THE SUSTAINABLE MANAGEMENT OF POST-MINING LANDUSE; AN AHP APROACH A CASE STUDY: EX-SAND MINING IN INDRAMAYU REGENCY, WEST JAVA

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ABSTRACT

Recently, the sustainable management of post-mining land use has received great attention. The mining-closure, due to the mine has no longer economic value, or the mined material has run out; often leaving poor landscapes and degraded land. The mining company have to rehabilitate the ex-mining land so that it can be returned to its original baseline stage or can be used for other more useful activities. The objective of research is to arrange the sustainable management plan of post-mining land use at ex sand-mining in Indramayu Regency, West Java. The Analytical Hierarchy Process (AHP) approach used to determine the priority of activities that will be carried out on the land. Several criteria and alternative were calculated by Saaty's AHP pairwise comparison scale. The research results reveal that in post mining land use management based on sustainable management, economic criteria must be considered first, followed by environmental, socio-culture and finally technical criteria. Fishery, cattle breeding and agriculture were found to be the optimal alternative for sand post-mining land use.

Keyword: Post-mining, Analytical Hierarchy Process, Environmental, Economic, Social-cultural.

INTRODUCTION

A mining activity carried out by mining A mine is closed when its reserves are exhausted, or it is no longer economically profitable, besides the low market price cannot be ignored (Sonya Kivinen, 2017; Laurence, 2011). When mining ends; the local communities around the mine site are the most affected; as a result of landscape degradation, decreased environmental quality (water, land or air); and socio-economic problems. Some mines are often abandoned after they stop producing, leaving large holes; forest which has been cleared without regard to potential hazards to the environment, humans and social dimensions. So that the ongoing discourse related to the post-mining process is currently getting great attention from various parties..

Mining activities whether a small or large scale have a large positive or negative impact on the local or regional environment during the production process. Positive impacts such as increase the country's foreign exchange, source of local revenue (PAD), create jobs, and others. Meanwhile, the loss of topsoil, removing some parts of the vegetation, loss of soil organic matter, loss of microorganisms, increasing erosion rates, damage to habitat and wildlife, damage to water catchment areas, and disturbing the level of land stability; is a negative impact that may arise. In Indonesia; over the last 20 years many ex-mining areas have ended in acceptable or incomplete mine closure processes. The Indonesian Government Regulation has stipulated that the mining closure and reclamation processes are an integral part of the production process; which is integrated in the Environment Impact Analysis, Feasibility Study, Reclamation Plan and Mine-Closure Plan documents .Overall these documents are required, with the aim of returning the land to its baseline condition to ensure public safety, minimize potential negative environmental impacts, and to allow for alternative land use opportunities after mining is complete. However, it still refers to the Regional Spatial Plan where the mine is located

The former sand mining area in Indramayu Regency, West Java has entered the final production stage (Figure. 1). Even though it has been planned in the reclamation and mining closure documents, the local communities and regional government still involve in planning the use of the ex-sand mining land; so that the mine closure process can be accepted by all parties.

In deciding the criteria and alternative activities to be carried out at the former sand mining site; is used with the Analytical Hierarchy Process (AHP) approach which introduced by Prof. Thomas L. Saaty in 1970. The AHP is a decision-making method that involves a number of criteria and alternatives selected based on the consideration of all related criteria (Saaty, 2004; Uberman and Ostrega, 2005; Akbari et al, 2006)

The aims of study to identify alternatives and attributes that will be used in determining post mining land use.

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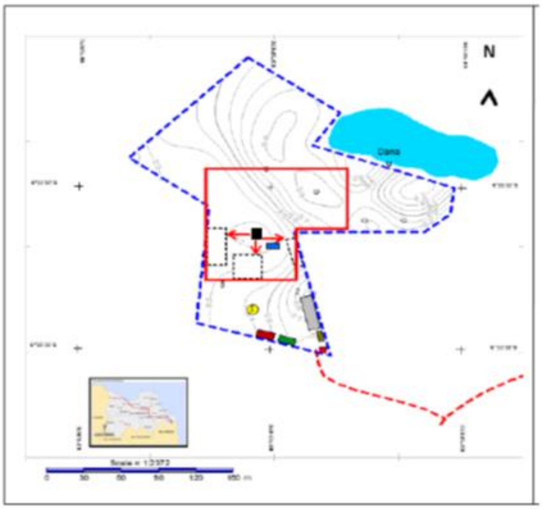

Figure 1. Location Map sand-mining in Bantarwaru Village, Indramayu Regency

RESEARCH METHOD

The location that becomes the object of this The best solution to problems that arise in post-mining can be done by identifying a number of alternatives and attributes by using several techniques, including: decision tables, trees decision, or several method of Multiple Attribute Decision Making (MADM). In this study we used one of the MADM methods, namely the Analytical Hierarchy Process (AHP) method.

The definition of Multi-Attribute Decision Making (MADM) as follows:
For examples A = {ai | i = 1, ..., n} is the set decision alternatives and C = {cj | j = 1, ..., m} is the set of expected goals, it will the alternative x_0 is determined which has the degree of expectation highest level of relevant objectives c_j.

Some of the parameters used in AHP are:

- **Alternatives**, are different objects and have the same opportunity to be chosen by decision maker.
- **Attributes,** often referred to as characteristics, components, or decision criteria. Although on most criteria are one level, but they are not close the possibility of sub-criteria related to the criteria that have been given.
- **Conflict between criteria**, some criteria usually have a conflict between one another others, for example the profit criteria will conflict with the cost criteria
- **The decision weight**, the decision weight shows the relative importance of each criterion, W = (w1, w2, ..., wn). At MADM, the weight of interests will be sought of each criterion
- **Decision matrix**, an X decision matrix measuring m x n, contains the elements x_{ij}, that is represents the rating of the alternative A_i (i = 1,2, ..., m) against the criteria C_j (j = 1,2, ..., n).

In MADM, the decision matrix of each alternative is against each attribute, X, is given as:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1))$$

where x_{ij} is the *i* alternative rating against the *j* attribute.

- Weight value that indicates the level of relative importance each attribute, given as, W:
  W = (w1, w2, ..., wn}. (2)

The overall process of post mining land use management can be seen in the figure 2.

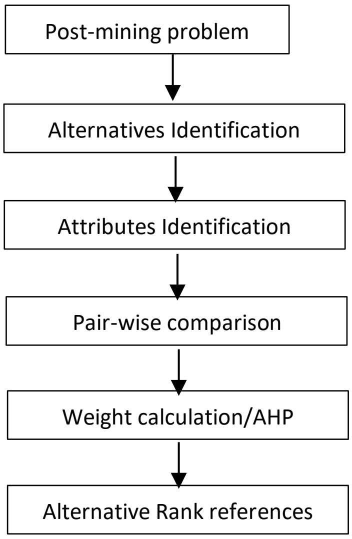

Figure 2. The flow chart of determining the preference rank of alternatives.

RESULT AND DISCUSSION

MINING GEOLOGY

Stratigraphically; the sand production concession area, consists of one main rock unit, and surface sediment, if ordered from old to young, are as follows:

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1. The Tuffaceous Unit

Consists of an alternation of clay, siltstone, tuff and conglomerates. Tufa, grained fine to coarse, brownish in color, soft to hard, quartz, mafic mineral and glass volcanic. Claystone, grey to brown, soft to hard, still contain tree root. Conglomerate, showing the materials component of igneous rock with granule to pebble, which embeded in tuffaceous matric and ferrous oxide cemented. Total thickness of this unit estimated at 775 meters, deposited in a terrestrial environment.

2. Alluvium unit

Looses soil, sand and gravel units according to the Geological Map of the Kalijati Sheet are included in the Alluvium (Qa) deposit which is Holocene in age.

The geological map of sand-mining in Bantarwaru Village, Indramayu Regency was shown in Figure 3. A three-dimensional distribution of tuffaceous sand is seen in Figure 4

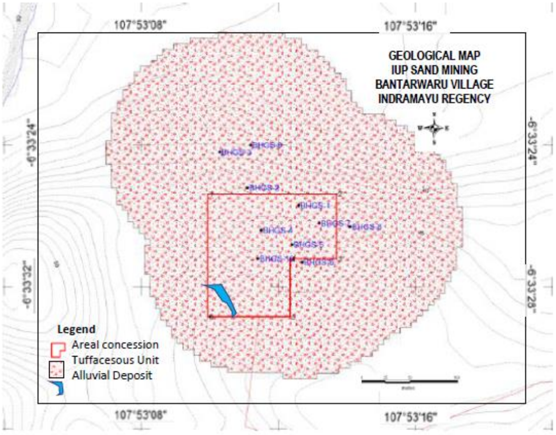

Figure 3. Geological Map of sand-mining concession in Bantarwaru Village, Indramayu Regency

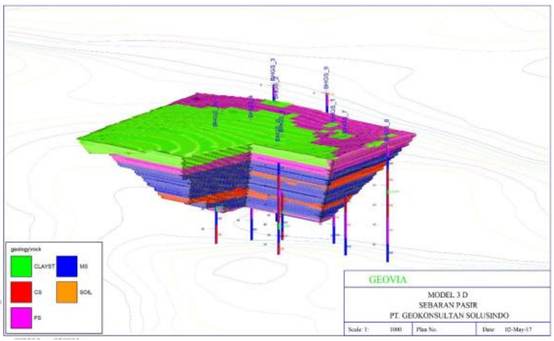

Figure 4. A 3D distribution of tuffaceous sand in sand mining concession, Bantarwaru Village, Indramayu Regency

Sand Reserves

The sand reserves is 197,353 bcm (276,294.20 lcm), and amount of overburden rock is 42,535 bcm (51,042 lcm). The average stripping ratio of 1: 0.18.

The Mining Methods

Sand excavation is carried out using the open pit method with the following stages:

- Mine planning and stake out based to the mine plan.
- Land clearing and land arrangement which includes drainage arrangement.
- Construction of mine surface erosion control ponds.
- Temporary removal and storage of overburden consisting of topsoil and subsoil.
- Manual excavation and sorting of materials using heavy equipment against sand and chunks.
- Spray sand with a high pressure water monitor.
- Suction of sand mixed with water using a 10 inch centrifugal pump. Composition of sand: water = 15%: 85% (Figure 5)
- Screening using a vibrating screen at the mouth of the mine with a maximum size of 10 mm (Figure 6)
- Sand stocking and sales.
- Ex-mine drainage arrangement.
- Reclamation of ex-mining land.
- Revegetation or other use.

Figure 4. Sand-mining excavated activity in sand mining concession IUP PT. GS

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Figure 6. Sand screening by vibrating screen activity in sand mining concession

Mining Reclamation

The sand excavation activity has left several holes filled with large volumes of water to form lakes (Figure 7). So that the company took the initiative to use the lake for freshwater fish cultivation together with the communities surrounding mining area as Corporates Social Responsibility (CSR) from a sand mining company

Figure 7. Comparison of land conditions before mining (left) and after mining (right)

The characteristic of the lake-waters ex-sand excavation are closed in nature so that the water circulation is relatively non-existent, generally, there is the only continuous addition of water either rainwater or water from irrigation or other sources. This can happen because the waters from the excavation of sand were not originally designed as a container for fish cultivation. Fish cultivation containers, either in the form of ponds or ponds, have one of the technical requirements of the water management system, both intake and discharge, can be carried out by gravity, while the waters of the former sand mining area have a lower or deeper bottom than the bottom of the channel so that it is difficult to remove water by gravity.

POST-MINING LAND USE ALTERNATIVES AND EFFECTIVE ATTRIBUTES

In this study, the Analytical Hierarchy Process (AHP) method was used to identify suitable alternatives for post-mining land use. The basis for determining criteria is based on sustainability and spatial planning considerations; that are, eenvironmental, technical, economic and socio-cultural aspects (Figure 8). The consideration of the ecological sustainability of the ex-mining location, seen from the ecological aspect, is considered as one of the post mining criteria. Besides that, the technical aspect is also the criteria for land suitability in post mining activities. Economical factors indicate that the alternatives chosen are alternatives that are beneficial to the community around the location. Cultural factors are also considered in the concern of land use for cultural sustainability. Thus, it is hoped that the determination of ex-mining land activities will achieve optimal results.

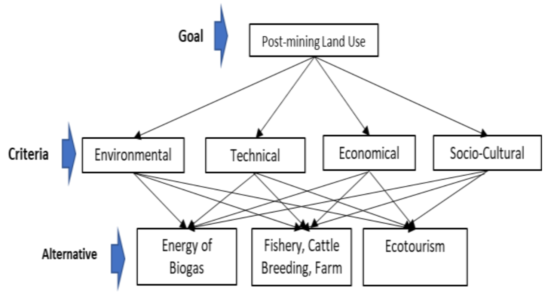

Figure 8. The AHP diagram for the Post-mining Land use management

In this study, several alternatives were determined as a reference for the development of ex-mining land. The first alternative is to develop freshwater fisheries, cattle breeding and agriculture. Meanwhile, the second alternative is to develop biogas energy from cow dung. Meanwhile, the third alternative is to develop a pond formerly used for galain land as a source of clean water (water treatment) and the fourth alternative is to develop ecotourism.

The Table 1 shows the calculations of Pairwise comparison between criteria and objective

Table 1. Preference indexes matrix for post-mining land use criteria.

Goal	Ec	Te	Env	Sc	Rank
Ec	0.51	0.49	0.49	0.59	1
Te	0.10	0.10	0.12	0.07	4
Env	0.26	0.20	0.24	0.29	2
Sc	0.13	0.20	0.12	0.15	3
Consistency Ratio : 0.016					

Ec : Economical Te : Technical
Env : Environment Sc : Socio-culture

Referring to the pair-wise calculation of the criteria chosen to determine the goals of post-mining land use management (Table 1); shows that economic criteria are meet the first priority with a result of 59%. while environmental criteria is a second rank (29%); followed by socio-cultural criteria)15%) and technical criteria as the fourth ranking criteria (7%). AHP assessment results show a consistency ratio of 1.6% (0.016) which indicates that the analysis results meet the requirements as proposed by Saaty (2008); ie less than 0.1.

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The next step, is to do. Furthermore, the pairwise comparative assessment of alternative options in determining the most suitable alternative and will be a priority. The results of the pairwise comparison analysis between the alternative criteria for determining the priority of post-mining utilization strategies are shown in table 2.

Table 2. Preference indexes matrix for post-mining land use alternatives

Ec	EB	FCB	EC	TPV
EB	1	0.25	0.5	0.14
FCB	4	1	2	0.57
EC	2	0.50	1	0.29
Te				
EB	1	0.25	0.2	0.10
FCB	4	1	1	0.43
EC	5	1.00	1	0.47
Env				
EB	1	0.33	5	0.30
FCB	3	1	5	0.61
EC	0.2	0.20	1	0.09
Env				
EB	1	1	4	0.41
FCB	1	1	7	0.50
EC	0.25	0.14	1	0.09
Total Value Priority				
EB : Energy of Biogas				0.20
FCB:Fishery,Cattle Breeding,Farm				0.53
EC : Ecotourism				0.27

The results of the assessment of the determined alternatives, it was found that the alternative development of fishery, cattle farming and agriculture were superior alternatives on each criterion; with a Total Priority value (TPV) is 53%. The alternative development of ecotourism is the second choice with a TPV value of 27%. While the last option is a biogas energy production project using cow dung; which is indicated by a low TPV value (20%). The consistency ratio (CR) of each alternatives were low (below 0.01); CR EB: 0.041; CR FCB : 0.026, and CR EC : 0.031, respectively. So that the results of the analysis above can be accepted and can be carried out to get optimal results in the use of ex-mining land.

CONCLUSION

Based on a study of criteria and alternatives on the management of ex-mining sand land; using the Analytical Hierarchy Process method in Bantarwaru Village, Indramayu Regency; It can be concluded that the economic criteria are the best criteria for managing post-mining land use. Meanwhile, the development of freshwater fish cultivation, cattle and agriculture are the best alternatives in the use of post-mining landuse.

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