

## The Analysis of the Land Cover Changes to Surface Flows of Bulok Watershed, Lampung Province

Dian Aprianto<sup>1</sup>, Liana Ristiara<sup>2</sup>

<sup>1</sup>Bandar Lampung City Environmental Service, Lampung, Indonesia

<sup>2</sup>PT. Sudden Coffee, Bandar Lampung, Lampung, Indonesia

\*Corresponding author : [aripramuja36@gmail.com](mailto:aripramuja36@gmail.com)

**ABSTRACT.** The Way Bulok Watershed (DAS) is a tributary of the Way Sekampung Watershed which is administratively located in Pringsewu Regency, Lampung Province. The use of land cover due to increasing human numbers and activities has a significant impact on surface flow (runoff) of the Way Bulok Sub-watershed. This research aims to analyze changes in land cover and to determine the effect of changes in land cover on surface flow in the Way Bulok Sub-watershed area. The results of research conducted show that total rainfall has increased, in 2011 rainfall was 1342 mm/year and in 2017 it increased to 1570 mm/year. This is in line with the increase in river discharge, where the annual average river discharge in 2011 was 21.69 m<sup>3</sup>/s, increasing to 35.40 m<sup>3</sup>/s in 2017. Likewise, the surface flow coefficient value has increased from 0.19 to 0.27. The land cover in the Way Bulok Sub-watershed area is still dominated by agricultural areas which have an area of more than 50% each year, compared to the forest area which is only 2,123% of the total area of the Way Bulok Sub-watershed in 2017.

**Keywords :** *rainfall; river discharge, runoff, way bulok sub-basin, forest cover*

### INTRODUCTION

The need for land use is increasing due to the increase in human numbers and activities (Pratama & Yuwono, 2016). Changes in the use of land cover result in the availability of land cover decreasing. Supriyadi et al., (2018) said that land requirements and water use will continue to increase due to increasing population. Therefore, it is necessary to plan land use in the River Watershed (DAS) area. This is because land use planning is very important so as not to have a negative impact on the characteristics of a watershed (Mubarok et al., 2015). The change in land from vegetated land to built-up land or non-vegetated land will result in increased runoff discharge in rivers (Nugroho et al., 2018).

One of the watershed areas in Lampung Province that has good land cover is the Way Bulok Sub-watershed area which is a tributary of the Way Sekampung Watershed where administratively the location of the Way Bulok Sub-watershed is in Pringsewu Regency. The area of the Way Bulok sub-watershed reaches 887.37 km<sup>2</sup> with a length of 1,584.4 km (BPDAS WSS, 2008). The Sekampung Watershed is a large watershed in Lampung Province. The area of the Sekampung watershed is 484,181.80 ha. The Sekampung watershed is the main river basin in Lampung Province which is the main food storage or producer of food, export commodities as well as fisheries and other food products to support millions of people. The Bulok sub-watershed is one of the sub-watersheds in the Way Sekampung watershed (Rosalifa and Afra, 2022).

A watershed will be sustainable if the land cover in the watershed area is in good condition. However, changing land use to open areas will reduce the value of river discharge in the watershed (Raharjo, 2009). It should be noted that river discharge will affect land cover in river basin areas (Harifa et al., 2017). Romlah et al. (2018) said that vegetation on good land cover will influence river discharge. Based on the function of land cover which has an influence on river discharge, many researchers have carried out such research, such as the influence of changes in forest cover on discharge in Way Seputih Hulu (Romlah et al., 2018), studying the impact of land use changes on the flow discharge of the Cujung watershed (Sulaeman et al., 2018). 2014), even research in the same location, namely analysis of land use changes on hydrological characteristics in the Bulok watershed (Pratama & Yuwono, 2016). The Bulok watershed experienced a change in land cover from forest and wetland to residential and dryland agriculture, which affected the river discharge and surface flow coefficient (Pratama, 2016).

Research conducted by Pratama & Yuwono (2016) looked at the influence of land cover changes in 2001, 2006 and 2011. Meanwhile, this research looked at the influence of land cover changes in 2011, 2014 and 2017. Therefore, it is important to carry out research to determine the influence of discharge. rivers on land cover in the watershed area. Changes in land cover in the Bulok Sub-watershed during the period 2009 to 2018 generally experienced insignificant changes, however

the changes that occurred led to an increase in residential land and a decrease in forest land. Using land without paying attention to its sustainability results in ongoing criticality of land (Riswulan et al., 2021). Way Bulok is a 2nd order river which accommodates or receives flow from 3rd order rivers above it, including the Way Semah, Way Tebu, Way Baturaja, Way Kedondong, Way Manak and Way Minong rivers as well as several other rivers (Amanda et al., 2023).

This research aims to analyze changes in land cover during the period 2011-2017 in the Way Bulok Sub-watershed, another aim is to analyze the influence of land cover on surface flow (runoff) in the Way Bulok Sub-watershed, Lampung Province. So it is hoped that this research can provide information regarding the influence of changes in land cover during the 2011-2017 period on river discharge in the Way Bulok Sub-watershed area. Apart from that, this research can be used for related research and it is hoped that it can be used as input for policy makers and other stakeholders, in order to make decisions regarding the rehabilitation and management of the Way Bulok Sub-watershed in the future.

## MATERIALS AND METHODS

This research was carried out using the results of studies or research that had been carried out previously using secondary data. The first stage in the research carried out was preparing the data. In this research, the data used are rainfall data, river discharge data and land cover data for the period 2011-2017 in the Way Bulok Sub-watershed. Data collection components can be seen in the table below.

Tabel 1. Data components are in nature study

No	Component data	Jenis	Source data	Method taking
1	Profil Sub-DAS Way Bulok	Secondar	B P D A S Province L a	S t u d i References
2	Data rainfall on Sub - DAS Bulok	Way Secondar	B P D A S Province L a	S t u d i References
3	Data debit river on Sub - DAS Bulok	Way Secondar	B P D A S Province L a	S t u d i References
4	Location Sub -DAS Way Bulok in time 2 0 1 1 - 2 0 1 7 .	Secondar	B P D A S Province L a	S t u d i References

The second stage carried out was analysis of the digital map. This analysis aims to obtain land use data in the Way Bulok Sub-watershed area. The third stage is to carry out data analysis on monthly rainfall and monthly discharge data in 2011, 2014 and 2017. This analysis aims to obtain discharge fluctuation data in the Way Bulok Sub-watershed area. The fourth stage is to analyze the relationship between river discharge in 2011, 2014 and 2017 which is then connected to the state of land use changes in the Way Bulok Sub-watershed area.

The tool used in this research is the research study area carried out, namely in the Way Bulok Sub-watershed area, Lampung Province. A map of the research location can be seen in Figure 1 below. The tools used in this research are computer devices with computer software such as Microsoft Excel and writing tools. The materials used in this research are rainfall data and river discharge data.

Data Analysis. The discharge data obtained from BPDAS-WSS is the result of measurements throughout the day every year in the period 2011, 2014 and 2017. The data is then processed as research data. Based on the discharge data obtained, the total monthly discharge, average discharge, and maximum and minimum discharge are determined. Data analysis for river discharge uses discharge fluctuation calculations. By knowing the discharge fluctuation value, it can be seen whether land use in the watershed area is good or not (Arsyad, 2010). Meanwhile, the discharge fluctuation equation uses the formula stipulated by Minister of Forestry Regulation Number 61 of 2014. The next data analysis is the surface flow coefficient or runoff . Furthermore, the value of the surface flow coefficient (C) can determine the runoff coefficient class classification .

## RESULTS AND DISCUSSION

### 1. Rainfall

Rainfall values are generally relatively different in each region in Indonesia. However, according to Hidayat & Empung (2016) the average amount of rainfall in Indonesia is around Rainfall in the Way Bulok Sub-watershed area is obtained from the Way Seputih-Sekampung Watershed Management Agency (BPDAS-WSS). Rainfall was obtained from the 2011-2017 time period. To determine the distribution of rainfall in the Way Bulok Sub-watershed, it was taken from the observation station at Gatel DAM. Rainfall in the Way Bulok Sub-watershed area can be seen in Table 2.

Based on the results obtained, total rainfall tends to increase, namely 1342 mm in 2011 and increased to 1570 mm in 2017. Meanwhile, of the three years observed, the highest total rainfall occurred in 2017. It can be seen in Table 2 that the average - The average minimum rainfall for the three years observed occurred in August, while the maximum rainfall occurred in December. The results of this analysis are the same as research conducted by Pratama & Yuwono (2016) in the same location in the period 2001-2011. This proves that in December in the Way Bulok sub-watershed there is quite a lot of rain compared to other months.

Table 2. Monthly rainfall in the Way sub-watershed Bulok 2011-2017.

Bulan	Rainfall (mm)		
	2011	2014	2017
January	272	197	84
February	173,5	160	281
March	77,5	251,5	242,5
April	164	137	109,5
Mey	71,5	92	126,5
June	59,5	57	64,5
July	23	69	107
August	1,5	67	22
September	26,5	43	78
October	67	30	53,5
November	120	136,5	177,5
December	286	269	224
<b>Total</b>	<b>1342</b>	<b>1509</b>	<b>1570</b>
<b>Average</b>	<b>111,83</b>	<b>125,75</b>	<b>130,83</b>
<b>Max</b>	<b>286</b>	<b>269</b>	<b>281</b>
<b>Min</b>	<b>1,5</b>	<b>30</b>	<b>22</b>

Sumber: Primary Data (2024).

Setyowati (2010) stated that high runoff is caused by high rainfall, but runoff will vary under relatively similar rainfall conditions depending on the condition of the land. Large rain intensity in a short time can describe large total rainfall values with few rainy days in a year (Handayani, 2011). In general, high amounts of rainfall influence an increase in river discharge and vice versa, but increased rainfall does not affect discharge fluctuations. This is because discharge fluctuations are influenced by forest cover in the Way Bulok Sub-watershed area..

### 2. Land Cover

In 2017, the Way Bulok Sub-watershed area had seven land covers, namely forest, bushes, plantations, settlements, dry land agriculture, mixed dry land agriculture and rice fields. Changes in land cover in the Way Bulok Sub-watershed area can be seen in Table 3 below.

Table 3. Land cover in the Way Bulok sub-watershed area in 2011-2017.

Land Cover	Year (ha)					
	2011	%	2014	%	2017	%
Forest	1376	1,570	1867,607	2,130	1861,228	2,123
Thickets/shrubs	4653	5,307	4329,085	4,938	1925,511	2,196
Plantation	2322	2,649	2322,077	2,649	1815,67	2,071
Settlement	5994	6,837	5693,124	6,494	7380,907	8,419
Meadow	0	0	225,2413	0,257	0	0
Water Body	0	0	10,79926	0,012	0	0
Dryland Farming	57431	65,508	14485,46	16,523	1191,665	1,359
Mixed dry land farming	6067	6,920	57820,25	65,952	51041,59	58,220
Cloud	11	0,013	0	0	0	0
Ricefield	9816	11,197	916,3588	1,045	22453,43	25,611
<b>Total</b>	<b>87670</b>	<b>100,000</b>	<b>87670,01</b>	<b>100,000</b>	<b>87670</b>	<b>100,000</b>

Sumber: Pratama dan Yuwono (2016) and Data Primer (2024)

Based on the table above, it can be seen that land cover in the Way Bulok Sub-watershed area in the 2011-2017 period is dominated by agricultural land cover which always has an area above 50% every year. In 2011, dry land farming dominated the Way Bulok Sub-watershed with an area of 65.508% of the total area. However, in 2014 and 2017, land cover shifted to mixed dry land agriculture which dominates the watershed area. It can be seen that in 2014 the area of mixed dry land farming was 65.952% and in 2017 it was 58.22%. According to Pratama & Yuwono (2016), the change in agricultural land use is because the area is planted with coffee ( *Coffea spp.* ) which is in the upstream area and cocoa ( *Theobroma cacao* ) which is evenly distributed in the middle and downstream areas. The increase in land cover in mixed dry land farming indicates that meeting the living needs of the population around the Way Bulok Sub-watershed area is highly dependent on the agricultural sector, thus causing a decrease in the area of forest cover in the area.

Forest areas have a relatively small area, ranging from 1-2% annually. It should be noted that forest areas have enormous potential to be utilized (Aprianto et al., 2016), where the role of forest areas is quite important in regulating water systems that influence water runoff or river discharge in the Way Bulok Sub-watershed area . The decline in forest area between 2014 and 2017 is inversely proportional to the increase in settlements. This indicates that there is land clearing in forest areas to be used as residential land or other open areas. The conversion of forest land causes a decrease in river discharge and an increase in surface water flow (Wirdhana, 2014). Apart from that, forests can also increase the rate of water infiltration which can penetrate the subsurface layers which then become springs (Handayani & Indrajaya, 2011).

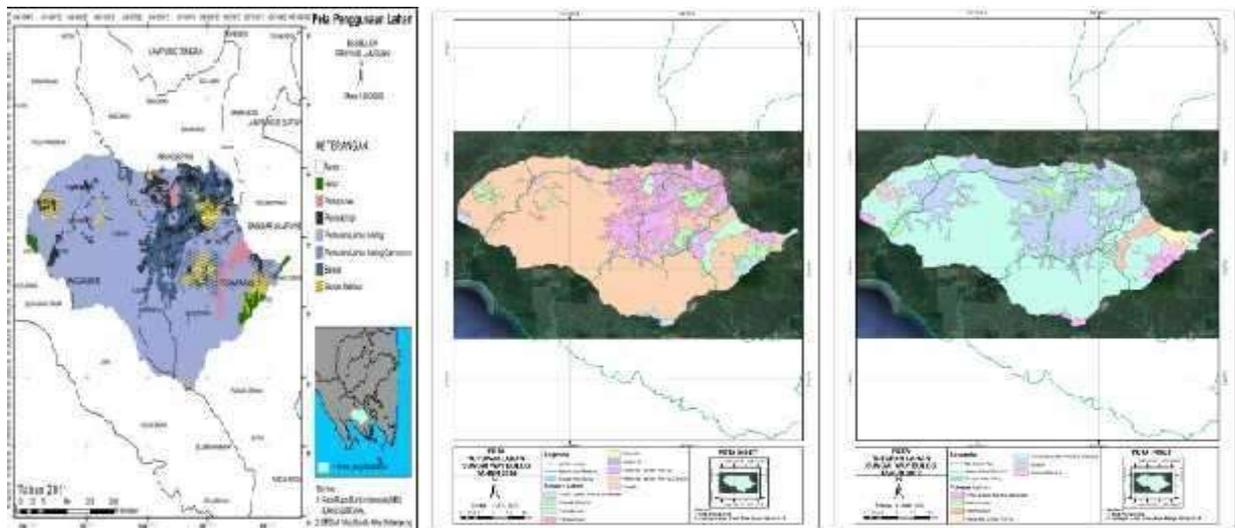


Figure 1 . Changes in land cover area in the Way Bulok Sub-watershed area in 2011 (Pratama, 2016) as well as in 2014 and 2017 (Primary Data, 2024).

Land cover for rice fields tends to increase. Even in 2014, paddy field cover was only 1.045%. The area of rice fields experienced a sharp increase in 2017 to 25.611 percent of the total area of the Way Bulok Sub-watershed. This indicates that rice fields have an important role in improving the economy of the population around the Way Bulok Sub-watershed area.

This is different from bush/shrub land cover which decreases throughout the year. It should be noted that bushes/shrubs have an important role in land conservation, this is because bushes/shrubs can reduce the rate of erosion and surface flow which can increase water infiltration into the soil (Sutrisno, 2011). T Plantation land cover decreased from 2.649% in 2011 and 2014 to 2.071% in 2017. Abidin (2018) in his research said that plantation land has a role in preventing erosion and flooding. However, the plantation area in the Way Bulok Sub-watershed area tends to be low.

### 3. River Discharge

The average river discharge in the Way Bulok Sub-watershed area has increased throughout the year as described in Table 4. River discharge is the amount of river water runoff that flows per unit time or the amount of water stored in a place (Mulyono, 2014). According to Neno, et al. (2016) stated that the ability to measure flow discharge is very necessary to determine the potential of water resources in a watershed area.

It can be seen in Table 4 that the total river discharge in the Way Bulok Sub-watershed area has increased throughout the year. Where in 2011 the average river discharge in the Way Bulok Sub-watershed was 21.69 m<sup>3</sup>/s and increased in 2014 to 24.15 m<sup>3</sup>/s. In 2017 the river discharge increased to 35.40 m<sup>3</sup>/s. One of the causes of the increase in river discharge in the Way Bulok Sub-watershed throughout the year is due to the decrease in land cover in forest areas in 2017. This is because, based on research conducted by Salim et al. (2019) in their research said that decreasing forest cover can increase water discharge and surface flow.

**Tabel 4. Debit sungai di Sub-DAS Way Bulok**

Bulan	Tahun (m <sup>3</sup> /s)		
	2011	2014	2017
Januari	30,689	42,916	25,027
Februari	47,028	36,4476	153,691
Maret	33,385	35,666	34,288
April	18,082	24,2097	35,478
Mei	18,079	19,3409	23,869
Juni	20,487	18,3628	21,653
Juli	11,572	15,365	20,061
Agustus	2,266	20,173	17,121
September	29,667	10,4987	19,128
Oktober	7,132	13,2494	17,641
Desember	26,144	35,8854	26,957
<b>Total</b>	<b>260,28</b>	<b>289,85</b>	<b>424,84</b>
<b>rata-rata</b>	<b>21,69</b>	<b>24,15</b>	<b>35,40</b>
<b>Max</b>	<b>47,03</b>	<b>42,92</b>	<b>153,69</b>
<b>Min</b>	<b>2,27</b>	<b>10,50</b>	<b>17,12</b>
<b>Qmax/Qmin</b>	<b>20,75</b>	<b>4,09</b>	<b>8,98</b>

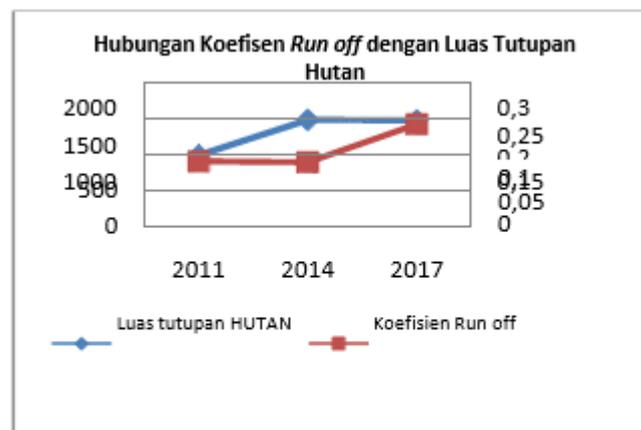
Sumber: Data Diolah (2024)

The indicator for evaluating the condition of a watershed is the discharge/FD fluctuation value (Romlah et al., 2018). The discharge fluctuation value is obtained from the comparison between the maximum discharge and the minimum discharge (Arsyad, 2010). Discharge fluctuations in the Way Bulok Sub-watershed have decreased, where the FD value in 2011 was 20.75 and decreased to 8.98 in 2017. So with this value, discharge fluctuations in the Way Bulok Sub-watershed can be categorized as low class in 2015 and became very low class in 2017. Changes in discharge fluctuations in the Way Bulok Sub-watershed are the same as research conducted by Hidayat et al. (2013), in this study, flow discharge fluctuations that occurred at this location were caused by intensive land conversion and poor land management.

#### 4. Surface Flow Coefficient (Runoff)

One indicator to find out whether a watershed area is experiencing physical disturbance is to know the value of the surface flow coefficient in that area (Supriyadi et al., 2018). The surface flow coefficient ( runoff ) is a value by Kurniawan et al. (2015). Where in research conducted in the Blorong watershed area in 2003-2013, the surface flow coefficient value increased.

The increase in surface flow that occurs in the Way Bulok Sub-watershed shows that the ability of land cover in the Way Bulok Sub-watershed is less than optimal to hold and store rainwater. As a result, a lot of runoff water goes directly into the river, so that there is little water available in the soil during the dry season to become river flow discharge (Supriyadi et al., 2018). However, the Way Bulok Sub-watershed does not experience physical watershed disturbance because of the coefficient value surface flow is below 30% (Asdak, 2010). The relationship between surface flow coefficient and forest cover area can be seen in Figure 3.



Gambar 3. Hubungan koefisien aliran permukaan dan tutupan hutan.

Increasing the surface flow coefficient value affects the value of river discharge due to the impact of land use patterns (Permatasari et al., 2017) and decreasing forest cover area. This is similar to research conducted by Narulita & Marganingrum (2017) in the Cerucuk watershed area, the results of which were that the surface flow coefficient value increased due to the expansion of open land or conversion of forest land. Apart from the small size of the forest area, one of the causes of the increase in surface flow coefficient in the Way Bulok Sub-watershed is dominated by dry agricultural land which is less than optimal in storing water in the soil.

#### CONCLUSION

Changes in land cover which is dominated by agricultural land and a small number of forest areas in the Way Bulok Sub-watershed in the period 2011, 2014 and 2017 have an effect on increasing rainfall from 1342 mm/year to 1570 mm/year, increasing average discharge from 21, 69 m<sup>3</sup>/s to 35.40 m<sup>3</sup>/s, increasing surface flow coefficient ( runoff ) from 0.19 to 0.27.

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