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Analysis of Land Cover Changes in the Brown Canyon Mining Area Associated with Restrictions on Community Activities

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ABSTRACT

The high land use as area mining has resulted in changes in land cover and impacts the surrounding environment. In 2020, the Semarang City government implemented a Restrictions on Community Activities (RCA) policy to prevent the spread of the COVID-19 virus, indirectly limiting mining activities in the area of the Brown Canyon mine. This study aims to analyze the land cover change in the Brown Canyon mine area linked to the RCA policy. Assessment of land cover change is carried out by land cover classification on multitemporal Landsat imagery using Random Forest (RF) method. Based on the classification results, it was found that there was a change in mining land cover in Brown Canyon which increased by 3.713 Ha when the RCA policy was implemented from 46.305 Ha to 50.018 Ha. Likewise, after the implementation of RCA, there was an increase of 3.510 Ha from 50.018 Ha to 53.528 Ha. The accuracy of land cover classification before RCA was 90.12%. During RCA was 88.18%, and after RCA was 89.94%. Then, if related to the results of the interview data processing, the change in mining land cover that occurred was influenced by mining activities in the study area during the RCA period. So, it can also be said that RCA does not significantly influence mining activities in the Brown Canyon mining area. Several suggestions can be used for further research, such as using high-resolution satellite imagery and having mining area boundary data for each site.

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1. INTRODUCTION

The high use of land as an extractive industrial area, especially as a mining site, can create land damage that occurs continuously every year, resulting in changes in land cover. According to (Emiru et al., 2018), mining activities are also one of the main causes of the loss of vegetation cover. This implies that mining can significantly affect changes in the natural landscape. Brown Canyon Mining is a site for class C excavations such as stone, sand, and lime in Rowosari Village, Tembalang District, Semarang City, Central Java Province. Research (Iswanti, 2016) declares that the mining project there has caused a change in the natural landscape and has impacted the surrounding environment, along with increasingly widespread mining activities. In addition, a study of changes in land cover that occurred in the Brown Canyon mining area also needs to be analyzed so that the local government and the community can identify, monitor, mitigate, and manage mining impacts sustainably. Since the discovery of the COVID-19 virus in Indonesia in 2020, the Semarang City government has implemented a Restricting Community Activities (RCA) policy to prevent the spread of the COVID-19 virus. RCA policy is set based on Semarang Mayor Regulation No. 18 of 2020, which runs from April 27 to July 5, 2020 (Walikota Semarang, 2020).

Of course, this policy restricts human activities, including running mining activities in the Brown Canyon mining area. Previously, the Semarang City government had stopped mining activities, but mining workers were still carrying out mining activities until now. Monitoring is necessary to determine changes in land cover in the Brown Canyon mining area associated with RCA activities.

Land cover change assessment is carried out by utilizing remote sensing technology. The use of remote sensing technology in geospatial analysis of changes in land cover has been carried out (Hazami, 2021). This research discusses the assessment and monitoring of land cover changes in mining concession areas in Kalimantan by utilizing multitemporal Landsat imagery. Besides Rafi Hazami (Ang et al., 2021), others researched the analysis of land cover change from mining landscapes in the Philippines using supervised classification.

This study aims to investigate the phenomenon of Brown Canyon mining using multitemporal Landsat images with a supervised Random Forest (RF) classification method before the implementation of the RCA policy, during the implementation of the RCA policy, and after the implementation of the RCA policy. Vegetation index images are also used in the classification process to improve overall classification accuracy. In addition, other studies also show that the RF classification method performs better than other classifiers and is strong against potential collinearity and overfitting problems that may arise from integrating similar NDVI and EVI spectral layers (Teluguntla et al., 2018). The accuracy and validation of the classification results are carried out by testing the confusion matrix using AcATAMa (Accuracy Assessment of Thematic Maps) in QGIS. Meanwhile, mining land cover changes and activities related to RCA policies in the Brown Canyon mining area were carried out based on classification results and interview data.

This study focuses on determining land cover changes in the Brown Canyon mining area before, during, and after implementing RCA policies based on classification results. Then, to determine the accuracy and validation of land cover classification results based on the Random Forest method. Last, to determine the relationship between mining land cover changes and mining activities related to RCA policies in the Brown Canyon mining area.

2. METHOD

2.1. Location

The Brown Canyon mining area is a class C quarrying area for stone and sand located in Rowosari Village, Tembalang District, Semarang City, Central Java Province. Geographically, it is located at longitude coordinates 110° 16' 20"–110° 30' 29" East and longitude coordinate 6° 55' 34"–7° 07' 04" South. It is said that the mining site is called Brown Canyon by the people of Semarang because it looks like the Grand Canyon in America (Figure 1).

As a mining area, Brown Canyon has a rough and rocky surface. The area was originally a flat and high hill with various flora and fanatically a flat and high hill with various flora and fauna. Mining in Brown Canyon began in 1980. Based on information obtained from residents, this mining activity was initially managed by a family company. The activity begins with dredging or mining traditionally, using simple tools such as a hammer and hoes rather than heavy equipment as it is now. Using this heavy equipment has resulted in large excavated holes, which in turn have caused land damage over the years (Wardhana et al., 2014).

2.2. Data

The time range for image acquisition used was from January to March 2020 (before COVID-19 and the implementation of the RCA policy), April to June 2020 (RCA policy implementation), and July to September 2020 (after the RCA policy implementation). The high-resolution satellite image data used is Pleiades imagery 2020 from Badan Pertanahan Nasional Semarang. Then, the data used is data from field interviews. This data was taken at the research location to discover mining activities that occurred before RCA until after RCA. The primary data used in this study are shown in Table 1.

2.3. Image Pre-Processing

The pre-processing stages in this study include geometric verification and radiometric calibration. Landsat 8 imagery used in this study is a Level 1 Precision Terrain (Corrected) (L1TP)

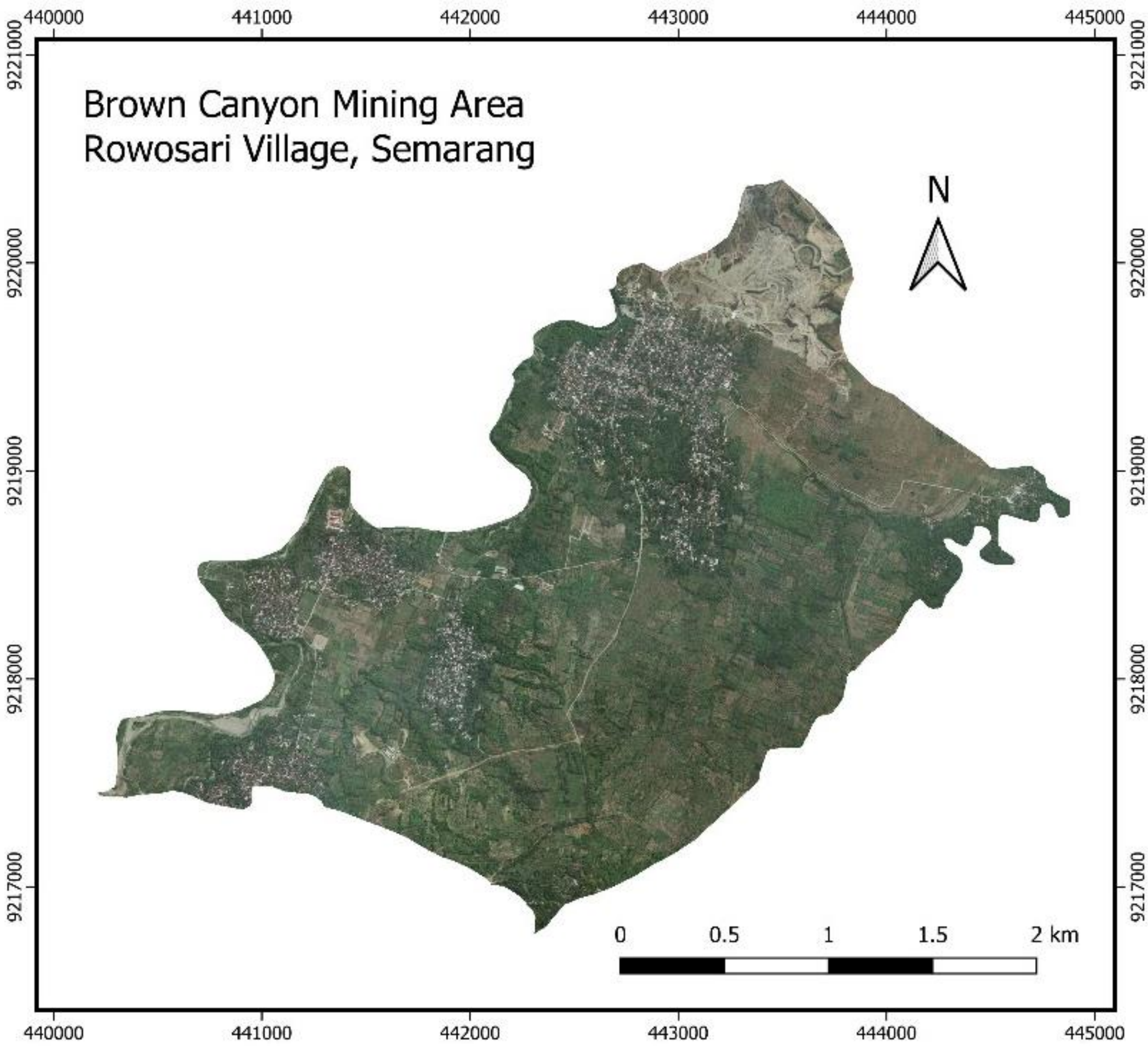

Figure 1. Research location

product that has been geometrically corrected (USGS, 2020). Therefore, it is necessary to verify geometric accuracy to determine the value of image accuracy. Verification of geometric accuracy in this study was held by image-to-image method with 12 ICP (Independent Check Point) points. Radiometric calibration is held to change image data, represented by a Digital Number (DN), into radiance and reflectance (Figure 2). The radiometric calibration process for Landsat 8 images used in this study was carried out using the QGIS software using the SCP plugin (Congedo, 2021).

2.4. Image Classification

The classification technique used is the Random Forest (RF) method. RF, also called the ensemble method,s used to improve classification accuracy by combining classification methods (Haristu & Rosa, 2019). The classification process is performed on the SCP plugin using Landsat 8 imagery that has been clipped (Jia et al., 2014). Image cropping is done using administrative

Table 1. Research data

Data	Source	Date	Comments
Landsat 8	USGS	19/01/2020 (Before RCA)	17.12 %
Landsat 8	USGS	27/06/2020 (During RCA)	4.53 %
Landsat 8	USGS	15/09/2020 (After RCA)	11.82 %
Pleiades Image of Semarang City	BPN Semarang City	01/2020, 06/2020, 09/2020	Cloud free
RBI Map of Semarang City	Inageoportal	2022	-
Interview Data	Survey	2022	-

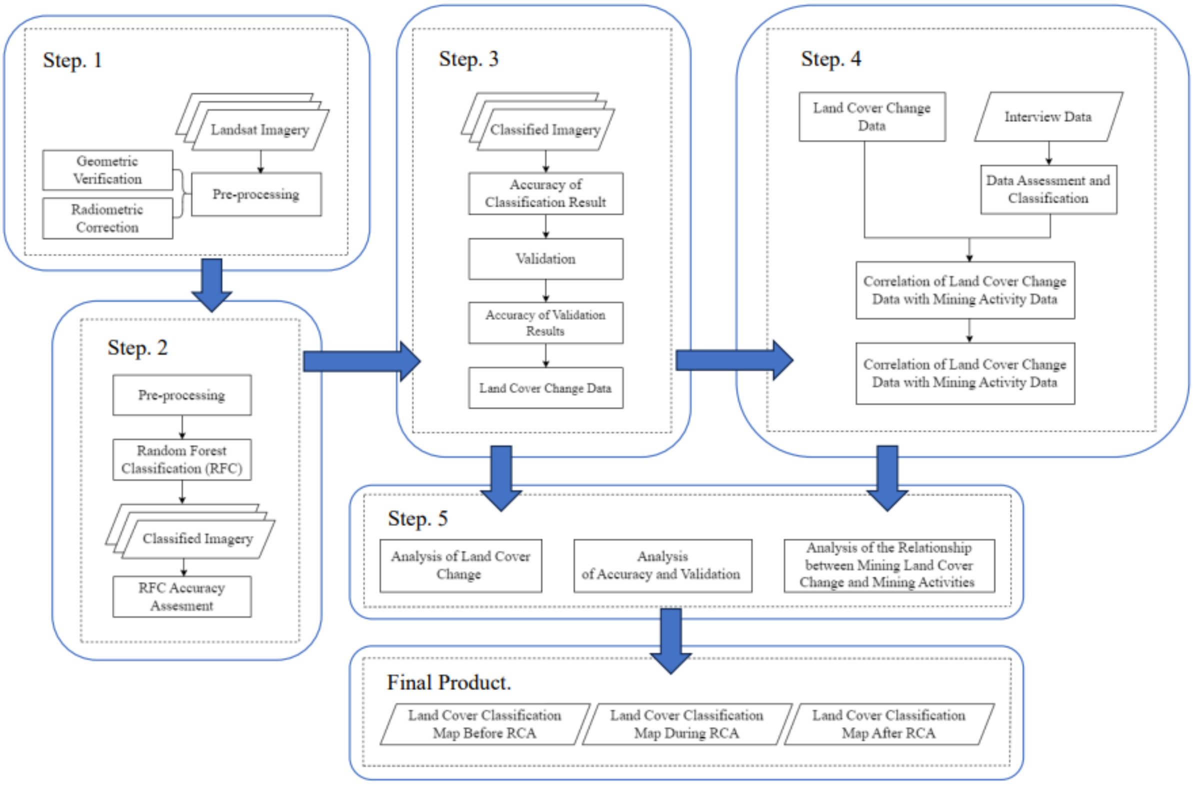

Figure 2. Research flowchart

vector data for Rowosari sub-district the Brown Canyon mining area is located (Figure 2). The bands used in the classification stage are bands 1 to 7, Landsat 8, coupled with the image processing results of the NDVI, NDWI, and EVI indices. The NDVI, NDWI, and EVI formulas can be seen in Equation 1, Equation 2, and Equation 3.

$$\text{NDVI}=\frac{\text{NIR Band - SWIR Band}}{\text{NIR Band + SWIR Band}} \qquad 1$$

$$\text{NDWI}=\frac{\text{NIR Band - Red Band}}{\text{NIR Band + Red Band}} \qquad 2$$

$$\text{EVI}=\frac{2.5\times(\text{NIR Band - Red Band})}{(\text{NIR Band} + 6\times\text{Red Band} - 7.5\times\text{Blue Band} + 1)} \qquad 3$$

Description: NIR Band is Channel 5 reflectance Landsat 8 imagery; SWIR Band is Channel 6 reflectance Landsat 8 imagery; Red Band is Channel 4 reflectance Landsat 8 imagery; Blue Band is Channel 2 reflectance Landsat 8 imagery.

2.5. Accuracy Assessment

An accuracy test is carried out to determine the confidence level in the image classification results. The accuracy test is carried out using a confusion matrix, namely by making a matrix of the calculation of each error (confusion matrix) on each form of land cover from the interpretation of remote sensing imagery (Solichin, 2017). The confusion matrix calculates the overall accuracy based on the following formula:

$$\text{Overall Accuracy (\%)}=\frac{\sum \text{Total number of all correctly classified pixels}}{\text{Total number of pixels in all classes}}\times 100 \qquad 4$$

Referring to BIG Head Regulation No. 15 of 2014 (BIG, 2014), the standard accuracy of research results is at least 85%. This accuracy test using the confusion matrix utilizes one of the plugins in QGIS, namely AcATAMa. The AcATAMa plugin can estimate the area of land cover classes and assess the accuracy of the resulting land cover classification maps (QGIS, 2022).

2.6. Validation

Validation is carried out to check whether the land use classification map follows the actual situation. Validation in this study was carried out using a grid sampling technique. The grid used in this study is a square grid system with a size of 30" x30" or 0.9 km x 0.9 km according to the size of the grid system with a variety of scales for Indonesian environmental data with a total sample size of 42 (Sofiyanti, 2010). Sampling validation of land cover type classification was carried out using the SW Maps application, which is one of the applications that can identify the location of coordinates and take pictures of validation samples (Verhan.id, 2021).

3. RESULTS AND DISCUSSION

3.1. Land Cover Change Before RCA, During RCA, and After RCA

This research classifies Land cover in the Brown Canyon mining area as divided into six classes: water class, mining class, residential and built-up land class, non-agricultural land class, agricultural land class, and open land class. The determination of this class refers to the SNI Regulation of 2014 about the classification of land cover, which is conditioned by the research area. Land cover classification (based on Landsat Imageries) is determined based on training sample data based on image interpretation (Pleiades Imageries) and field surveys. The number of training sample data used in this study was 43 samples. The results of a land cover classification in the Brown Canyon mining area shows in Figure 3, and the area in each class can be identified as shown in Table 2.

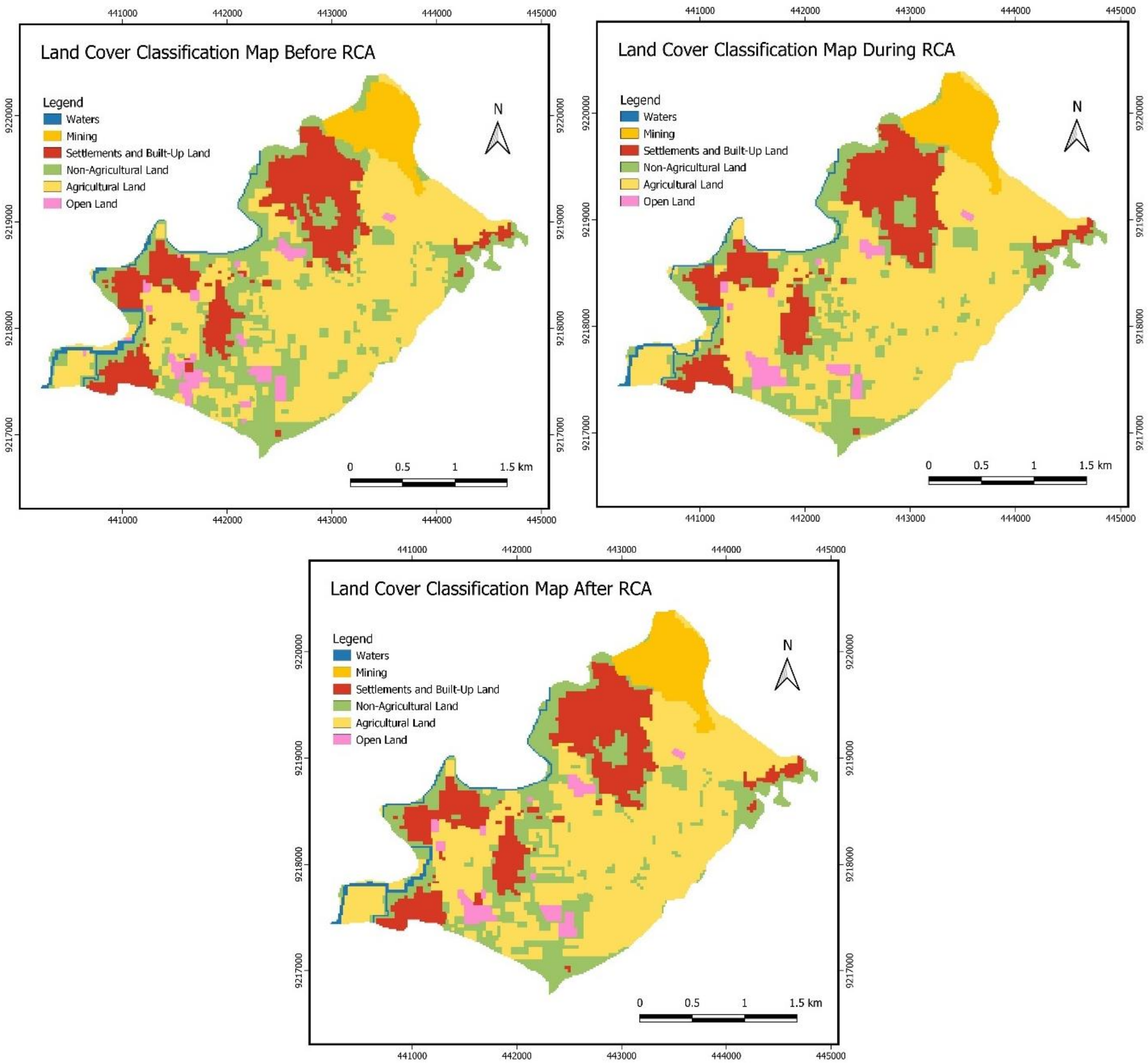

Figure 3. Land cover classification map before RCA, during RCA, after RCA

Table 2. Area of land cover before RCA, during RCA, and after RCA

Land cover classes	Area (Ha)		
	Before RCA (19/01/2020)	During RCA (27/06/2020)	After RCA (15/09/2020)
Waters	11.408	10.350	10.958
Mining	46.305	50.018	53.528
Settlements and built-up land	131.715	132.030	137.520
Non-agricultural land	185.558	147.488	157.905
Agricultural land	331.920	370.688	349.358
Open land	21.983	18.315	19.620
Total area	728.888	728.888	728.888

Based on the results of calculating the area for each land cover class, it can be seen that before the implementation of the RCA policy, the largest area was in the agricultural land class at 45% with an area of 331.920 Ha. Then the second largest percentage of area is in the non-agricultural land class at 28% with an area of 185.558 Ha. The third largest percentage of area is in the residential and built-up land class at 17% with an area of 131.715 Ha, then the mining class is 5% with an area of 46.305 Ha, the open land class is 3% with an area of 21.983 Ha, and the last is the water class of 2%, with an area of 11.408 Ha. Similarly, before the implementation of the RCA policy, the largest percentage of land cover at the time of the implementation of the RCA policy was in the agricultural land class at 51%, with an area of 370.688 Ha. Then the second largest percentage of area is in the non-agricultural land class at 20% with an area of 147.488 Ha. The third largest percentage of area is in the residential and built-up land class at 18% with an area of 132.030 Ha, then the mining class is 7% with an area of 50.018 Ha, the open land class is 3% with an area of 18.315 Ha, and the last is the water class of 1%, with an area of 10.350 Ha. After the implementation of the RCA policy, the largest percentage of land cover when implementing the RCA policy was in the agricultural land class at 48% with an area of 349.358 Ha. Then the second largest percentage of area is in the non-agricultural land class at 22% with an area of 157.905 Ha. The third largest percentage of area is in the residential and built-up land class at 19% with an area of 137.520 Ha, then the mining class is 7% with an area of 53.528 Ha, the open land class is 3% with an area of 19.620 Ha, and the last is the water class of 1% with an area of 10.958 Ha.

Based on Table 2, there was a change in the area of mining land cover of 3.713 Ha from before the implementation of the RCA policy to during the implementation of the RCA policy and a change of 3.510 Ha from during the implementation of the RCA policy to after the implementation of the RCA policy. The increase in the mining area was due to ongoing mining activities during the implementation of the RCA policy. The demand for mining materials is still ongoing, so mining production continues. This led to an expansion of the mining area.

Based on the results of calculating the area of each land cover class, it can be seen that there was a change in the area of land cover in the Brown Canyon mining area before the implementation of the RCA policy, during the implementation of the RCA policy, and after the implementation of the RCA policy as shown in Figure 4.

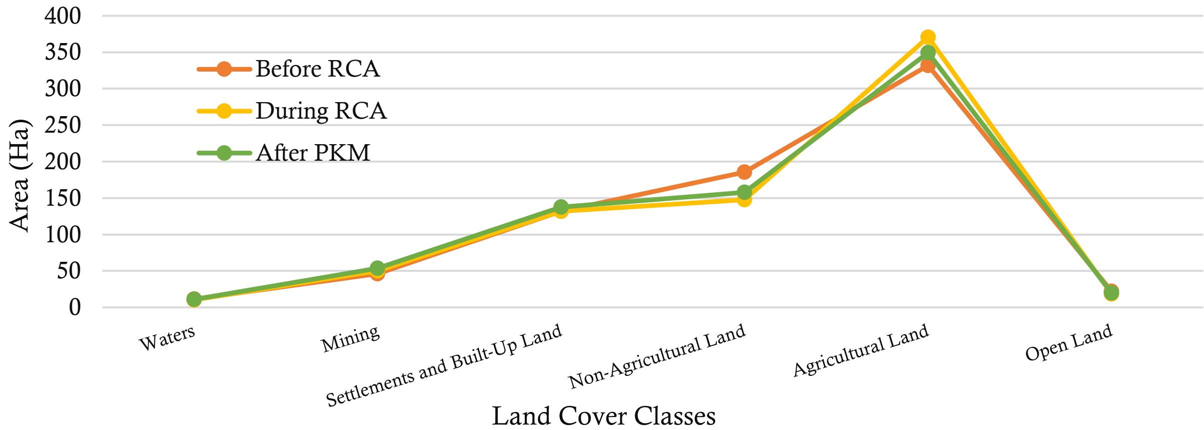

Figure 4. Diagram of land cover change before RCA, during RCA, and after RCA

Table 3. Accuracy results of land cover classification

	Before RCA	During RCA	After RCA
Overall accuracy	90.12%	88.18%	89.94%

Table 4. Accuracy results of land cover classification validation

	Before RCA	During RCA	After RCA
Overall accuracy	89.36%	95.45%	97.67%

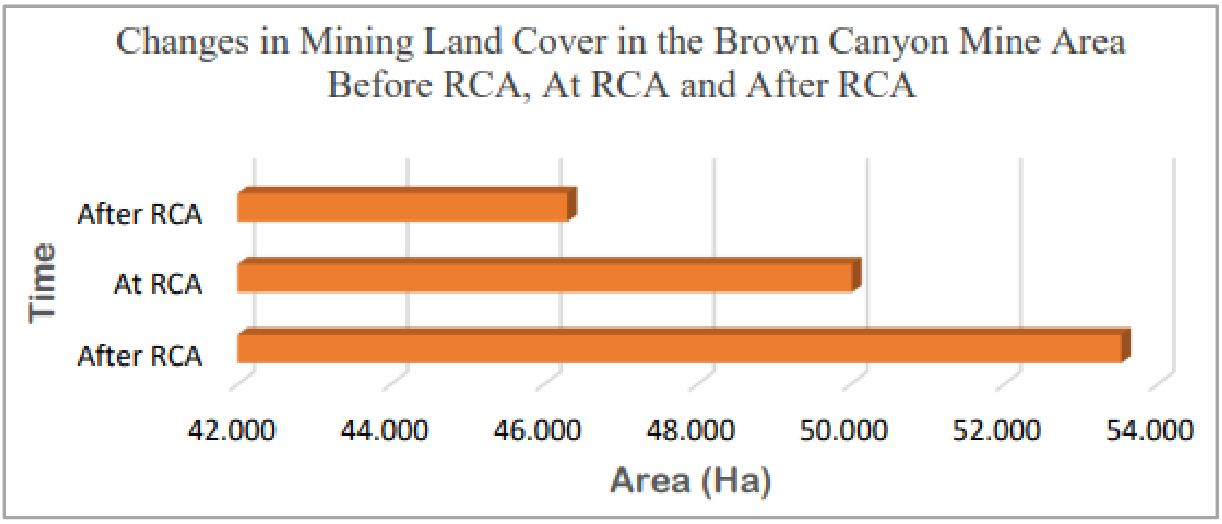

Figure 5. Changes in mining land cover from before RCA to after RCA

3.2. Accuracy and Validation of Land Cover Classification Results

The results of calculating the overall accuracy value of land cover classification before implementing the RCA policy were 90.12%. Then the overall accuracy value of land cover when implementing the RCA policy was 88.18%, and the overall accuracy value after implementing the RCA policy was 89.94% (Table 3). Based on the results of these calculations, it can be stated that the overall accuracy value of the land cover classification results is above 85%, which, based on Anderson's rules, makes the land cover classification results in this study acceptable. Then, based on the results of field validation of 42 points, the overall accuracy value of land cover classification validation before implementing the RCA policy was 89.36%. Then the overall accuracy value of land cover classification validation when implementing the RCA policy was 95.45%, and the overall accuracy value of land cover classification validation after implementing the RCA policy was 97.67% (Table 4). Based on the results of these calculations, it can be stated that the overall accuracy value of the validation results of land cover classification is above 85%, which, based on Anderson's rules, makes the land cover classification results in this study acceptable.

3.3. Relationship between Mining Land Cover Change and Mining Activities in the Brown Canyon Mining Area Related to RCA Policy

This research examines changes in mining land cover in the Brown Canyon mining area which will then be linked to the existence of an RCA policy. Based on Table 2, there is an increase in the area of mining land cover which can be seen in Figure 5. Interview data is needed to determine the relationship between changes in mining land cover and mining activities related to the RCA policy in the Brown Canyon Mine area. The data from the interviews were classified based on the range and judgments made by the researcher. The ranges and ratings used are shown in Table 5, while the classification range of data assessment results is shown in Table 6.

Based on the results of the classification of mining data, it was found that before RCA, mining activities had a high value for the four mining sites in Brown Canyon, with a classification value of 45 (Table 7). Then, during RCA, mining activities at the mining sites owned by Maki, Edi, and Darmo fell to medium, while mining activities at Mudiyono's site are still of high value (Table 8). So that it can be said that RCA mining activities are of medium value with an average classification value of 38.75; after RCA, mining activities are of medium value, with an average classification value of 37.5 for the four mining sites in Brown Canyon (Table 9). The information obtained during

Table 5. Mining data range and value

Data	Range	Value
Production (Ton)	0-400	5
	401-800	10
	801-1200	15
	1201-1600	20
	1601-2000	25
Workers (Person)	1-10	5
	11-20	10
	21-30	15
	31-40	20
	41-50	25
Time (Hour)	1-5	5
	6-10	10
	11-15	15

Table 6. Classification range of data assessment results

Range	Classification
< 20	Low
< 21 - 40	Medium
> 41	High

Table 7. Classification of mining data prior to implementation of RCA

Mine owners	Production		Workers		Time		Total	Classification
	Data (Ton)	Value	Data (Person)	Value	Data (Hour)	Value		
Maki	1250	20	30	15	10	10	45	High
Edi	1250	20	30	15	10	10	45	High
Darmo	1500	20	30	15	10	10	45	High
Mudiyono	1500	20	32	15	10	10	45	High

Table 8. Classification of mining data prior to implementation of RCA

Mine owners	Production		Workers		Time		Total	Classification
	Data (Ton)	Value	Data (Person)	Value	Data (Hour)	Value		
Maki	750	10	23	15	10	10	30	Medium
Edi	1000	15	23	15	10	10	40	Medium
Darmo	1000	15	23	15	10	10	40	Medium
Mudiyono	1250	20	24	15	10	10	45	High

Table 9. Classification of mining data prior to implementation of RCA

Mine Owners	Production		Workers		Time		Total	Classification
	Data (Ton)	Value	Data (Person)	Value	Data (Hour)	Value		
Maki	750	10	23	15	10	10	35	Medium
Edi	750	10	23	15	10	10	35	Medium
Darmo	1000	15	23	15	10	10	40	Medium
Mudiyono	1000	15	24	15	10	10	40	Medium

the interview stated that during the implementation of the RCA, mining activities were still ongoing; it's just that there were obstacles in the process of distributing mining materials, which were caused by accessibility roads being restricted during the RCA period, as a result of which the wheels for the distribution of mining products were slightly hampered, and production decreased.

Based on these two things, if it is associated with changes in the area of mining land cover which tends to increase, it can be stated that mining activities influence these changes in land cover in the Brown Canyon mine area, which are still ongoing even during the RCA period. So, it can also be said that RCA does not significantly influence mining activities in the Brown Canyon mine area.

4. CONCLUSIONS

Based on the data processing results in this study, the conclusions are that the classification of land cover in the Brown Canyon mine area produces six classes of land cover: waters, mining, settlements and built-up land, non-agricultural land, agricultural land, and open land. Based on the classification results, it was found that there was a change in mining land cover in Brown Canyon which increased by 3.713 Ha when the RCA policy was implemented from 46.305 Ha to 50.018 Ha. Likewise, after the implementation of RCA, there was an increase of 3.510 Ha from 50.018 Ha to 53.528 Ha. The calculation results of the accuracy test of land cover classification results produce an accuracy value of land cover classification in 2019 of 87.99%, an accuracy of land cover classification before RCA was 90.12%, an accuracy of land cover classification during RCA was 88.18%, and accuracy land cover classification after RCA was 89.94%. Likewise, validation of land cover carried out with 42 sample points has shown compatibility between the classified land cover results and conditions in the field.

Based on the results of interview data processing, it is known that the mining activities that occurred in the Brown Canyon mining area before RCA had a high value with an average classification value of 45, and during the implementation of RCA and after RCA mining activities that occurred in the Brown Canyon mine area were of medium value with an average classification value of 38.75 and 37.5. Based on these results, if it is associated with changes in the mining land cover shown in Table 2, it can be stated that mining activities influence the changes that tend to increase. So, it can also be said that RCA does not significantly influence mining activities in the Brown Canyon mine area. Mining activities are still ongoing as long as the implementation of the RCA policy. Demand for mining materials is still ongoing, so mining production continues. However, the RCA policy still slightly impacts the mining results distribution because of a road restriction implementation. Several suggestions can be used for further research, namely using satellite imagery with high resolution to get more accurate land cover classification results, data on the delineation of mining ownership areas are needed to determine the correlation of land cover change with mining activities that occur in each ownership area, and the interview data which includes data on production, workers and mining time should have a larger number so that the correlation between mining activity and changes in land cover can be identified.

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