formula is:
\[ \text{Net } B/C = \frac{\sum_{t} B_t - C_t}{(1 + i)^t} > 0 \]

\[ \frac{\sum_{t} B_t - C_t}{(1 + i)^t} < 0 \]

d. Internal Rate of Return (IRR)

The IRR formula is:

\[ IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)} \times (i_2 - i_1) \]

Whereas:

- \( i_1 \) = interest rate that produces positive NPV (%)
- \( i_2 \) = interest rate that produces negative NPV (%)
- \( NPV_1 \) = positive NPV (Rp)
- \( NPV_2 \) = negative NPV (Rp)

3. Results

3.1. Land Capability Classification

To determine the land suitability was used land characteristic data and plant technical growth requirements were. The characteristic data was obtained from the analysis result and compared to land suitability criteria for plants. The land capability classification will establish the appropriate use and treatment types required for sustainable plant production. Sitorus (2004) split the land into several categories based on the amount of inhibitory factor intensity which influenced the plant growth, namely from the highest to the lowest category (class, sub-class, and management unit) [29]. Land capability is classified as class I, where there are no main inhibitors for plant growth.

In contrast, a land capability is classified as class VIII due to containing a heavy inhibitor which is possibly unable for commercial plant productions. Based on the soil quality aspect, the main obstacles in land rehabilitation are low nutrient and organic material contents, certain toxicity elements, nutrient and water absorption capability, soil pH, soil physical characteristics. Therefore, suitable plants for former mining land are highly adaptive plants to marginal lands [30]. Soil 1 Observation Sampling Mining Pit Plan VW Batuah Pit can be seen on the following Table 1.

| Note                   | Result                          |
|------------------------|---------------------------------|
| Slope                  | 14 %                            |
| Slope Length           | 50 m                            |
| Vegetation             | Shrubs, Rose Myrtle, Rambutan, Cempedak |
| Erosion Level          | Low                             |
| Flood Condition        | Absent (F0)                     |
| Soil water depth       | Deep, > 100 cm                  |
| Effective depth        | > 100 cm                        |
| Drainage               | Goof                            |
| Structure Type         | Angular Blocky                  |

3.2. Soil Fertility Level

Soil contains four primary materials, namely minerals, organic matter, water, and air. These materials are at different amounts for each soil type or subsoil. The fertile soil condition commonly has 45% minerals, 3 - 5% organic matter, 20 – 30% air, 20 – 30% water [31]. A pre-study performed by taking soil samples randomly in Seberang Tenggarong Sub-district and Sebulu Sub-district by Sinaga (2008) discovered a soil before coal mining activity was still classified in a quite fertile soil due to containing
4.27% organic-C matter [32]. Meanwhile, soil after coal mining was less fertile due to low organic matters at less than 3%, followed by lower total-N and phosphorus elements (P). Soil Fertility Level can be seen on the following Table 2. Fourth Environmental Document Amendment on The Environmental Impact Analysis of PT ABK in 2016 -2027 provided the following data [33]:

| No. | Sample | Cation Exchange Capacity (CEC) (me/100g) | Basic Concentration (BC) (%) | P2O5 (ppm) | K2O (mg/100g) | Organic-C (%) | Status |
|-----|--------|----------------------------------------|-----------------------------|------------|---------------|---------------|--------|
| 1.1 | 1      | 6.66                                   | 13.72                       | 1.36       | 11.14         | 0.74          | Low    |
| 2.2 | 2      | 4.92                                   | 6.84                        | 1.07       | 7.92          | 0.61          | Extremely Low |
| 3.3 | 3      | 6.22                                   | 14.28                       | 1.89       | 5.97          | 0.90          | Low    |
| 4.4 | 4      | 7.43                                   | 60.73                       | 2.19       | 6.48          | 1.29          | Low    |
| 5.5 | 5      | 15.35                                  | 96.74                       | 2.19       | 6.13          | 2.33          | Low    |
| 6.6 | 6      | 8.80                                   | 96.21                       | 3.07       | 7.20          | 1.60          | Low    |

Source: Analysis Result of Soil Science Laboratory, Tropical Forest Research Center, Mulawarman University, 2016

Note: R = Low, SR = Extremely Low, S = Intermediate, T = High

Location note:
1 = Mining Pit Plan of PT. MSA (VW Batuah Pit) S : 00° 41' 34.6" E : 117° 03' 17.4"
2 = Mining Pit Plan of PT. MSA (MNOPS Pit) S : 00° 42' 27.2" E : 117° 02' 16.8"
3 = Mining Pit Plan of PT. MSA (22 Pit) S : 00° 40' 53.7" E : 117° 01' 33.6"
4 = Mining Pit Plan of PT. MSA (7 KLB Pit) S : 00° 41' 03.5" E : 117° 02' 05.6"
5 = Reclamation Area of PT. MSA I S : 00° 39' 03.6" E : 117° 04' 42.9"
6 = Reclamation Area of PT. MSA II S : 00° 39' 24.3" E : 117° 03' 30.4"

3.3. Financial Feasibility of Pepper Plant in The Post-Mining Land

The financial feasibility analysis of pepper cultivation business in the post-mining land owned by PT ABK in Kutai Kertanegara District uses an economic period of 6 years following the pepper plant planting cycle. The first year is the investment year. There are many capitals and soil physical, chemical, and biological improvements in the post-mining land. For soil improvement, it is performed simply by using manure or compost only around the planting land. Moreover, the seeds required in pepper cultivation business in this post-mining land at 1 Ha land area are 2,400 seeds from malanon variety with 2 x 2.5 m space, whereas 400 seeds are reserved seeds to anticipate the dead plants. The plant supporting role uses an ironwood pole at 2,000 units. The salary of farmer labourers in Kutai Kertanegara District is Rp 120,000.00/day of work.

The pepper business acceptance is due to pepper fruit harvest produces on the 3rd year after planting. The price provided is Rp 100,000.00/kg. Besides the acceptance from fruit, the pepper cultivation business also sells seeds pruned from the pepper branches in the 1st year. This condition occurs for better pepper plant growth and fruit product qualities. In the last year, acceptance was also obtained from the firewood pole selling. Based on the survey results of cultivation business during the economic period, this pepper cultivation business will provide cost, acceptance, and the investment criteria in pepper commodity business in the 1 ha post-mining land can be seen in the following Table 3.

| No. | Component          | Value             |
|-----|--------------------|-------------------|
| 1.  | Total Cost         | Rp 224,530,000.00 |
| 2.  | Benefit*           | Rp 358,133,333.00 |
| 3.  | Net Benefit        | Rp 133,603,333.00 |
4. **Factor Discount** 17.5%
5. **PV of total cost** Rp 142,251,457.00
6. **PV of benefit** Rp 191,736,094.00
7. **NPV** Rp 49,484,637.00
8. **Gross B/C Ratio** 1.35
9. **Net B/C Ratio** 2.56
10. **IRR** 39.2%

Source: Processed Data

### 3.4. Financial feasibility of rice plant in the post-mining land

The post-mining land can also be used for food plant cultivation, one of which is the gogo rice plant which can adapt in marginal land similar to post-mining land. The feasibility analysis of the rice plant cultivation business was simulated for six years following the pepper plant production period. The planting index (IP) of 200 used an assumption for a year. The calculation result for 1 ha land area obtained the total cost, benefit, and feasibility below can be seen in the following Table 4.

| No  | Component          | Value                  |
|-----|--------------------|------------------------|
| 1.  | Total Cost         | Rp 386,102,200         |
| 2.  | Benefit*           | Rp 420,000,000         |
| 3.  | Net Benefit        | Rp 33,898,000          |
| 4.  | Factor Discount    | 6%                     |
| 5.  | PV of total cost   | Rp 245,813,292.61      |
| 6.  | PV of benefit      | Rp 254,467,046.33      |
| 7.  | NPV                | Rp 8,653,753.72        |
| 8.  | Gross B/C Ratio    | 1.04                   |
| 9.  | Net B/C Ratio      | 1.39                   |
| 10. | IRR                | 8.50%                  |

Source: Processed Data

### 4. Discussions

#### 4.1. Financial Feasibility of Pepper Plant in The Post-Mining Land

From the community perspective, they had a pretty good awareness of the danger of mercury during the gold processing in the ASGM, as presented in Figure 1. The attractive condition is that the community (miners) still uses mercury, although aware of other methods (non-mercury method) to extract gold and quite aware of the emergency of mercury for the environment and human health. However, based on the interview results, the community still uses mercury due to its lower price. It is more accessible to obtain, can be used repeatedly, and is more effective in extracting gold.

The investment criteria calculation result above demonstrates that the NPV value from the pepper cultivation business in the post-mining land is more significant than zero, namely at Rp 49,484,637.00/ha in the OCC level (capital return rate) with 17.5%. This condition shows that the total cost spent is smaller than the total net acceptance from the pepper cultivation business during the economic period. Based on the NPV criteria, the pepper cultivation business in the post-mining land is feasible.

Besides the NPV criteria, the gross B/C ratio and net B/C ratio becomes feasible business criteria. Based on the calculation result, the gross B/C ratio of pepper cultivation business in the post-mining land is 1.35, while the net B/C ratio is 2.56. The gross B/C ratio and net B/C ratio are more than 1, indicating that the post-mining land's pepper cultivation business is feasible. The gross B/C ratio of 1.35 means that Rp 1,000 of the cost will produce a pepper cultivation business at Rp 1,350.
Meanwhile, the net B/C ratio of 2.56 means that each Rp 1,000 of the net cost will produce a net acceptance at Rp 2,560.

The final criterion used is IRR, as a business is categorized to be feasible when obtaining more excellent IRR value than OCC (Opportunity Cost of Capital) level. In this study, the OCC level used is 17.5%. Based on the calculation result, the IRR value of 39.2% demonstrates that the pepper cultivation business in the post-mining land will produce a turnover (NPV = 0) at 39.2% of interest rate. The smaller the OCC level used, the more excellent NPV value. This means that a greater IRR value than the OCC level indicates that the post-mining land's pepper cultivation business is feasible.

Therefore, the pepper cultivation business is feasible by considering the NPV value, gross B/C ratio, net B/C ratio, and IRR. Similar to Maryadi (2016), the marginal land utilization of pepper cultivation business obtained the B/C value among 1.5 – 2.1 with an average payback period of 4.5 years.

When being compared to the non-post-mining land, the B/C value reached 3.5 – 4.4. This condition was influenced due to the high initial investment cost in the first year of pepper cultivation business in the post-mining land as the post-mining land processing is focused on the soil physical, chemical, and biological improvements that spend much cost.

4.2. Financial feasibility of rice plant in the post-mining land
For the rice plant cultivation business in the post-mining land, the NPV is Rp 8,653,753.72, Gross B/C is 1.04, Net B/C value is 1.39, and IRR value is 8.50%. Based on these calculations, the rice plant cultivation business in the post-mining land is feasible as the value of NPV > 0, Gross B/C and Net B/C were more than one, and the IRR value is greater than the OCC level, 6%. The 6% OCC level is the loan interest rate in bank during this was performed. The similar result was also presented in the rice plant cultivation business in acidic dried land at Bangka, whereas the feasibility level was among 1.05 – 1.67, depending on the variety used [34].

4.3. Discussion between market and agriculture land requirement
Rice is highly available in market as primary product due to the increased number of community and infrastructure needs, such as housing, roads, industries, companies, and other buildings which caused an increased land requirement. Moreover, high economic development also causes a fast growth in several economic sectors. Growth needs a wider land, which causes an increased land requirement for further development. Meanwhile, land availability still relatively causes a land use competition. Most transformed lands are generally from agricultural lands due land rent.

Land rent can provide an economical value obtained from a land that can be used for production process. Rented land is more relatively used for non-agricultural activity than for agricultural land managed by farmers. Land becomes the main element in supporting the livelihood. Land function is a place for human activity to sustain its existence. Increased land use by human, such as for homes, business places, public access, and other facilities will cause a decreased available land. This condition occurs due to land use activity without notifying land capability, carrying capacity, and designation form. Increased market requirement in agricultural land becomes the main reason for the use of post-mining land as an alternative land to balance the inproductive land transformation, following its suitability level [35].

5. Conclusions
The post-mining land in Kutai Kertanegara District can be used both for plantation and food plants. Based on the feasibility analysis, the pepper and rice plant can be feasibly performed. The analysis results indicate that the pepper plant in the post-mining land with 6-year period produces the Net Present Value (NPV) at Rp 49,484,637.00 with the Benefit/Cost (B/C) Ratio at 1.347, Net B/C Ratio at 2.56, and Internal Rate Return (IRR) at 39.20%. Meanwhile, rice plant in 6-year simulation period produces the NPV value at Rp 8,653,754.00, B/C Ratio at 1.035, Net B/C ratio at 1.3871, and IRR value at 8.50%. Based on the average value of soil chemical properties compared to soil fertility
criteria, the study location is included in a less fertile soil. The economical analysis results on all indicators, namely NPV, B/C, net B/C, and IRR, demonstrate that the pepper and rice plant cultivation in the coal post-mining land can be feasibly performed. Based on the average value of soil chemical properties compared to soil fertility criteria, the study location is included in a less fertile soil.

References

[1] [BG] Badan Geologi. 2013. Sumberdaya dan Cadangan Batubara. Bandung (ID): BG

[2] Kodir A, Hartono DM, Haeruman H, Mansur I. 2017. Integrated post mining landscape for sustainable land use: A case study in South Sumatera, Indonesia. Sustainable Environment Research 27:203-213.

[3] Irawan A.A., 2013. Economic Impact and Social Activities of Coal Mining PT. Tanito Harum for the Community in Loa Tebu Village, Tenggarong District. Government Science eJournal 1 (1): 46-56.

[4] Ardhana I P G.2011. Damages of forest resources due to mining activities. ECOTROPHIC 6 (2):87 - 93

[5] Fauzi A. 2014. Economic Valuation and Assessment of Damage to Natural Resources and the Environment. Bogor (ID): IPB Press.

[6] Sudirman D. 2011. Optimization of Environmental Damage Compensation Costs for Coal Mining Activities in Protected Forests [Dissertation]. Bogor (ID): Bogor Agricultural University.

[7] Gitosuwondo S. 2011. Environment friendly open pit mining systems and reclamation post-mining efforts to improve the quality of land resources and soil biodiversity. Indonesian Journal of Land Resources 5 (12):83-94.

[8] Kumar A, Pandey, A.Ch. 2013. Evaluating impact of coal mining activity landuse/landcover using temporal satellite images in South Karanpura Coalfields and Environs. Jharkhand State, India. IJARSG– An Open Access International Journal 2 (1): 183 -197

[9] Nzunguru Z., Chauke, H. 2012. Sustainability through responsible environmental mining. Journal of the Southern African Institute of Mining and Metallurgy 112 (2): 135 – 139

[10] Sitori S. R. P. 2012. Land Quality. Degradation and Rehabilitation. Graduate School Third Edition. Bogor (ID): Bogor Agricultural University.

[11] ESDM Provinsi.2019. Based on the data of Department of Energy and Human Resource in East Kalimantan District

[12] [ESDM]Ministry of Energy and Human Resources Regulation 18/2008 and 7/ 2014

[13] [ESDM]Ministry of Energy and Human Resources Decision 1827/2018.

[14] Mulyanto B. 2008. Institutional management of post-mining areas. Paper Seminar and Workshop on Reclamation and Management of Post Mine Closure Areas. Journal of Pusdi Reklatam, Bogor 22: LPPM Bogor Agricultural University

[15] Soltanmohammadi, H., Osanloo, M., Bazzazi, A.A. 2010. An analytical approach with a reliable logic and a ranking policy for post-mining land-use determination. Land Use Policy 27 (2): 364-372.

[16] Ioannis P, Michael G, Christos R, Francis P. 2017. Selection of optimal land uses for the reclamation of surface mines by using evolutionary algorithms. International Journal of Mining Science and Technology 27: 491–498.

[17] Dariah A. Abdurachman A, Subardja D. 2010. Reclamation of Ex-Mining Land for Agricultural Extensification. Jurnal Sumberdaya Lahan. 4 (1): 1 - 12

[18] Narrei S, Osanloo M. 2011. Post-mining land-use methods optimum ranking, using multi attribute decision techniques with regard to sustainable resources management. OIDA International Journal of Sustainable Development 02(11): 65 -76

[19] Mashud N, Manaroinsong E. 2014. Utilization of Coal Mined Land for the Development of Sago Palm. B. Palma. 15 (1): 56 – 63.

[20] Soelarno 2007. Planning of post mining development for supporting sustainable development
(Case study on coal mining of PT Kaltim Prima Coal in East Kutai Regency East Kalimantan Province)

[21] [BPS]. 2021. East Kalimantann Department of Statistics

[22] Maryadi, Sutandi A, Agusta I. 2016. Analysis of pepper farming and directions for its development in Central Bangka Regency. Journal of Social and Agricultural Economics 9 (2): 23-29.

[23] Strongman. 2002. Sustainable mining development from concept to action. Proceeding of the Mining and the Community II Conference; Madang Papua New Guinea (PNG) 16 September 2002

[24] Robertson A, Shaw S. 1999. Mine closure - introduction. http://www. Robertsongeo consultants.com/rgc_environmine/issue/closure.asp.

[25] Limpitlaw D, Briel, A. 2014. Post-mining land use opportunities in developing countries – a review. Journal of the Southern African Institute of Mining and Metallurgy. 114 (11): 899 - 903.

[26] Haque M.A, Topal, E, Lilford, E. 2014. A numerical study for a mining project using real options valuation under commodity price uncertainty. Resources Policy 39: 115-123.

[27] Heikkinen P.M., Noras, P., Salminen, R. 2008. Mine Closure Handbook. In Environmental Techniques for the Extractive Industries. Finland (FIN): Geological Society of Finland: 169 pp.

[28] Nurmalina R, Sarianti T, Karyadi A. 2014. Studi kelayakan bisnis. IPB Press Bogor.

[29] Sitorus S. R. P. 2004a. Sustainable Land Source Development. Bogor: Laboratory of LanResource Development Plan, Department of Soil, Faculty of Agriculture, IPB University.

[30] Sitorus S. R. P. 2004b. Land Quality, Degradation, Rehabilitation. Graduate School. IPB University. Bogor.

[31] Hardjowigeno, S. 1995. Land Suitability for Agriculture, Recreational Regions, and Building development. Department of Community Service of IPB University and National Land Agency. Bogor.

[32] Sinaga N. 2010. Policy Design and Strategy for Sustainable Post-Coal Mining Area Management [Dissertation]. Bogor (ID): IPB University.

[33] AMDAL. 2016. Environmental Document Amendment of Environmental Impact Analysis about the duration of mining and expansion of disturbed land in 2016 - 2027

[34] Issukindarsyah, Sulistyaningsih, E, Indradewa D, Putra, E T S. 2015. 2015. The growth of three varieties of black pepper (Piper nigrum) under different light intensities related to indigenous hormones role. Biodiversitas. 21 (5): 1778-1785.

[35] Badoa M.D, Kapantow Gene H. M, Ruaau E. 2018. Factors influencing the agricultural land transformation in Tomohon Selatan Sub-district, Tomohon. Agri-SocioEconomic of Unsrat 14(2): 195-204.