# ANALYSIS OF LAND COVER CHANGES TO FLOW REGIME COEFFICIENTS AND SURFACE FLOW CONDITIONS
## (Case Study in Bulok Watershed Sub Watershed in Lampung Province)

**Nano Suryono[1], Apriadi[1], Alawiyah[1], Zacky Michael Pah[1], Bainah Sari Dewi[2, 3]**

1.Magister of Forestry Sciences Faculty of Agriculture, University of Lampung
2. Research and Development Center for Tropical Biodiversity Institute for Research and Service
University of Lampung
3. Forestry Department, Faculty of Agriculture, University of Lampung

Prof. Dr. Sumatri Brojonegoro Street No 1 Gedung Meneng Bandar Lampung. 35145
E-mail: nanodipasena@yahoo.com; Hp: 085709316226

Land degradation that occurs in the Bulok Sub-watershed results in the function of the Bulok Sub-watershed as a catchment area with the aim of providing water for people's lives such as agricultural irrigation, domestic water needs and other activities will be disrupted. Analysis of land cover changes to river flow regime coefficients and surface flow conditions is carried out by using arc gis as a tool used to analyze spatial data, and using secondary data on rainfall and river discharge in time series from 1996/2006/2016. Secondary data and spatial data were processed quantitatively based on Minister of Forestry regulation number 61 of 2014. This land damage was caused by the increase of settlement land and rice fields from 1996 to 2016. The addition of paddy fields from 1996 which was originally only 1.05% of the Bulok Sub-watershed area in 2016, it was 25.61% of the Bulok watershed area. This situation resulted in KRA values experiencing a considerable change, in 1996 KRA had a value of 35, 85 in 2006 had a value of 56.50 and in 2016 had reached a very high KRA class, amounting to 175.49. Changes in land cover patterns also greatly affect surface flow. In 1996 the surface flow was 0.33 or by 33% of falling rainfall. In 2006 the surface flow was 43% and in 2016 it was 44%. Suggestions for improvement of the Bulok watershed, the easiest way is to make land cover close to land cover in 1996, because land cover in 1996 had a surface flow of 33%. Based on Minister of Forestry Decree No. 61 of 2014, a surface flow of 33% was in the medium category.

**Keywords: land cover change, flow coefficient, surface flow**

## A. Background

Watershed or DAS is a land area unit which is a unity with rivers and children - tributaries which function to accommodate, store, and drain water from rainfall to the lake or to the sea naturally, which limits on land are topographical separators and boundaries in the sea to waters that are still affected by land activities (Law No. 37 of 2014).

Sekampung watershed is the second largest watershed in Lampung Province. The area covers seven districts (Tanggamus, Pringsewu, Pesawaran, South Lampung, Metro, Bandar Lampung and East Lampung). Watershed conditions As the foundation of the community is now increasingly alarming (Suryono, 2017).

The Bulok Sub-watershed is one of the seven sub-watersheds in the Sekampung watershed. Bulok Sub-watershed Comparison between maximum and minimum discharge is 54: 1, this value indicates that the Way Bulok sub-watershed has been degraded. Asdak (2007) states that the Qmax / Qmin> (30: 1) ratio shows that a watershed has been damaged. The magnitude of the maximum discharge that occurred in addition to being caused by high rainfall in the month, was also caused by the type of land use which was dominated by dry land farming of 36.33% and dry land mixed with bush by 16.75% of the total area of the Way Bulok watershed . In addition, the magnitude of the maximum discharge that occurred on the Way Bulok river was also influenced by its topographic conditions, where 35% of its topography was in the rather steep to very steep category. So that even though the land cover is quite good, because the slope is quite steep, it causes more rainwater to fall into surface flow (47.91%). Such conditions will cause high discharge, especially if there is high intensity of rain in a relatively long time (BPDASHL, 2015).

Land degradation that occurs in the Bulok Sub-watershed results in the function of the Bulok Sub-watershed as a catchment area with the aim of providing water for people's lives such as agricultural irrigation, domestic water needs and other activities will be disrupted. The study related to the analysis of changes in land cover to the flow regime in the Bulok Sub-watershed is needed to determine the state of the water system in the Bulok Sub-watershed from time to time.

## B. Method

This research was conducted in Bulok DAS Sekampung Watershed, by looking at the current situation, especially the condition of critical land. Then saw land cover changes from the last 20 years, namely from 1996, compared to 2006 and 2016. This study used secondary data and spatial data analysis.

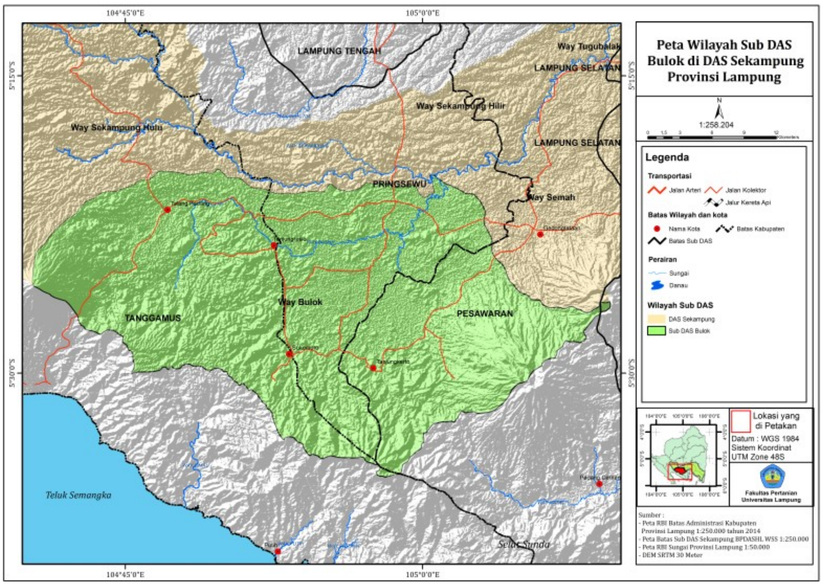


Figure 1. Map of Research Location

1. Spatial Analysis

Spatial analysis is an analysis carried out using spatial data. Spatial analysis in spatial data management using the Geographic Information System (GIS). The use of GIS is done to overlay some spatial data. The use of GIS can also be used to find out the extent of various types of data. Geographic Information Systems (GIS) are computer-based systems that are used to enter, store, manage, analyze and reactivate data that have spatial references for various purposes related to mapping and planning (Burrough, 1986; Aronoff, 1989).

2. Analysis of Flow Regime Coefficient (KRA)

Flow Regime Coefficient (KRA) is the ratio between maximum discharge (Qmax) and minimum discharge (Qmin) in a watershed. The high KRA value indicates that the runoff value in the rainy season (flood water) is large, while in the dry season the flow of water that occurs is very small or shows drought. Indirectly this condition shows that the power of land absorption in the watershed is less able to hold and store falling rainwater and many runoff water continues to enter the river and is discharged into the sea so that the availability of water in the watershed during the dry season is little (BPDASHL, 2014).

3. Annual Flow Coefficient Analysis (KAT)

The Annual Flow Coefficient (KAT) is a comparison between thickness annual flow (Q, mm) with annual rainfall thickness (P, mm) in the watershed or it can be said what percentage of the rainfall becomes the runoff in the watershed. Flow thickness (Q) is obtained from the volume of discharge (Q, in units of m3) from SPAS observations in the watershed for one year or formula calculation divided by the watershed area (ha or m2) which is then converted to mm units (BPDASHL, 2014).

## C. Results

Based on the calculation of spatial data, the Bulok Sub-watershed has a total area of 87,670 ha. The area of the Bulok watershed is only about 18% of the total area of the Sekampung watershed. Although it only has 18% of the total area of the Sekampung watershed, the Bulok watershed passes through 4 regencies / cities. Data detailing the proportion of Bulok watershed existence can be seen in Table 1.

Table 1. Proportion of Bulok Sub-watersheds in several districts passed.

| No | District / City | Area (Ha) | % |
|---|---|---|---|
| 1 | Pringsewu | 24.836,71 | 28,33 |
| 2 | Pesawaran | 25.083,87 | 28,61 |
| 3 | Bandar Lampung | 67,76 | 0,08 |
| 4 | Tanggamus | 37.681,66 | 42,98 |
| | Total | 87.670,00 | 100,00 |

Source: BPDASHL Data Analysis, 2014.

Table 1. Shows if Tanggamus district is the district that has the largest proportion in the Bulok Sub-watershed. As much as 42.98% of the Bulok Sub-watershed area is located in Tanggamus District. Whereas Pringsewu and Pesawaran districts had almost the same proportions of 28, 33% and 28.61%. While Bandar Lampung City only has a proportion of 0.08% or 67.76 ha.

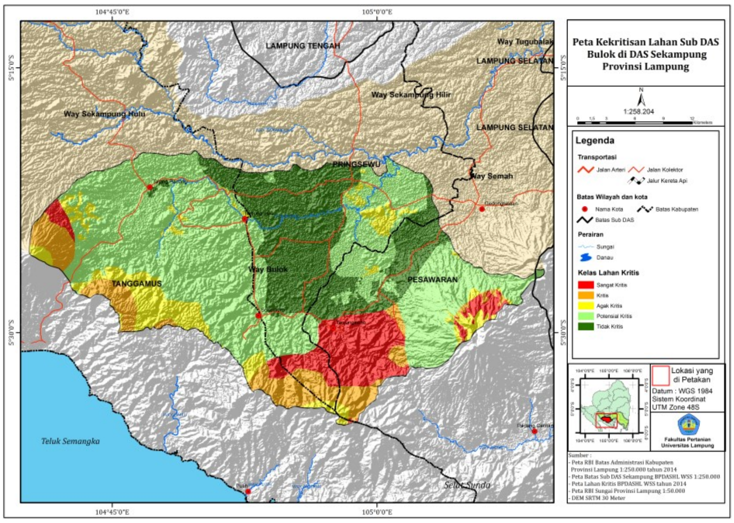


Figure 2. Map of Land Critical Classes

Figure 2. Describing the condition of critical land classes in the Bulok watershed. The Bulok River Basin has the most critical land classes in Pesawaran District. This situation can be seen in Figure 1. The class of very critical land is red, and critical land is orange. Watershed Sekampung has been known to have critical land as Nurhaida et al. (2005) if the watershed area is 477,439 ha, with an irrigation area of 66,500 ha, with a large watershed area but the watershed Sekampung since 1984 has been designated as one of the watersheds with critical conditions along with 21 other watersheds in Indonesia.

Table 2. Percentage of Land Critical Classes in the Bulok Sub-watershed

| No | Land Critical Class | Area (Ha) | % |
|---|---|---|---|
| 1 | Not Critical | 19.386,38 | 22,11 |
| 2 | Critical Potential | 44.484,12 | 50,74 |
| 3 | Rather Critical | 7.794,49 | 8,89 |
| 4 | Critical | 7.666,27 | 8,74 |
| 5 | Very Critical | 8.338,74 | 9,51 |
| | Total | 87.670,00 | 100,00 |

Source: BPDASHL Data Analysis, 2014.

Table 2. Explain the division of land in the Bulok Sub-watershed against land criticality classes. Land classes based on Ministry of Forestry Regulation No. 61 of 2014 are explained if land critical classes are categorized into five classes. The criticality of the land class is uncritical land, critical potential land, rather critical land, critical land and very critical land. Whereas the land category can be said to be critical if the land has a critical and very critical class.

The Bulok watershed has thousands of hectares of critical land. This can be seen in Table 2. The class of critical land has a proportion of 8.74% or equal to 7,666.27 hectares, while the land class is very critical at 9.51% or equal to 8,338.74 hectares. So that the number of critical land in the Bulok watershed is 18.25% of the total area of the Bulok watershed. Land can be said to be critical if the land function or land function has been disturbed in its designation (Barus, et al., 2011).

Critical land occurs because of land use that is in accordance with the ability of the land and by following the principles of soil and water conservation. Critical land is generally caused by the exploitation of land use that exceeds the capacity of the land. However, naturally critical land is supported by the less favorable physical conditions of the area, such as high rainfall, steep slopes and erosion sensitive soil conditions (Kubangun, 2014).

Land cover is one of the causes of land degradation. The conversion of forest land to agricultural land is caused by a lack of maximum watershed management. Good watershed management is the rational use of natural resources in the watershed to get maximum production in an unlimited time and reduce the danger of damage (land degradation) to a minimum, and obtain evenly distributed water yield throughout the year (Banuwa et al. , 2008).

Table 3. Land Closure Changes in the Bulok Sub-watershed in 1996/2006/2016

| No | Land Closure | Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1996 | | 2006 | | 2016 | |
| | | Ha | % | Ha | % | Ha | % |
| 1 | Secondary Forest | 1.867,61 | 2,13 | 1.867,61 | 2,13 | 1.870,29 | 2,13 |
| 2 | Non-productive dry land | 4.329,09 | 4,94 | 4.329,09 | 4,94 | 1.925,51 | 2,20 |
| 3 | Plantation | 2.322,08 | 2,65 | 2.322,08 | 2,65 | 1.815,67 | 2,07 |
| 4 | Settlements | 5.469,06 | 6,24 | 5.693,12 | 6,49 | 7.380,91 | 8,42 |
| 5 | Dry grass and swamp grass | 225,24 | 0,26 | 225,24 | 0,26 | - | 0,00 |
| 6 | Water Body | 10,80 | 0,01 | 10,80 | 0,01 | - | 0,00 |
| 7 | Dry land farming | 14.485,46 | 16,52 | 14.485,46 | 16,52 | 1.191,66 | 1,36 |
| 8 | Dryland agriculture mixed | 58.044,32 | 66,21 | 57.820,25 | 65,95 | 51.032,52 | 58,21 |
| 9 | Rice field | 916,35 | 1,05 | 916,35 | 1,05 | 22.453,43 | 25,61 |
| | Total | 87.670,00 | 100,00 | 87.670,00 | 100,00 | 87.670,00 | 100,00 |

Source: BPKH Data Analysis, 2016.

Changes in land cover that occur in the Bulok watershed can be seen in Table 3. Changes in land cover presented in the table above are changes in land cover in the last 20 years. Changes in land cover that occurred within a period of 20 years, from 1996 to 2016 the closure of secondary forest land only increased by about 3 hectares. In general, almost every type of land cover does not have a real change. However, in 2016 changes in land cover were very visible.

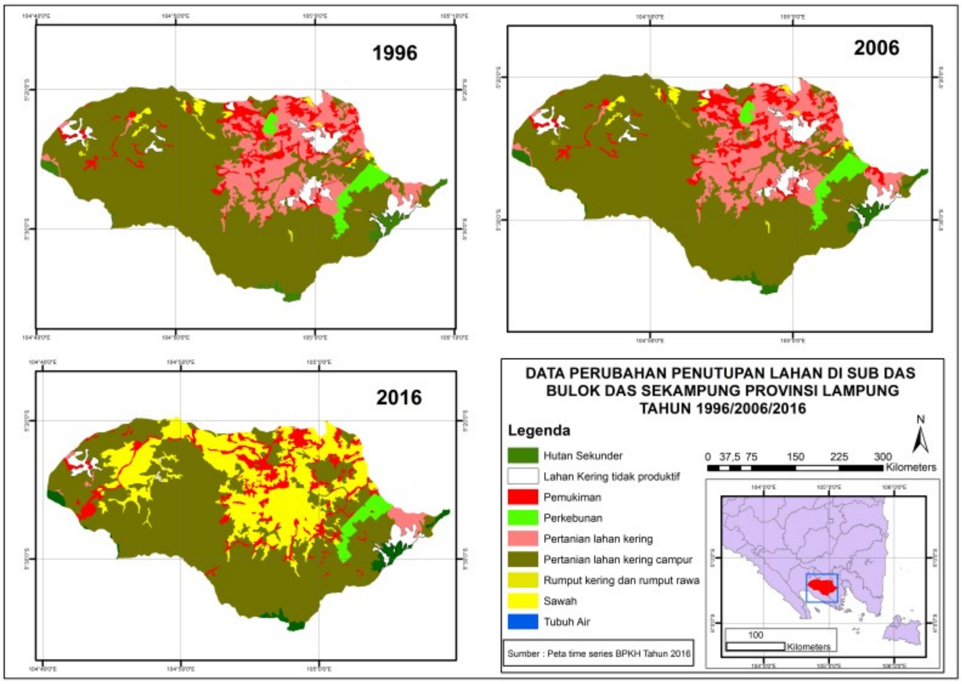


Figure 3. Changes in Land Cover in the Bulok Watershed of 1996/2006/2016

Figure 3. Explaining contrasting color changes occurred in 2016. Comparison of these color changes indicates a large change in land cover. Meanwhile in 1996 when compared to 2006 only experienced a slight change in land cover. Closure changes that occurred in 1996 to 2006 only occurred in the type of land cover and mixed dry land farming. In the settlement shows an increase in value, from 6.24% in 1996 increased to 6.49% in 2006. The closure of mixed dryland agricultural land decreased from 66.21% in 1996, decreased to 65.95%.

Changes in land cover that occurred in 2006 until 2016 experienced many changes. Can be seen in Figure 3. The yellow color is the type of rice field cover and agricultural land. Rice fields increased from 1.05% in 2006, increasing to 25.61%. Whereas for the type of swamp land cover, swamp and water bodies are no longer visible. Pawitan (2009) Says that changes in land use patterns have resulted in a decrease in regional water availability due to increased seasonal fluctuations with increasingly extreme symptoms of floods and droughts and watershed sizes as well as the capacity of watershed storage systems on the surface (plants, rice fields, swamps, lakes / reservoirs and river) and subsurface (soil and water layer of the earth) are the dominant factors that determine the vulnerability and carrying capacity of the region's water resources system to climate change.

Progress in development in one region is in line with the increase in population growth accompanied by an increase in the quality and quantity of life needs. The impact of increasing the quality and quantity of life, namely the occurrence of land use changes is difficult to control (Untari, 2012).

Pringsewu Regency was formed in 2008 based on RI Law No. 48 of 2008, the establishment of Pringsewu district is believed to have caused significant developments and changes in land use. Regional expansion has led to a concentration of population due to large-scale development in the centers of the district / city capital. This concentration of population and development also causes the concentration of business activities and supporting business activities in the area. basically, the area of land is constant meaning supply is constant. While the demand for dynamic land demand will increase. So what will change is the use of the land / land (Maramis, et al. 2016)

Table 4. State of the Surface Flow Coefficient in the Bulok Sub-watershed

| Year | Min ($m^3/s$) | Max ($m^3/s$) | KRA |
|---|---|---|---|
| 1996 | 3,18 | 114,00 | 35,85 |
| 2006 | 1,01 | 57,20 | 56,50 |
| 2016 | 1,10 | 137,18 | 175,49 |

Source: Analysis of BBWSS data, 2016

Data on the state of KRA in the Bulok watershed. KRA is a comparison of the minimum debit value (Daily) with maximum debit (Daily). KRA value upgrading in each time period, since 1996 then 2006 to 2016 affected by land cover in the Bulok Sub-watershed. Changes in land use in watershed areas that do not pay attention to conservation rules, can result in reduced water absorption which will cause an increase in the amount of running water that enters the river which causes a large increase in maximum discharge (Saraswati, et al. 2017).

Table 4. describes the value of KRA in the Bulok watershed has increased. This increase indicates damage to land that occurred in the Bulok Sub-watershed. The last KRA value in 2016 shows a value of 175.46. The higher the KRA value indicates if the difference between minimum and maximum discharge is very large. This is because the water that falls on the land in the Bulok Sub-watershed is mostly runoff or runoff and is not stored so that when rainfall is high, high surface flow and vice versa. Based on Minister of Forestry Decree No. 61 of 2014, the value of KRA 175.46 in 206 shows a very high class, which means there is very severe damage. Asdak (2010) stated that if the high fluctuation of flowrate is more than 30: 1, it indicates that a watershed has been damaged. The smaller the debit fluctuations, the better the land use condition of a watershed, and the greater the value of the debit fluctuations, the worse the condition of land use in a watershed (Arsyad, 2010).

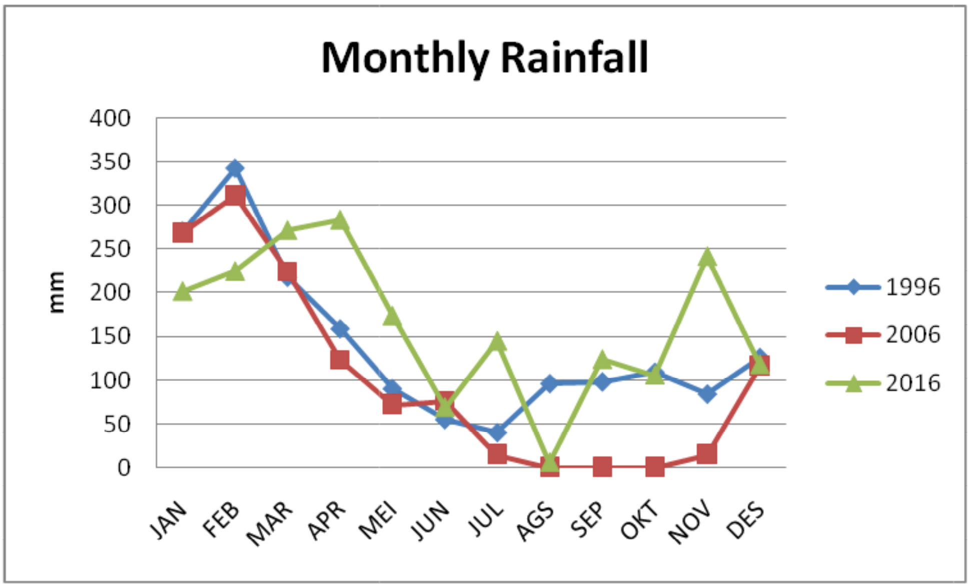


Figure 4. Rainfall graph time series 1996/2006/2016

Monthly rainfall from 1996/2006/2016 can be seen in Figure 4. Rainfall patterns that occur in the Bulok Sub-watershed are fluctuating, or do not experience stability. In 1996 the monthly rainfall pattern was depicted with a blue line, showing normal rainfall patterns. Normal rainfall patterns such as high rainfall patterns in wet months are at the beginning and end of the year, then in the dry months do not experience a rainy day. In 2006 the monthly rainfall pattern experienced a very sharp decline in July to November. Whereas in 2016 the rain pattern experienced considerable fluctuations, until in August the rainfall was very small.

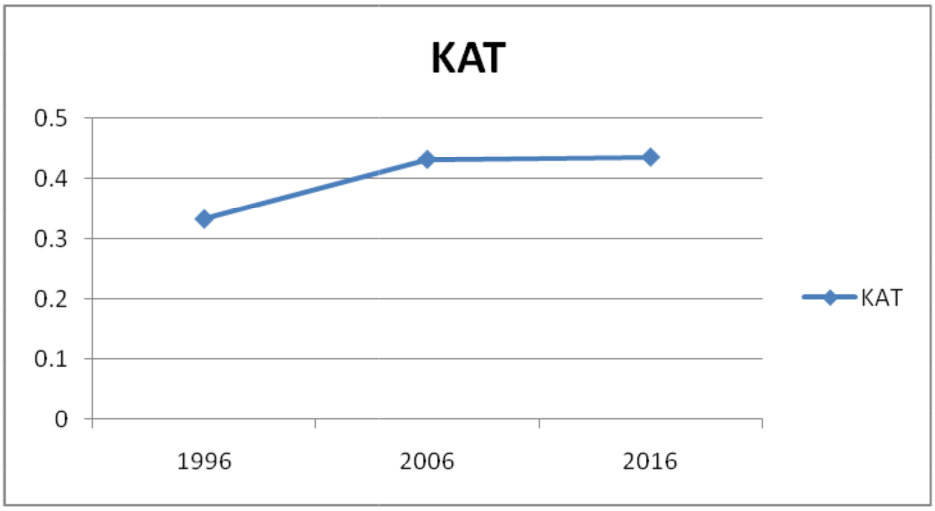


Figure 5. Graph of surface flow in the Bulok Sub-watershed

Runoff graph can be seen in Figure 5. The graph shows an increase from 1996 to 2006 and in 2016. This increase in graph shows the presence of surface flow that continues to increase. In 1996 the surface flow was 0.33 or by 33% of falling rainfall. In 2006 the surface flow was

43% and in 2016 it was 44%. According to Asdak (2010), if the surface flow has exceeded 30%, it indicates that the watershed has been damaged.

Bulok watershed experienced forest conversion, increased settlement area, increased dryland agriculture and decreased rice fields due to a decrease in flow discharge, especially in the dry season (Pratama, 2016).

Surface flow value in 2016 of 44% shows a high surface flow class, based on Permenhut No. 61 of 2014. Calculation of surface flow in 2001 showed a value of 41% with a high surface flow class (Primary, 2016). The increase in the value of surface flow each year is caused by an increase in the area of rice fields and settlements in the Bulok Sub-watershed. Sudadi (1991) states that the effect of land use change on river flow characteristics is related to the change in conservation area into extensive agriculture into intensive agricultural areas and settlements

reduce the ability of the soil to retain water. According to Asdak (2010), changes in land cover that occur can increase flow discharge if one type of vegetation is replaced from deep rooted plants to shallow rooted plants. It is better if the Bulok Sub-watershed wants to be repaired, the easiest way is to make land cover close to land cover in 1996, because land cover in 1996 had a surface flow of 33%. Based on Minister of Forestry Decree No. 61 of 2014, a surface flow of 33% was in the medium category.

## D. Conclusions and Suggestions

The current state of the Bulok Sub-watershed has been damaged, as much as 18.25% of the area of the Bulok Sub-watershed or around 15,004.01 hectares has become a critical land with critical and very critical class criteria. This land damage was caused by the increase in settlement land and rice fields from 1996 to 2016. The addition of paddy fields from 1996 which was originally only 1.05% of the Bulok Sub-watershed area, in 2016 became 25.61% of the Bulok Sub-watershed area. This situation resulted in KRA values experiencing a considerable change, in 1996 KRA had a value of 35, 85 in 2006 had a value of 56.50 and in 2016 had reached a very high KRA class, amounting to 175.49. Changes in land cover patterns also greatly affect surface flow. In 1996 the surface flow was 0.33 or by 33% of falling rainfall. In 2006 the surface flow was 43% and in 2016 it was 44%. Suggestions for improvement of the Bulok watershed, the easiest way is to make land cover close to land cover in 1996, because land cover in 1996 had a surface flow of 33%. Based on Minister of Forestry Decree No. 61 of 2014, a surface flow of 33% was in the medium category.

**Refferences**


Arsyad S. 2010. *Konservasi tanah dan air*. Buku. IPB Press. Bogor. 396p.

Aronoff, S.1989. *Geographic Information System*. Management Perspective. WDL. Otawa.

Asdak, C. 2007. *Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Gajah Mada University Press. Yogyakarta.

Asdak, C. 2010. *Hidrologi dan pengelolaan daerah aliran sungai*. Buku. Gadjah Mada University Press. Yogyakarta. 630p.

Banuwa, I.S, N. Sinukaban, S.D. Tarigan, D. Daarusman. 2008. *Evaluasi kemampuan lahan DAS Sekampung Hulu*. Jurnal Tanah Tropika. 13(2):145--153.

Barus, B., Gandasasmita, K., Tarigan, S. dan Rusdiana, O. (2011). Laporan Akhir Penyusunan Kriteria Lahan Kritis. Pusat Pengkajian Pengembangan Wilayah (P4W) Institut Pertanian Bogor. Bogor.

Burrough, D.A. 1986. *Principles of Geographical Information System For Land Resources Assessment*. Clarendon. Oxford.

BPDAS, 2015. *Monitoring dan Evaluasi DAS Sekampung*. Buku. BPDAS Way Seputih Way Sekampung Press. Lampung.

Kubangun, S. H., Haridjaja, Oteng dan Komarsa G. 2014. *Model Spasial Bahaya Lahan Kritis di Kabupaten Bogor, Cianjur dan Sukabumi*. Majalah Ilmiah Globë. Volume 16 No. 2 : 149 – 156

Nurhaida, I., S. P. Haryanto., S. Bakri., A. Junaidi, dan P. Syah. 2005. Penginventarisan kearifan lokal dalam praktik wanatani kopi dalam debat kelestarian fungsi Hidro-Orologis wilayah resapan di Lampung Barat. *Jurnal Pembangunan Pedesaan*. 5 (2) : 92 dst

Maramis, Joubert Barens., Polii, Jhon Vian Bobby., Najoan, Jemmy., Masinambow, V.A. Junius. 2016. *Studi Prilaku Pasar tanah di Daerah Pemekaran Provinsi Sulawesi Utara*. Jurnal Riset Bisnis dan Manajemen Vol. 4, No. . 461-488

Pawitan, H. 2009. *Penilaian Kerentanan dan Daya Adaptasi Sumberdaya Air Terhadap Perubahan Iklim*. Jakarta : Makalah Seminar Nasional, Kantor Mentri Negara Lingkungan Hidup.

Pemerintah Republik Indonesia.2008. *Undang – Undang RI Nomor 48 Tahun 2008 Tentang Pembentukan Kabupaten Pringsewu di Provinsi Lampung* .Jakarta

Pemerintah Republik Indonesia.2014. *Undang – Undang RI Nomor 37 Tahun 2014 Tentang Konservasi Tanah dan Air*. Jakarta

Permenhut P.61, 2014. Peraturan Mentri Kehutanan Republik Indonesia No.P.61/Menhut-II/2014. *Monitoring dan evaluasi daerah aliran sungai*. Kementeri Kehutanan Republik Indonesia. Jakarta. 33p.

Pratama, Willy dan S. B. Yuwono. 2016. *Analisis Perubahan Penggunaan Lahan Terhadap Karakteristik Hidrologi di DAS Bulok*. Jurnal Sylva Lestari. Vol. 4 No. 3 ISSN 2339-0913

Saraswati, Galuh Febriana., Suprayogi, andri., Amarohmah, Fauzi Janu. 2017. *Analisis Perubahan Tutupan Lahan DAS Blorong terhadap Peningkatan Debit Maksimum Sungai Blorong Kendal*. Jurnal Geodesi Undip. Vol.6, No. 2 ISSN: 2337-845x

Sudadi, U.D.P.T. Baskoro, K. Munibah, B. Barus dan Darmawan. 1991. *Kajian pengaruh perubahan penggunaan lahan terhadap aliran sungai dan penurunan kualitas lahan di sub DAS Ciliwung Hulu dengan pendekatan model simulasi hidrologi*. Laporan Penelitian. Jurusan Tanah. Fakultas Pertanian IPB. Bogor. 85p.

Suryono, Nano. 2017. *Pendugaan Erosi dengan Pengukuran Muatan Sedimen dan Metode Universal Soil Loss Equation untuk Perencanaan Pengelolaan DAS*. Skripsi. Universitas Lampung. Lampung.

Untari, Adelia. 2012. *Studi Pengaruh Perubahan Tata Guna Lahan Terhadap Debit di DAS Ci Tepus*. Tesis. Institut Teknologi bandung. Bandung.