The identification of coal mining clearance impact on hydrology behavior of Batang Ombilin catchment area

Indah Elok Mukhlisah
Master of Mining Engineering, Institut Teknologi Bandung, Jl. Ganesha 10 Lebak Siliwangi, Bandung 40132, Indonesia

*Email: indahelokmukhlisah1206357@gmail.com

Abstract. This research is to see the impact of coal mining activities between before and after the rise of coal mining; since the Regional Autonomy Regulation executed to the latest conditions, based on the hydrological behavior of the Batang Ombilin Catchment in Sawahlunto. The Batang Ombilin Catchment is one of the significant drains in Sawahlunto with ± 2215 km² of its area. Henceforth, this research focus is only on the analysis of ten sub-catchments with area ± 348.42 km² of ± 2215 km² total of the catchment area that they contribute significantly to the catchment. This research uses Land cover data from Landsat images of the United States Geological Survey (USGS) Earth Explorer. Henceforward, the Interpretation used is Guided Interpretation with the Maximum Likelihood method. This such Interpretation is to ease the distinction of vegetated lands classification (i.e., densely vegetated land, sparsely vegetated land (bare), and open land; due to rivers, housing, gardens, fields, and mining areas). The research results that changes in government regulations have a significant impact on the growth of the mining industry in Sawahlunto, which is direct, impacted the land utilization to the mining industry utilization for years. The regulations also guide the behavior of the people involved in the mining industry of the land utilization management directly. This indication based on the decrease of the land utilized for the open area that the mining industry boomed after the reclamation went through. In short, the change in land utilization has a direct impact on hydrological behavior.

1. Introduction

Coal is one of the vital energy commodities in Indonesia. Furthermore, coal mining is a complex activity to do. The miner has to start from land clearing, topsoil overburden, transporting to the stockpiling site, and coal mining [1]. Thus, this activity potentially changes the shape of topography, causes deforestation, and changes the behavior of the hydrological condition (i.e., runoff and surface water fluctuations) [2]. Indonesia has started a modern mining era more than 40 years ago, since the enactment of Mining Government Regulation No. 11 of 1967 along with Government Regulation No. 1 of 1967 concerning Foreign Investment that founded large-scale mining of mineral commodities in the name of national economic growth and they only contain a few of environmental issue [3]. Thus, both of the laws deal with the relationship between the development and the environment.

Henceforward, coal mining in Sawahlunto started 132 years ago. Nevertheless, until 1999, coal mining activities were not yet widespread even though the Regional Autonomy Law had come into effect. The Law on Regional Government (Law Number 22 of 1999), during the reform era in 1998-1999, brought the mining industry in a dilemma: environmental and social, political and statutory, and illegal labor and mining issues [4]. At that time, coal mining in Sawahlunto was only two large
companies that existed, PT Bukit Asam Ombilin Mining Unit and PT Allied Indo Coal Jaya. The Central Government holds the role of granting the mining business permits, as outlined in the form of PK2B. Whereas the Regional Autonomy had entered into a transitional period and had an impact on community resistance to the widespread illegal mining, coal mining was still not widely spread due to the difficulty of obtaining a mining authority permit in 2001. For instance, PT BA UPO had a loss profit in the 2000s because of the community resistance against PT BA UPO.

In 2006, the exploitation of natural resources in the form of mining products was a consideration for the effort of a region to manage its wealth independently and to obtain a source of local income that could carry out development; this such response drives the government to replace Law Number 22 of 1999 into Law Number 32 of 2004 concerning the Regional Government to Decentralize Mining, Energy, and Mineral Resource Affairs to the regions [5]. Hence, nine new companies came up after the domination of the two large companies before (i.e., CV Air Mata Emas, CV Bara Mitra Kencana, PT Guguak Tinggi Coal, PT Mayor Pratama Coal, CV Putri Surya Pratama Natural, PT Cahaya Bumi Perdana, PT Dasrat Sarana Arang Sejati, CV Tahiti Coal and PT Nusa Alam Lestari) that the authorization letter for the permits is under the consent of the chief of a region (Regent/Mayor). Later, the Government Regulation No. 11 of 1967 on Basic Mining Provisions is no longer appropriate since the Government Regulation No. 11 of 1967 only focuses on the national economy as the regulation put aside the issue of environment considering the environmental cost has the potential to increases the production cost [6]. It is necessary to change laws and regulations in the mineral and coal mining sector that can manage the minerals and coal potential resources independently, reliably, transparently, competitively, efficiently, and with environmental insight to ensure sustainable national development according to the rise of environmental issues. Hereafter, the government issued Regulation No. 4 of 2009. In 2011 coal mining in Sawahlunto has begun to switch from open pit mining to underground mining because it is no longer economical with the open-pit method to mine [7].

One of the environmental cases is the occurrence of erosion from the company's overburden piles around PT BA UPO, which has begun to enter its area. In 2014, the replacement of Government Regulation Number 32 of 2004 to Government Regulation No. 23 of 2014 concerning regional government, in which it changed the authority of district/city governments in issuing permits, which is currently the authority of the provincial government since many mining activities are out of the range of supervising [8]. For instance, in 2014, the erosion of the companies overburden piles around PT BA UPO has expanded into the PT BA UPO mining license area, even though this has occurred since 2011. 2018 shows better progress after the supervision of the provincial government, such as tighter environmental monitoring, that the routine report (RKAB) shows in detail. This research shows the impact of mining activities on hydrological behavior by observing the land cover changes before and after the booming mining activities through Landsat satellite imagery.

2. Methods

The Batang Ombilin Catchment is one of the significant drains in Sawahlunto with ± 2215 km2 of its area. The Batang Ombilin River flows through The Singkarak Lake in Solok to Satang Kuantan. Henceforth, this research focus is only on the analysis of ten sub-catchments with area ± 348.42 km2 of ± 2215 km2 total of the catchment area that they contribute significantly to the catchment. This research uses Land cover data from Landsat images of the United States Geological Survey (USGS) Earth Explorer. The analysis of the land cover focuses on the occurrence before and after the rise of coal mining Regional Autonomy Regulation implementation regarding the latest conditions. Interpretation and analysis of land cover use Landsat 4-5 ETM (Enhanced Thematic Mapper) imagery of 1999, 2001, 2006, and 2011.

Meanwhile, the Interpretation and analysis of land cover use Landsat 8 OLI (Operational Land Imager) imagery of 2014 and 2018. The Interpretation used is Guided Interpretation with the Maximum Likelihood method. This such Interpretation is to ease the distinction of vegetated lands classification (i.e., densely vegetated land, sparsely vegetated land (bare), and open land; due to rivers, housing, gardens, fields, and mining areas). A series of rows of steep hills in the form of rounded hills to steep
hillside shows the topographic conditions in this research area. Thus, if there is land clearing continuously and on a large scale, this has the potential to result in erosion and silting downstream due to sedimentation. Figure 1 and Figure 2 shows the Polygon Map of the Batang Ombilin Sub-catchment and Map of the Batang Ombilin River Research Area, as follows:

![Figure 1 Polygon Map of the Batang Ombilin Sub-Catchments](image1)

![Figure 2 Map of the Batang Ombilin River Research Area](image2)

3. Result and discussions

From the analysis of ten sub-catchments, there are two sub-catchments that their land covers show coal mining activities existed, i.e., Sub-catchment 23 and Sub-catchment 25. The following figure shows the changes in the land cover from the year of 1999, 2001, 2006, 2011, 2014, and 2018.
3.1 Sub-catchment 23

The figure 3 above shows significant changes of the area due to mining activities from 1999 to 2018 according to the regulatory developments in Indonesia, i.e., 1999 (Area: 365 Ha), 2001 (Area: 392 Ha), 2006 (Area = 492 Ha), 2011 (462 Ha), 2014 (Area: 319 Ha), and in 2018 (Area: 338 Ha). In 1999 and 2001, there were only two large companies that existed in Sawahlunto on Sub-DAS 23 (PT Bukit Asam Ombilin Mining Unit and PT Allied Indo Coal Jaya). After the development of the law, the companies much easy to obtain permits instead of the previous year as there were eight companies newly established in 2006 and started production, i.e., CV Air Mata Emas, CV Bara Mitra Kencana, PT Guguak Tinggi Coal, PT Mayor Pratama Coal, CV Putri Surya Pratama Natural, PT Cahaya Bumi Perdana, PT Dasrat Sarana Arang Sejati, and PT Nusa Alam Lestari. All those companies are still operating.

![Figure 3: The Map of Land Cover Changes of Sub-Catchment 23](image)

3.2 Sub-catchment 25

The figure above shows significant changes of the area due to mining activities from 1999 to 2018 in Sub-DAS 25 according to the regulatory developments in Indonesia, i.e., 1999 (Area: 434 Ha), 2001 (Area: 450 Ha), 2006 (Area = 394 Ha), 2011 (397 Ha), 2014 (Area: 245 Ha), and in 2018 (Area: 233 Ha). In 1999 and 2001, it was only one large company that existed in Sawahlunto on Sub-DAS 25 (PT Bukit Asam Unit Penambangan Ombilin). After the development of the law, the companies much easy to obtain permits instead of the previous year as there were eight companies newly established in 2006 and started production (CV Tahiti Coal) and still operating until today.
3.3 The impact of the land area closure regarding coal mining activities

The following Table 1 and Table 2 show the impact of the land area closure on hydrology behavior. According to these tables, coal mining activities in Sub-DAS 23 were rampant and showing an impact in 2006 through the rise of the land opening area or the shift of the land area function into the mining industry.

The rainfall in 2006 was the lowest with 690 mm that results in less erosion and runoff values even though the area of land clearing due to mining activities was broader than other years, while the highest occurred in 2011 amounted to 2595 mm. Therefore, the highest of runoff and erosion value was in 2011 even though the mining area had decreased since 2006 because it had begun to carry out reclamation and a shift in the mining system from open pit to underground mining.

Table 1 The Assumption of the Relationship between Erosion Value and Runoff on Land Opening Area due to Coal Mining Activities in Sub-Catchment 23

| Year | Densely vegetated land (Ha) | Sparlessly vegetated land (bare) (Ha) | Open land (Ha) | Mining (Ha) | Precipitation (mm) | Run Off (mm) | Erosion (Ton/Year) | Description |
|------|----------------------------|--------------------------------------|---------------|------------|-------------------|-------------|-------------------|-------------|
| 1999 | 3.462                      | 1.241                                | 30            | 365        | 1.999             | 1.313       | 321               | Regional autonomy, before the rise of mining, the enactment of Mining Government |

Figure 4 The Map of Land Cover Changes of Sub-Catchment 25
Regional autonomy, before the rise of mining, the enactment of Mining Government Regulation No. 11 of 1967, The Law on Regional Government (Law Number 22 of 1999),

Regional autonomy, the booming of mining, Law Number 32 of 2004, Government Regulation No. 4 of 2009

The replacement of Government Regulation Number 32 of 2004 to Government Regulation No. 23 of 2014 concerning regional government

### Table 2 The Assumption of the Relationship between Erosion Value and Runoff on Land Opening Area due to Coal Mining Activities in Sub-Catchment 25

| Year | Densely vegetated land (Ha) | Sparsely vegetated land (bare) (Ha) | Open land (Ha) | Mining (Ha) | Precipitation (mm) | Run Off (mm) | Erosion (Ton/Ha /Year) | Description |
|------|-----------------------------|-------------------------------------|---------------|-------------|-------------------|--------------|----------------------|-------------|
| 1999 | 4.029                       | 1.704                               | 174           | 439         | 1.999             | 1.247        | 187                  | Regional autonomy, before the rise of mining, the enactment of Mining Government Regulation No. 11 of 1967, The Law on Regional Government (Law Number 22 of 1999), |
| 2001 | 4.290                       | 1.457                               | 149           | 450         | 1.540             | 858          | 140                  | Regional autonomy, the booming of mining, Law Number 32 of 2004, Government Regulation No. 4 of 2009 |
| 2006 | 4.232                       | 1.517                               | 204           | 394         | 1.201             | 647          | 112                  | The replacement of Government Regulation Number 32 of 2004 to Government Regulation No. 23 of 2014 concerning regional government |
| 2011 | 4.132                       | 1.631                               | 186           | 397         | 2.595             | 1.805        | 282                  | |
| 2014 | 4.310                       | 1.630                               | 161           | 245         | 2.269             | 1.521        | 275                  | |
| 2018 | 4.071                       | 1.413                               | 629           | 233         | 1.377             | 754          | 245                  | |
In the Table 2, in 2001, coal mining activities were not yet rampant, but in Sub-DAS 25, PT BA UPO conducted massive open-pit coal mining near Kandi Lake, as the increase in land clearing or the conversion of land functions to the mining industry from 1999 showed. After regional autonomy in Sub-DAS 25, there were not many additional mining rights as in Sub-DAS 23 (only CV. Tahiti Coal). The table shows that the rainfall that fell in 2011 was the highest, amounting to 2595.3 mm. Hence, the highest of runoff and erosion value was in 2011 even though the mining area had decreased since 2006 because it had begun to carry out reclamation and a shift in the mining system from open pit to underground mining.

4. Conclusion
According to the result, the changes in government regulations have a significant impact on the growth of the mining industry in Sawahlunto that it impacts on land-use changes or land-use changes to the mining industry from year to year. Regulations also guide the behavior of those in the mining industry in managing the environment (land use) directly. The indication is that the changes in the area of land openings decreased since the boom of the mining reclamation. Furthermore, the land-use changes directly impact hydrological behavior, where rainfall, land- use, slope length, and slope and soil type determine the value of erosion and runoff. In this study, the rainfall changes and land cover area significantly contribute to the erosion value. On another side, the soil texture influences the runoff strongly (CN value) that the involvement of mining activities that impact land management. However, there was no significant contribution to the erosion and runoff value by years. Mining land management activities through reclamation are actions to reduce the impact of mining activities on erosion and runoff.

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