IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

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To cite this article: Nurlina *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **499** 012014

IOP Conf. Series: Earth and Environmental Science **499** (2020) 012014 doi:10.1088/1755-1315/499/1/012014

Analysis of Environmental Vulnerability Using Satellite Imagery and Geographic Information System in Coal Mining Area Planning at Banjar Regency

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Abstract. It has been done research of environmental vulnerability degradation in coal mining area planning using satellite imagery and Geographic Information System. Vulnerability of environmental degradation is the condition of areas that has potential to damage the environment because of human activities or activity that has potential to cause environmental impacts. Monitoring of environmental degradation can be done to determine the ecological vulnerabilities so as to predict and overcome the future events. The development of remote sensing technology and geographic information systems can facilitate the spatial analysis especially environmental degradation. This research was done to map the vulnerability of environmental degradation in coal mining area planning in Banjar regency and classify environmental damage in the area. The analysis based on scoring and weighting of each index resulting ecological vulnerability index (EVI). The results of the overlay and weighting using weighted summation model's method in coal mining area planning was plotted into four types of zone, i.e., appropriate exploitation zone, optimized exploitation zone, needs to monitoring exploitation zone, and recommended not to be exploitation zone. Thus, the classification of environmental damage in the coal mining area planning of which are moderate to severe erosion, surface runoff in the watershed, moderate salinity resulting in soil degradation, vegetation does not grow well and loss of recharge area.

1. Introduction

Natural resources have an important role in improving the welfare of society. The good management and utilization of the environment for natural resources in an area is strived so as not to damage and be sustainable, so that environmentally sound development becomes the main principle in every regional development planning. Utilization of resources that ignores the physical factors of the land without looking at the potential of land in accordance with those determined in utilizing the land, then the potential to experience environmental damage [1]. One of the ways to monitor environmental damage is by knowing the ecological vulnerability index. The importance of knowing the value of the ecological vulnerability index simultaneously checks the level of risk and present conditions, predicts environmental conditions and addresses future events [2]. Mapping the vulnerability of environmental damage can make it easier to carry out monitoring and supervision, especially in the affected area, so that the mitigation efforts can be planned and implemented properly.

Utilization of satellite imagery and remote sensing technology has been widely applied in environmental damage analysis, as has been done by Hardiyanti [3] using Landsat TM imagery used to monitor environmental damage in the Meratus area. As for other studies, Slone [4] identified environmental damage due to coal mining with geographic information systems. The results of this study indicate that environmental damage can be analyzed, monitored and monitored and evaluated using a geographic information system with results that are faster, more efficient than direct observation.

Banjar regency area is 4,668.50 km^2. It has abundant natural resources and has a fairly diverse mining land from mining materials class A, B and C [5]. The mining sector is the most environmentally damaging compared to other natural resource exploitation activities. The forest area in the Banjar regency has changed its function to become residential land, mining and plantation, this is certainly not in accordance with the function of the area and will certainly damage the environment. Rosadi's research [6] states that groundwater quality in coal mining areas in Banjar regency contains heavy metal Fe 11 mg L^{-1} and Cd of 0.008 mg L^{-1}, beyond the maximum threshold set 907/Menkes/SK/VII/2002 it is permissible for drinking water to contain heavy metals Fe of 0.3 mg L^{-1} and Cd of 0.003 mg L^{-1}. Therefore, this research study is focused in Banjar Regency using a coal mining planning map. The use of coal mining planning maps is done in order to facilitate monitoring and supervision so that areas with potential damage can be monitored and evaluated in making decisions for exploitation of coal mining [2]. This research uses ArcGIS 10.5 software by using the method scoring on the parameters used.

2. Method

2.1. Experiment I.

This research consists of the preparation stage, namely primary and secondary data collection, data processing consisting of making DEM slope, NDVI transformation, erosion prediction processing using formula USLE (Universal Soil Loss Equation) by taking into account several factors, namely rain permittivity, factors soil vulnerability, length and slope factors, vegetation cover and plant management factors, special soil conservation factors. Scoring on each indicator using the AHP method and the value of the scores were tested for consistency, overlay slope index data, vegetation greenness index and hydrogeological index in order to obtain an ecological index, overlay was data also performed on the erosion index, soil erodibility index, soil salinity index so that the ecological sensitivity index was obtained. The weighting of the ecological index and the ecological sensitivity index uses the AHP method. Ecological index and ecological sensitivity index in the overlay obtained Environmental Vulnerability Index (EVI) which can be used in the data analysis stage using the grid system on the geo statistical method.

2.2. *Experiment II.*

Equipment and materials used in this study consist of a laptop to process data and analysis results, ArcGIS 10.1 software used for data processing, GPS is used to determine coordinates and elevation when checking field data, display color charts to know the structure, soil texture, digital camera for field documentation. Landsat 8 imagery is used for transformation of vegetation greenness index, aster image for slope analysis, Banjar Regency Spatial Planning Map 2013-2032 (RTRW) as a coal mining planning reference, Banjar Regency land type map, Banjar Regency hydrogeology map, Banjar Regency soil salinity map. Banjar Regency monthly rainfall data for 2009-2014 was used as parameters.

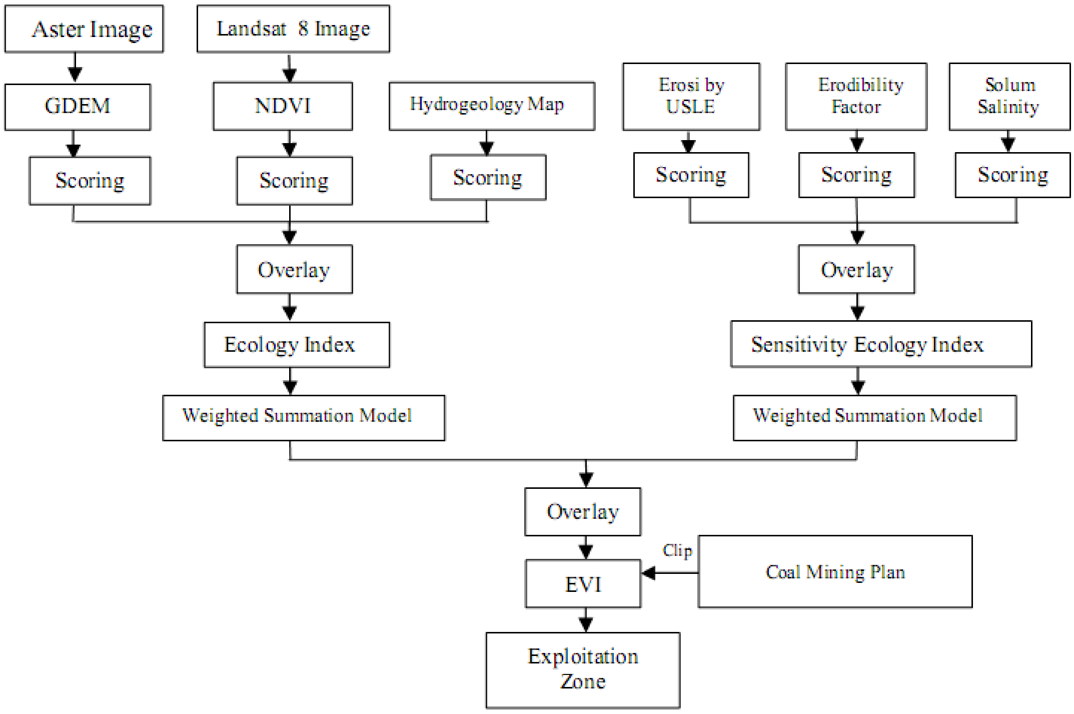

Figure 1: Research flow chart.

3. Results and Discussion

Banjar Regency coal mining planning area based on the 2013-2032 RTRW there are five planned locations for the coal mining area. The coal mining planning area was named Location A, location A was in the Pengaron District with the Paau formation consisting of volcanic breccia, blackish gray, andesite-basalt rock components measuring 5-30 cm, associated with lava, blackish gray with basalt composition. its thickness is estimated at 750 m. This location was based on the geological map where there were folds or faults. At Location B which was in the northwest of Sungai Pinang District with the Tanjung Formation and the Berai Formation. At Location C there was a Tanjung formation which was also found by contact folds or faults with direction and slope of the layer towards the southwest which was in Telaga Bauntung District, precisely in the Southwest of Banjar Regency. For Location D and E, there were in the Paau formation located in Telaga Bauntung District and Paramasan District, precisely in the North of Banjar Regency. Map of Banjar Regency mining planning can be seen in figure 2.

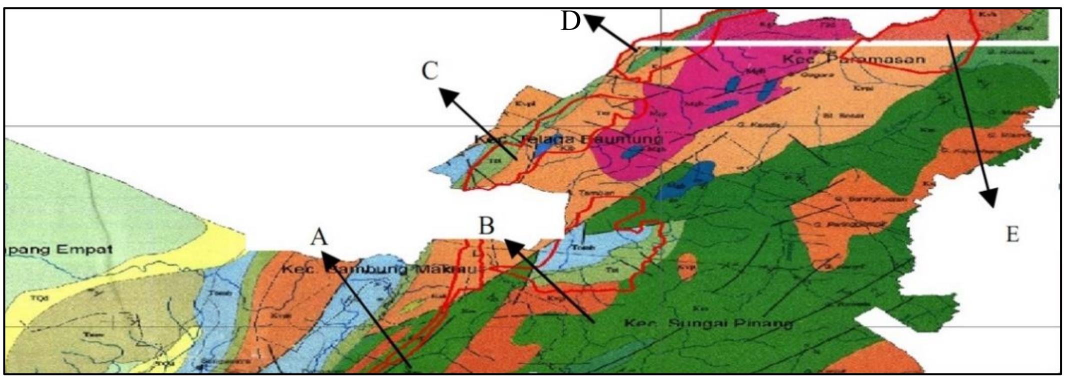

Figure 2: Geological map overlay with coal mining planning in Banjar Regency (Regional Planning Agency, 2013).

The superposition of the layout of coal mining planning and overlaying the ecological index with an ecological sensitivity index obtained the EVI (Ecological Vulnerability Index) with the lowest value of 1.219 and the highest value of 2.854. The results of the vulnerability index can be plotted against the area into four zones, namely suggested exploitation zones, exploitation zones optimized, exploitation zones need supervision, zones should not be exploited. Map of environmental damage vulnerability can be seen in figure 3.

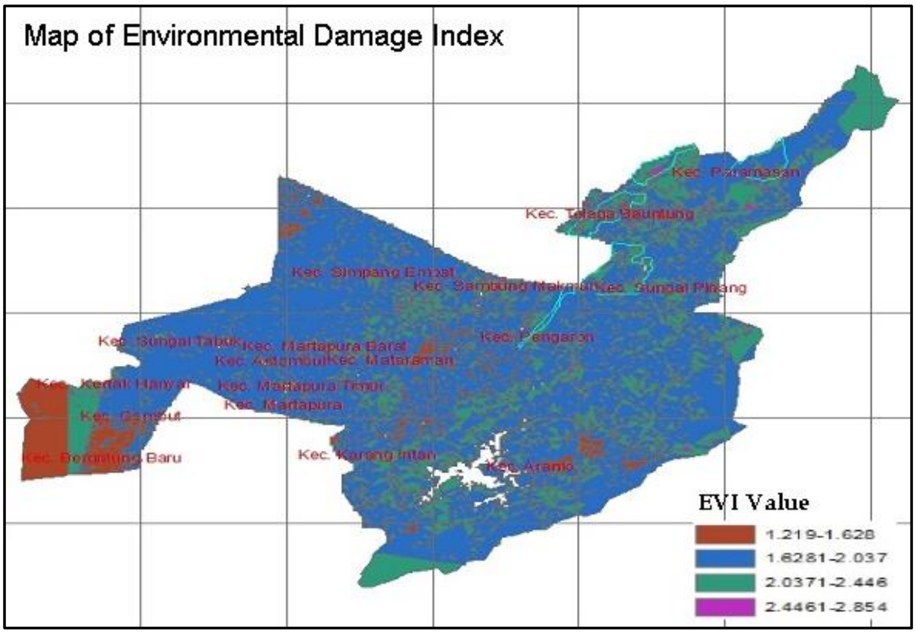

Figure 3. Map of environmental damage index in Banjar Regency.

The zoning results of the coal mining planning area can be seen in table 1 below:

Location of Planning	Exploitation Zoning	Range	Area (ha)	Percentage
Location A	Exploitation is suggested	1,219-1,6280	1235.62	98.17
	Exploitation needs to be optimized	1.6281-2,0370	23.05	1.83
Location B	Exploitation needs to be optimized	1.6281-2.03370	3,714.74	76.51
	Exploitation needs supervision	2,0371-2,4460	1,140.24	23.49
Location C	Exploitation needs supervision	2,0371-2,4460	3,346.27	95.23
	should Exploitation not be carried out	2,4461-2,8540	167.52	4.77
Location D	Exploitation needs to be monitored	2,0371-2,4460	1,793.08	87.20
	should Exploitation not be conducted	2.4461-2.8540	263.09	12.80
Location E	Exploitation needs to be optimized	1.6281-2.03370	2.837.10	86.04
	Exploitation needs supervision	2.0371-2.44460	460.33	13.96

Table 1: The zoning results of the coal mining planning area.

Recommended exploitation zones were areas with low vulnerability and were not within the scope of nature reserves and conservation forests. Coal mining activities at this location had a relatively small effect on the vulnerability of environmental damage, but cannot be completely ignored due to groundwater problems, land subsidence caused by coal mining cannot be avoided, so prevention measures are still needed. The exploitation zones that need to be optimized were some optimizations that can be done, namely restoration of vegetation around the coal mining area, while sophisticated technology for exploitation must also be used to reduce the ecological impact caused by mining. Exploitation zones need to be supervised, namely by supervising the volume of coal taken per day in order to avoid massive exploitation that can result in aggravating environmental damage. The condition was affected by steep slopes and erosion which is classified as severe, so this exploitation zone needs supervision. For areas where exploitation was not recommended if exploitation had to be carried out, more supervision was needed at this location.

Potential environmental damage in the coal mining planning area from the results of the analysis with the geographic information system at Location A was mild erosion (15-60 t ha^{-1} y^{-1}) with an area of 852.67 ha (67.74%) caused by several factors namely slope the steep (25-45%) of 578.72 ha (45.98)%, the rare canopy density of 845.40 ha (67.17%), mild soil erodibility factor (0.16-0.32) area 1,033.7 ha (82.13%), mild salinity (2-4 dS m^{-1}) of 758 ha (60.22%) can interfere with plant growth and soil degradation. Potential environmental damage at Location B was moderate erosion (60-180 t ha^{-1} $year^{-1}$) with an area of 2,485.98 ha (51.20%), moderate soil salinity (4-8 dS m^{-1}) covering 3,465.52 ha (71.38%), the density of vegetation was rarely 1,305.23 ha (26.89%). Potential environmental damage at Location C was heavy erosion (180-480 t ha^{-1} y^{-1}) covering an area of 2,513.79 ha (71.54%), land subsidence caused by low erodibility factors (0.16-0.21) covering an area of 1,854, 79 (52.79%), moderate soil salinity (4-8 dS.m^{-1}) covering 1,881.79 ha (53.55%), can damage vegetation in Location C with dense vegetation density of 817.49 ha (23.27%). Potential environmental damage at Location D was heavy erosion (180-480 t ha^{-1} y^{-1}) of 957.12 ha (46.55%), land subsidence due to low erodibility (0.16-0.21) area of 1,256, 66 ha (61.12%), medium soil salinity (4-8 dS.m^{-1}) covering an area of 927.43 ha (45.10%). At Location E the potential for environmental damage that occurred was moderate erosion (60-180 t ha^{-1} y^{-1}) with an area of 2,387.90 ha (72.42%), moderate soil salinity (4-8 dS.m^{-1}) covering an area of 1,797.03 ha (54.50%), can damage dense vegetation of 2,795.84 ha (84.79%). Monthly rainfall of 20.93 cm which was classified as a wet month climate around the mining planning area can result in runoff of water levels during high rainfall.

4. Conclusion

It could be concluded that:

1. The vulnerability index results obtained in the planning plot of coal mining into four zones, namely the recommended exploitation zone at Location A with an area of 1235.62 ha (98.17%) while the one that can be optimized is ha (2.83%). The exploitation zone needs to be optimized at Location B at 3,714.74 ha (76.51%) while the exploitation zone needs supervision at 1,140.24 ha (23.49%). Exploitation zones need supervision at Location C of 3,346.27 ha (95.23%) and zones should not be exploited in those zones of 167.52 ha (4.77%). Location D in the exploitation zone needs to be monitored with an area of 1,793.08 ha (87.20%) and the zone should not be exploited with an area of 263.09 ha (12.80%). Location E in the exploitation zone needs to be optimized with an area of 2,837.10 ha (86.04%) and the exploitation zone needs supervision with an area of 460.33 ha (13.96%).
2. The classification of environmental damage in the coal mining area planning of which are moderate to severe erosion, surface runoff in the watershed, moderate salinity resulting in soil degradation, vegetation does not grow well and loss of recharge area.

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