Land Capability Evaluation of Reclamation Areain Indonesia Coal Mining Using LCLP Software

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Abstract

Land capability evaluation is process to evaluate land potency according to its capability for sustainable land uses. It is important to be implemented for management reclamation area in coal mining operation because as generally known that land is limited resource and improper land management led to decline in land productivity, so reclamation area needs to be well managed for sustainable land use. Purpose of this study is to evaluate land capability of reclamation area in Indonesia coal mining. The required data for land capability evaluation are climate properties, slope, erosion risk, soil properties, and natural hazard risk. This process consist of collecting land characteristic data include, soil properties, topographic properties, erosion risk, flood risk and landslide risk; soil laboratory analysis; data input and analysis using Land Classification and Land Use Planning (LCLP) software; land capability classification using LCLP.

Land capability analysis in this study is carried out using LCLP software. LCLP is software to classify land and to generate new map according to the class of land capability. As open source software, it is possible to modify parameters for analysis according to data availability and purpose of the study. The result of this study is categorized the study area as land can be cultivated which is varying from class II, III and IV based on land characteristic and limitation factor.

Keywords:

1. Introduction

As generally known land availability is limited, due to high growth in the industrial sector, agriculture, housing, mining and other sectors. So the existing land include ex-mining land should be used optimally to increase land productivity and prevent land degradation.

Most of coal mines in Indonesia are adopted on open pit mining method which temporarily disturbs land. Impacts of mining that affects land potency and productivity that may occur are physical disturbance, land stability,
erosion, sedimentation and flooding (Greb, et al., 2006). Reclamation is needed to reclaim ex-mining land to be safe, stable and productive land; it should be well managed for sustainable use of ex-mining land.

Considering the importance sustainable use of ex-mining land, Indonesia government has issued several law and regulation related to post mining. Indonesia government regulation No. 78/year 2010 concerning reclamation and post mining mentions that one of principles of protection and management of environmental mining is the utilization of ex-mining land is according to the intended use (The Republic of Indonesia, 2010).

Determination of the ex-mining land use must be carried out carefully by considering the physical soil properties, topography condition, microclimate, and risk hazard to achieve a sustainable and productive use. It can be done by land potency evaluation method.

2. Land potency for optimum land utilization can be determined from land capability evaluation. Land capability evaluation is process to evaluate and classify potency of land according to its capability for sustainable land utilization. Land capability evaluation function is to define management improvements are necessary to prevent land degradation. These improvements include the selection of land use type and conservation efforts that need to be applied in developing a long-term conservation program (Notohadiprawiro, 1991).

The purposes of this study are to classify land capability and to evaluate potency and limitation of reclamation area. The evaluation is based on soil properties, topographic properties, erosion risk, flood risk and landslide risk. This process consists of collecting land characteristic data include, soil properties, topographic properties, erosion risk, flood risk and landslide risk; soil laboratory analysis; data input and analysis using Land Classification and Land Use Planning (LCLP) software; land capability classification using LCLP.

Land capability classification used in this study is according to USDA classification. The classification system comprises eight class ranks in order of limitation degree. Lands which categorized in Class I-Class IV are suited to cultivation and other uses, while lands which categorized in Class V-Class VIII are generally not suited to cultivation. Capability analysis will generate three major categories namely capability unit, capability class and capability sub class. Capability unit is group of land unit that have same categories in land management. Capability class classify all land into eight classes depend on the risk of soil damage or limitation factor which is greater progressively from Class I to Class VIII. Capability sub class provides information more detail of capability class concerning limitation and hazard (Klingebiel and Montgomery, 1973).

The main characteristic of class I is land have few limitation so reduce the choice of limitation. Class II has some limitation that reduce the choice of plant can be cultivated and needs moderate conservation practice. Class III has severe limitation that reduce the choice of plant can be cultivated and need special conservation practice. Class IV has very severe limitations that that reduce the choice of plant can be cultivated and need very careful conservation practice. Class V has no or little erosion risk but has other limitation. Class VI has severe limitation so generally not suited to cultivate plant. Class VII has very severe limitation so not suited to cultivated plant and restrict the utilization to grazing, woodland or wildlife. Class VIII has limitations that obviate utilization for production commercial plant and restrict the utilization to recreation, wildlife, water supply or aesthetic purposes (Klingebiel and Montgomery, 1973).

Land capability analysis has been used extensively over the years for various purposes in the world and in Indonesia. Generally land capability analysis is used for preliminary analysis of land. Land capability analysis has been applied on regional planning, agriculture survey, plantation survey, forestry survey, determination land utilization and land degradation evaluation.

3. Study Area

The area of this study is Melawan Pit PT. Kaltim Prima Coal (KPC), located in Sangatta, Kutai Timur, Kalimantan Timur, Indonesia which covers an area of 2,000 ha. The area is located at coordinate 0º 35' 33.695" N to 0º 37' 47.885" N and 117º 24' 46.434" E to 117º 27' 38.08" E in geographic coordinate.

The Study area belongs to tropical regions with annual rainfall between 1,549 mm – 2,993 mm and an average annual rainfall of 2129.6 mm. The temperature of study area varies from 22 to 31°C with an average temperature of 27°C (Source: PT. Kaltim Prima Coal).
The topography of study area is hilly, sloping down, with altitudes between 10 - 350 m above sea level. Percent of slope is varying from flat (0-3 %), undulating (3-8%), rolling (15-30%) and strongly rolling (15-30%).

Stratigraphy of study area consists of Balikpapan formation (sand, clay, silt, tuff and coal), PulauBalang formation (sandstone, claystone and siltstone, coal seam, limestone or calcareous sand stone) and Pamaluan formation (claystone, sandstone and coal) (P3G, 1995).


![Figure 1. Map of Study Area (Bakosurtanal, 2003 and 2012)](image)

3.1. Rehabilitation Specification PT. Kaltim Prima Coal

Rehabilitation specification is guidance in preparing land for reclamation area which has important role to the success of ex-mining land utilization. PT. Kaltim Prima coal issued Rehabilitation Specification which consist specification for dumping construction, erosion control, control of acid mine drainage, land clearing and soil management, revegetation, and completion criteria (PT. Kaltim Prima Coal, 2000).

The rehabilitation specification requires slope configuration as follows = maximum percent of slope 4 : 1, overall slope 5.5 : 1, maximum slope length 40 meter, and back slope 2%. Beside that also requires dumping non-acid forming overburden to be dumped in the outer bund, spreading 1 meter soil after completing slope setting, constructing drainage berm around dump face along slope which has potential for erosion, constructing drop structure along the face of dump to receive water flow from drainage berm and safely flow it to the down slope (PT. Kaltim Prima Coal, 2000).

4. Methodology

Method used in this study is integration between field observation, soil laboratory analysis and land capability analysis using LCLP software. Land capability class is determined based on the results of matching process between land properties with the criteria for sustainable land utilization and without long term damage or land degradation. The research tools used in this study were personal computer, LCLP software, GPS, and tools for soil sampling. Whereas input data used in this study were soil sample, rainfall data, contour map, and data from field observation.

4.1. Field Observation

Field observation is conducted to collect and observe soil properties (soil texture, drainage, soil depth, percentage of gravel and rock, and permeability), to measure topographic properties (slope), to observe hazard (flood, salinity, land slide and erosion) and also to collect soil sample. Field observation and sampling, carried out at 8 sample points representing a variety age of plant from 2004 to 2011.
4.2. Soil Laboratory Analysis

Soil laboratory analysis is intended to observe and measure the soil properties that could not be carried out by visual observation in the field. Soil properties observed by laboratory analysis are soil texture, salinity and soil properties for erosion analysis, whereas soil drainage and soil permeability could not be observed because the sample is disturbed soil sample.

4.3. Land Capability Analysis using LCLP Software

There are two main menus in LCLP software: Global Data and Land Analysis. Global data menu as can be seen in Figure 2, is facility to define limitation factor, description of limitation factor and class of limitation factor. Limitation factor determination depends on the condition of land and also the availability of data for land capability analysis.

![Figure 2. Global data menu in LCLP software](image1.png)

![Figure 3. Land analysis menu in LCLP software](image2.png)

Land analysis menu as can be seen in Figure 3, is facility for inputting land characteristics data for each sampling point/land unit. Inputting data is not manually by writing each value but executed by choosing class in drop down list which match with the value. Drop down list created in global data menu. After inputting data is complete then we can running analyze button to generate land capability class.
The output of land capability analysis using LCLP software is not only class of land capability but also sub class of land capability. The sub class of land capability indicate limitation factor of land expressed by one or two letters: l = slope, k = soil depth, b = gravel/rock, ta = soil texture, e = erosion, o = flood, g = salinity, ke = soil erodibility, l = landslide. The information related to the limitation factor of land is very important for decision making on land management, soil treatment, degree and type of conservation practice and other human intervention for sustainable use and continual improvement.

This study is conducted in reclaimed land with various year of planting from 2004 until 2011. The evaluation is limited to several parameters which are collected directly from field observation, soil laboratory analysis and also result from equation calculation for example for soil erosion rate and soil erodibility.

The result of this study is an overview the capability of land for general land use types, to determine the suitability of land for a specific use in example for plantation or housing it required further analysis using land suitability analysis.

5. Result

Parameters used for assessment of land capability in this study as can be seen in Figure 4, consisted of 9 parameters which are categorized as soil properties, topographic properties and hazard properties. These parameters are obtained from field observations and soil laboratory analysis results. The parameters include soil texture, salinity, percent of slope, gravel and rock, soil depth, flood hazard, land slide hazard, erosion hazard, and erodibility.

Limitation factor description in sub menu provides information concerning classification of each parameter. Each parameter classifies into four to six classes. Class of each parameter can be seen in Figure 5. Data from the field observation, soil laboratory analysis or from equation calculation should be classified refer to this classification.

Matrix of land capability criteria is compiled based on relationship between land capability class and classification criteria which are referring to definition of land capability class, land capability sub class and grouping of land characteristics (Arsyad, 2010). This matrix also used to classify each parameter/limitation factor. Classification of each parameter/limitation factor can be seen in Figure 6.

Soil laboratory analysis is needed to obtain soil texture; composition of sand, silt, clay and loam; percent of organic matter, soil structure and soil salinity. The result of soil laboratory analysis shown that soil texture in the study area consists of clay, clay loam and silty clay loam. Soil texture is used as parameter to evaluate land capability also used as input data for erosion analysis. Soil texture affect to plant growth and soil management because it will determine water content, porosity, soil structure, infiltration rate, drainage, and erosion. Soil salinity refers to the salts concentration in the soil and estimated by measuring the electrical conductivity (EC). High
concentration of salt in the soil causes inhibition of plant growth. Measurement result of salinity in the study area show various result from 0.03 -0.2 mS.

Parameters which are obtained from field observation are soil depth, percent of slope, stoniness (gravel and rock), flood and landslide hazard. These parameters are measured by visual measurement in the field and also by comparing with contour map for percent of slope parameter. The result of field measurement in sampling point is shown that lands relatively stable and no indication of hazard both landslide and flood, whereas topographic condition of study area is varying from flat (percent of slope 0-3%), undulating (percent of slope 3-8 %), rolling (percent of slope 8-15%), and strongly rolling (percent of slope 15-30%).

Erosion rate and soil erodibility are calculated using USLE equation. As generally known that erosion is influenced by many factors namely climate factor, topographic factor, soil properties factor, and human intervention factor in conservation practice and land management. The soil loss equation is needed the value of rainfall erosivity factor, soil erodibility factor, topography factor, cover and management factor, and support practice factor (Wischmeier and Smith, 1978).

Raw data used for calculating soil erosion using USLE equation are rainfall data, soil properties (soil texture and distribution of sand, silt, clay and loam; soil structure; % of organic matter and permeability class), topography factor (percent of slope and length of slope), cover and management factor and support practice factor. Soil erodibility in study area varies from 0.019 to 0.14, whereas soil erosion rate vary from 0.018 to 0.10 ton/ha/year,
which is lower than tolerable soil loss based on table of maximum tolerable erosion rate for various soil condition in Suripin (2002).

This is affected by the implementation of rehabilitation specification in reclamation land preparation consists of erosion control trough construction drop structure, terrace system, sediment trap, erosion protection bund and setting of percent of slope, length of slope and dumping which ultimately control the erosion rate.

![Figure 7. Land analysis menu in LCLP software](image)

The result of land capability analysis can be seen in Figure 7. The results shown that land capability class in the study area is all categorized as land can be cultivated consist of land capability Class II, III and IV. Land capability class in the study area is dominated by land capability class II which various limitation factor namely percent of slope and soil erosion rate. Based on the result, land can be applied for various uses include intensive farming; extensive farming and marginal farming depend on limitation factor.

5.1. **Land Capability Class II**

Land capability Class II is dominant in the study area, this class generally located in area which has percent of slope flat (0-3%) and undulating (3-8%). Type of limitation factors for the utilization of this class are percent of slope and erosion rate. Lands in capability Class II have few limitations that reduce the choice of utilization and need moderate conservation practice. This class is suitable for cultivated crops, pasture, range, production forest, woodland and industrial plant (Klingebiel and Montgomery, 1973 and Arsyad, 2010).

5.2. **Land Capability Class III**

Land capability Class III generally located in area which has percent of slope rolling (8-15%). Type of limitation factor for the utilization of this class is percent of slope. Lands in capability Class III have more severe limitations than Class II and need special conservation practice. This Class may be used for cultivated crops, pasture, range, production forest, protection forest and wildlife reserve (Klingebiel and Montgomery, 1973 and Arsyad, 2010).

5.3. **Land Capability Class IV**

Land capability Class IV generally located in area which has percent of slope strongly rolling (15-30%). Type of limitation factor for the utilization of this class is percent of slope. Lands in capability Class IV have more severe limitations than Class III that make the choice of plant more limited and require very careful management. This Class may be used for crops, pasture, range, woodland, production forest, protection forest and nature reserve (Klingebiel and Montgomery, 1973 and Arsyad, 2010).
6. Conclusion

Land capability class is determined by natural factor and human intervention factor. Natural factors that determine land capability class including climate properties, soil properties and topographic properties. Some of natural factor cannot be modified for example climate properties but other factors can be modified to reduce or remove the limitation for example percent of slope, length of slope, and soil salinity. Human intervention factor including good implementation of KPC rehabilitation specification; topsoil management from removal, transporting and handling, stockpiling and spreading and ripping; conservation practice for soil erosion control and land slide prevention.

Refers to the land capability analysis result in the study area, the limitation factors for land use in each class are percent of slope and erosion rate. Treatment or land management for slope problem and erosion problem are related each other. Land management to solve slope problem will effect on reducing soil erosion. Slope problem can be solved with various mechanic conservation methods which include application of bench terraces to reduce slope angel and length of slope, parallel terrace, contour terrace and contour planting/cultivation to slow run off and reduce erosion risk.

Erosion control is important part in mining operation especially in mine reclamation because it also determines the success of reclamation. It is reinforced with the issuance of technical guidance erosion control in general mining operation refer to decree of Director General of General Mining, Indonesia Ministry of Mining and Energy No 693.K/008/DDJP/1996. As mentioned above, erosion control has been implemented in the study area is refer to rehabilitation specification guidance.

7. Conclusion

After the land properties were analyzed based on land capability evaluation using LCLP software, this research makes the following conclusions:

- The study area is categorized as land can be cultivated which is varying from Class II, III and IV based on land characteristic and limitation factor. Refers to the land capability analysis in the study area, the limitation factors for land use in each class are slope and erosion rate. Treatment or land management for slope problem and erosion problem are related each other.
- The information related to the limitation factor of land is very important for decision making on land management, soil treatment, degree and type of conservation practice and other human intervention for sustainable use and continual improvement.
- LCLP software is very effective, rapid and flexible for land capability analysis by matching the land characteristics with land requirement for each capability class.
- Accuracy in setting global data and input data is affecting accuracy of land capability analysis result.
- Land capability analysis is intended to analysis the capability of land for general utilization, whereas to analyze suitability of land for specific purpose or utilization need further analysis namely land suitability analysis.

Acknowledgements

The authors’ wish to express their deepest gratitude to PT. Kaltim Prima Coal Indonesia, to Center of Urban Infrastructure, Environment and Resources (CUIER) Fukuoka, Japan for continuous support and to Faculty of Geography GadjahMada University - Indonesia for Land Classification and Land Use Planning (LCLP) software usage permit. First author greatly acknowledge the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) for MEXT scholarship and the Global-Center of Excellence in Novel Carbon Resource Sciences, Kyushu University for financial support.
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