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Land Use Cover Changes and Run Off Potention of Cipunten Agung Watershed Banten

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Abstract. The changes of landscape form such as Land Use Cover Changes (LUCC) of Cipunten Agung watershed could be identified periodically in 1995, 2005, and 2015. In general, land utilization in Cipunten Agung classified into protected region and cultivated region. In 2011, total of protected area is 885.80 ha or 22.54% of watershed area. Those conditions affected both positively to the community development and negatively to the water quantity condition in Cipunten Agung such as flooding, run off, and erosion. Therefore, the purpose of this research is to analyze LUCC impacts to run off potential in Cipunten Agung watershed. Supervised classification method and Soil Conservation Services (Qscs) approach were correlated to determine the figure out an optimal solution to reduce the rate of LUCC. Cipunten Agung watershed imagery was classified into five classes, namely water bodies, forest, cultivated tree, settlement and paddy field. The result shows that area of cultivation tree and paddy fields are larger than others in midstream, and settlement is denser in downstream, particularly at riparian landscapes. The LUCC into paddy field often occur at two period 1995 to 2005 and 2005 to 2015 with several area are 530.92 ha and 388.17 ha. The Qscs method calculation result for 1995 until 2015 was affected by land use cover composition in each year and it was defined by Curve Number (CN). High rainfall in 1995 was generating high run off potential volume. Nevertheless, curve number value was increase get near to 100, which indicate the potential of run off volume increases along with LUCC in each year, those are 70.95; 72.47; and 72.81.

1. Introduction
Landscape mozaic changes could occur by the addition of new landscape form and affect its function [1, 2]. The change of landscape form such as Land Use Cover Changes (LUCC) of Cipunten Agung watershed could identify periodically in 1995, 2005, and 2015. In general, land utilization in Cipunten Agung classified into protected region and cultivated region. In 2011, total of protected area is 885.80 ha or 22.54% of watershed area. The conversion of cultivated tree into paddy field area could decreasing infiltration area, increasing run off, and land erosion. LUCC from forest to developed area such as settlement could increasing run off from high rainfall and flooding in down stream [3]. Thus, when there is LUCC at Cipunten Agung, the function in water flowing also could be changed. The changes of run off volume, could identified by Curve Number in hydrology analysis. Therefore, the objective of this study was to analyze the effect of LUCC against potential run off volume at Cipunten Agung watershed. This study result could be as consideration in the sustainable and flood free of watershed planing and management.
2. Methods

2.1 Location, Tool, Materials

This study was located at Cipunten Agung watershed, Pandeglang Regency, Banten Province with coordinate 6°17’30” to 6°22’30” Latitude and 105°50’0” to 105°55’0” Longitude (Figure 1 Error! Reference source not found.). Cipunten main river length is 23.44 km. The tools used in this study consist of hardware, such as digital camera, GPS, and several geography information system (GIS) softwares. Materials used in this study are Landsat imagery of year 1995, 2005, 2015. Sub-district administration map, watershed boundary map, precipitation map, digital elevation model (DEM), soil type map, and series of Daily rainfall from BMKG (Figure 2).

Figure 1. Study area of Cipunten Agung watershed

![Figure 1](image1.png)

Figure 2. Daily rainfall (Source: BMKG)

![Figure 2](image2.png)
2.2 Method
The main method that used in this study was supervised classification for LUCC analyze and Soil Conservation Services for run off volume calculation. Land use and cover was classified into five classes, namely water bodies, forest, cultivated tree, settlement and paddy field. Curve Number (CN) value in Soil Conversion Services (SCS) method is determine by the combination of land use, soil type, and Antecedent Moisture Categories (AMC). The estimation of the value of CN can be initiated by determine the Hydrology Soil Group. In this study HSG were identified based on the soil type character. The equation used to determine the CN DAS value as follows:

\[ CN_{DAS} = \frac{\sum CN_l \times A_l}{\sum A_l} \]

Methods CN-SCS has been widely applied to calculate the surface runoff in some watersheds in Java, for example Citarum Watershed in West Java and Ciliwung Watershed in Jakarta [4]. The equation used in determining the amount of runoff volume with SCS method is as follows:

\[ S = \frac{25400}{CN} - 254 \text{ and } Q_{SCS} = \frac{(P-0.25)^2}{P+0.8S} \]

\(Q_{scs}\) is daily surface runoff (mm), \(S\) is the maximum potential retention after the start of the run-off (mm), CNI is Curve Number land use, and \(A_i\) is the area of land use (ha). CN value is also influenced by Antecedent Moisture Conditions (AMC) or the value of the previous humidity. Value AMC affect the value of the volume and rate of runoff. AMC classification based on:

- **Condition I**: soil in the dry state but not to the wilting pointy, once planted with satisfactory result
- **Condition II**: The state average
- **Condition III**: Heavy or light rain and low temperatures have accrued in the last five days, when saturated soil.

3. Result and Discussion
3.1 Land Use Cover Changes (LUCC)
Protected area of Cipunten Agung watershed consists of protected forest in Pulo Sari Mountain and shoreline area. Many of DAS Cipunten Agung area used as agricultural land. BPS Pandeglang (2015) state that most of 24.75 % family cultivates crops and 24.54 % cultivates horticulture. In 1995, either local community or government has not use Cipunten Agung resource optimally. There were residential development on cultivated tree area and floodplains with a distance 20 m from riparian area, it becomes flooding area in 2010, 2012, 2013, 2015, and 2016. Therefore LUCC were analyze for identify the increases of run off volume which can cause flooding.

The classification process use 15 training area in each class, namely water bodies, forest, cultivated tree, settlement, and paddy field. Classification of 1995 result shows (Figure 3), the smallest area is water bodies 38.98 ha and the widest area is cultivated tree 2570 ha. Land use as cultivated tree and paddy field was intensive for daily needs supply. The classification result for 2005 (Figure 4) shows the widest area is cultivated tree 2,286.01 ha or 57.44 % of total area. Cultivated tree was decreasing while paddy field was increasing to 969.9 ha or 24.37 % of total area. The dense area of settlement from 1995 indicates the communities tend to build at downstream.

The classification result for 2015 (Figure 5) shows the widest area is cultivated tree area with size 2,420.5 ha or 61.41 % of total area. LUCC from paddy field into settlement area many occur from 2005 to 2015 with size 64.62 ha. LUCC graphic (Figure 6) show the decreases of cultivated area and increases of paddy field from 1995 to 2005 and 2015. LUCC into paddy field many occur at Jiput sub district (Middle stream). LUCC into settlement area many occur at 2005 to 2015 with size 195.21 ha. The LUCC in rural landscape particularly change from forest area to paddy fields and gradually change to settlement area. The changing of rural landscape will also impact to the water quantity and quality in agricultural field [5].
Over all, the LUCC analysis from 2005 to 2015 shows there are several cultivated area inside the protected area with size around 49 ha. The size of protected area until 2011 is 885.80 ha (22.54%) of total area. It’s not suitable with Indonesia decree number 26 of 2007 clause 17 paragraph 5 which state a watershed must have a minimum of 30% forest area. Therefore a robust action should be arranged in order to reduce the acceleration of the LUCC in this watershed. The LUCC from forest to open field or settlement can cause run off which potential for flooding at downstream area [2, 6]. Run off volume changes could be identified through the Curve Number (CN) value in hydrological analysis. In addition, to reduce the CV number can be achieved by landscape services management in agricultural landscape. The management of landscape services due to landscape simplification can only be addressed by a concerted effort to fundamentally redesign agricultural landscapes [7].
3.2 Curve Number

Run off volume estimation start with the Curve Number calculation, it consists of Hydrology Soil Group (HSG), AMC, and land cover area. HSG indicate the infiltration potential after dampness in certain time [1]. Cipunten Agung watershed widest HSG is group B (litosol type) with area size 2,967 ha or 75.75% of total area, while group C (podsolik type) and D (alluvial type) has area 628 ha and 322 ha or 16.03% and 8.22% of total area. Podsolik and alluvial soil type has infiltration rate at 0-4 mm/ hours, it indicates small capability to infiltrate the water and easy to run off, so it can cause floodplains when heavy rain. In AMC II condition the highest CN for land cover type is 100.00 for water bodies and 84.00 for paddy field while the lowest CN is forest 55.00. Land cover size in each year and CN for each land cover type was calculate and generate watershed curve number (CN DAS) of each year, 70.95; 72.47; and 72.81 (Table 1). The lower value of CN indicates better infiltration capability, in the other side the high value of CN indicates there has
been a decreases in the ability of soil to retain the water, so the rain water falls onto the surface more into runoff.

Table 1. Watershed Curve Number (CN DAS) of 1995, 2005, and 2015

| Land Use Cover type (1995) | HSG | Area (ha) | AMC II | CN   |
|---------------------------|-----|-----------|--------|------|
| Water bodies              |     |           |        |      |
| B                         | 15.90 | 100.00   | 1,590.4 |
| C                         | 7.67  | 100.00   | 767.00  |
| D                         | 0.32  | 100.00   | 32.00   |
| Forest                    |     |           |        |      |
| B                         | 467.94 | 55.00   | 25,736.70 |
| C                         | 0.00  | 70.00    | 0      |
| D                         | 0.00  | 77.00    | 0      |
| Cultivated tree           |     |           |        |      |
| B                         | 1,826.46 | 69.00   | 126,025.70 |
| C                         | 520.99 | 77.00    | 40,116.23 |
| D                         | 237.35 | 83.00    | 19,700.05 |
| Settlement                |     |           |        |      |
| B                         | 68.28  | 83.00    | 5,667.24 |
| C                         | 8.87   | 89.00    | 789.43  |
| D                         | 19.12  | 91.00    | 1739.92 |
| Paddy field               |     |           |        |      |
| B                         | 585.32 | 73.00    | 42,728.36 |
| C                         | 90.10  | 81.00    | 7298.10 |
| D                         | 65.23  | 84.00    | 5,479.32 |
| CN DAS                    | 70.95          |          |        |

| Land Use Cover type (2005) | HSG | Area (ha) | AMC II | CN   |
|---------------------------|-----|-----------|--------|------|
| Water bodies              |     |           |        |      |
| B                         | 17.02  | 100.00   | 1,702.00 |
| C                         | 8.35   | 100.00   | 834.73  |
| D                         | 10.63  | 100.00   | 1,062.80 |
| Forest                    |     |           |        |      |
| B                         | 162.39 | 55.00    | 8,931.45 |
| C                         | 0.00   | 70.00    | 0      |
| D                         | 0.00   | 77.00    | 0      |
| Cultivated tree           |     |           |        |      |
| B                         | 1,710.50 | 69.00   | 118,024.50 |
| C                         | 433.48 | 77.00    | 33,377.96 |
| D                         | 162.34 | 83.00    | 13,474.22 |
| Settlement                |     |           |        |      |
| B                         | 95.37  | 83.00    | 7,915.37 |
| C                         | 5.13   | 89.00    | 456.89  |
| D                         | 8.98   | 91.00    | 816.86  |
| Paddy field               |     |           |        |      |
| B                         | 685.66 | 73.00    | 50,053.18 |
| C                         | 144.05 | 81.00    | 11,668.05 |
| D                         | 110.83 | 84.00    | 9,309.72 |
| CN DAS                    | 72.47          |          |        |

| Land Use Cover type (2015) | HSG | Area (ha) | AMC II | CN   |
|---------------------------|-----|-----------|--------|------|
| Water bodies              |     |           |        |      |
| B                         | 37.70  | 100.00   | 3,770.14 |
| C                         | 2.03   | 100.00   | 202.95  |
| D                         | 0.14   | 100.00   | 14.00   |
| Forest                    |     |           |        |      |
| B                         | 178.03 | 55.00    | 9,791.71 |
| C                         | 0.00   | 70.00    | 0      |
3.3 Run off volume
Run off volume estimation influence by rainfall, CN DAS, and the maximum potential of retention when runoff start (S) (Figure 7). Heavy rain about 84 mm/day was happen in January 18th, 1995 when cultivated tree and paddy field were dominated with area size 2,570.06 ha and 793.63 ha. Based on the CN DAS calculation the result is 70.90 and it’s lower than 2005 and 2015. The maximum retention of 1995 is 104.00 it could be identify after CN calculation. It indicates that land cover has potential to retaining the run off stream. In 1995 highest run off volume potential is 23.95 mm. Even though there were wider area of cultivated area, but it has not been able to reduce the run off potential volume that affected by heavy rainfall.

In 2005, land cover was dominated by cultivated tree and paddy field with area size 2,286.01 ha and 969.76 ha or 57.44 % and 24.37 % of total area. The maximum daily rainfall is 76 mm/day, based on the CN DAS calculation the result 72.47 and the maximum retention value is 96,49. It indicates the degradation of water retention capability from 1995. Highest run off volume calculation result in 2005 is 20.99 mm.

In 2015, land cover was dominated by cultivated tree and paddy field with area size 2,420.5 ha and 1,071.45 ha or 61.40 % and 27.18 % of total area. The maximum daily rainfall is 60.80 mm/day, based on the CN DAS calculation the result 72.81 and the maximum retention value is 94.85. It indicates the degradation of water retention capability from 2005. Highest run off volume calculation result in 2015 is 12.80 mm. It is predicted that the run-off will gradually occurred more frequently and denser.
3.4 LUCC vs Run off volume
Daily run off volume summation could be a water yield or total of water volume production from run off in one year period (Decree of the Director General of Land Rehabilitation and Social Forestry). Total water yield of 1995, 2005, and 2015 are 1,588.96; 1,442.59; and 1,575.80 mm. it could be increases in line with daily rainfall and causing flood, even though physically flooding causes are sedimentation and riparian constriction. Department of Water Resources and Resettlement of Banten Province state the initial steps to deal with flooding is reducing sedimentation in estuary area and water control construction. Land use cover and run off volume could be the consideration material in watershed management, especially the reduction of flooding and water quality improvement [8].

Based on run off volume analysis, it shows that run off volume more affected by daily rainfall than by the size of cultivated tree area or LUCC. The effects of LUCC to run off volume illustrated through the linear correlation with the Curve Number of each land cover type. The correlation graphic shows positive relation with $R^2 0.99$. It indicates CN value will be closed to 100 when the land cover type can not absorb the water well. The application of CN and Qscs method for run off estimation using remote sensing data (TRMM and Landsat) has a good potential to be developed as an early warning system against flooding, especially in predicting when the floods that can be determined from surface run off hydrograph.

4. Conclusion
LUCC affected run off volume was illustrated by the increases of watershed Curve Number. This indicates that the ability of Cipunten Agung watershed store water was decreasing with the intensive use of agricultural land and settlement. In 1995, cultivated tree was dominated land cover, but in that time still produce higher volume of run off than any period affected by the heavy rain. If Cipunten Agung watershed have a heavy rain with the decreases of cultivated tree area, then at downstream area will have a high potential of flooding.

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