Identification of soil erosion areas and soil conservation in the Ci Lutung watershed using the RUSLE method

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Abstract. Erosion is one of the geomorphological processes that play a role in the development of landforms. Erosion events are controlled by exogenous energy through geomorphological agents. The rate of soil erosion in each ecosystem differs depending on how strong the erosion factor affects the soil conditions. Erosion rates will be very dangerous if erosion occurs in large erosion and in large areas. This will result in disruption of human activities and harm to society. Therefore, the importance of knowing the rate of eroded land and its variables so that this can be used in developing development and so as not to cause harm to the community. The purpose of this study was to map the area of soil erosion that occurred in Ci Lutung watershed and how big the erosion was and to find out how effective soil conservation was carried out on erosion occurring. In this study using the RUSLE (Revised Universal Soil Loss Equation) method as an equation to determine the amount of erosion and the incidence of erosion at Ci Lutung watershed. The results showed that Ci Lutung watershed's erosion incidence was dominated by mild but extensive erosion events and the impact of severe erosion events could affect human activities.

1. Introduction
Erosion is one of the geomorphological processes that are collected in the development of landforms. Erosion events are transferred by exogenous energy through geomorphological agents. In Indonesia, wet tropical erosion is mainly caused by air power. Although it is done by exogenous energy, however, erosion cannot be separated from other factors, one of which is the erodibility and erosivity of the soil. [1]. The rate of eroded soils in each ecosystem varies depending on the strength of the erosion factor depending on the condition of the soil. Some parts of Indonesia are included in the wet tropical ecosystem in the western part of Indonesia which is classified as highly vulnerable to soil degradation. Wet tropical ecosystems alone, covering an area of about 1.5 billion ha in the world. Furthermore, 25% of the area is in Asia [2].

As one of the processes in geomorphology, producing erosion on a land is actually normal. However, the rate of erosion that is too large raises the problem of land damage, as well as involving siltation of rivers / canals that cause river water / irrigation to overflow the houses and rice fields owned by residents. Besides this river erosion can also cause soil movement that can harm humans.

Therefore, soil conservation needs to be done in order to avoid the occurrence of disasters, change of property, and soil damage due to soil erosion can be minimized and even can occur. In order to be accessed properly, it is necessary to evaluate erosion on the land and understand the distribution patterns in the Ci Lutung watershed, so that it can be used as a direction managed with appropriate soil conservation so that
the land can be sustainable. Therefore, this research was conducted by trying to study and analyze the spatial distribution patterns of soil erosion in the Ci Lutung River Basin and to analyze the conservation of land carried out by the people in the Ci Lutung River Basin.

2. Method

2.1. Study Area
This research area is the Ci Lutung watershed which is included in the Ci Manuk watershed (figure 1). Astronomically Ci Lutung watershed is located at 10°8'7" - 10°8'24" East Longitude and 6°47' - 7°0' South Latitude. The area of Ci Lutung watershed is 61,999.78 hectares (Ha). There are 2 districts in the Ci Lutung watershed area, namely Majalengka Regency and Sumedang Regency. In the Ci Lutung watershed, there are 11 sub-districts where 2 sub-districts are in Sumedang Regency, Tomo Sub-district and Wado Sub-district and 9 sub-districts are in Majalengka District, Kadipten Sub-District, Majalengka Sub-District, Maja Sub-District, Argapura Sub-District, Cikijing Sub-District, Jatigede Sub-District, Talaga Sub-District, Bantarujeg District, and Lemahsugih District.

![Figure 1. Map of the study areas (Ci Lutung Watershed).](image)

2.2. Data
The data needed in this study is divided into two, that is primary data and secondary data. Secondary data needed is soil type data, monthly rainfall data for 2008 - 2018, SRTM data, and land use data. Primary data needed in this study are the results of soil samples to determine soil erodibility factors and soil conservation data obtained from the Department of Agriculture and Forestry in Majalengka Regency. The types and sources of data needed in this study are shown in Table 1.
Table 1. Primary and Secondary Research Data.

| Data          | Type of Data          | Source Data                                      |
|---------------|-----------------------|-------------------------------------------------|
| Administration| Shapefile             | RBI scale 1:25,000 Majalengka – Geospatial Information Agency (BIG) |
| Rainfall      | Monthly rainfall data for 2008-2018 in tabular form | BBWS Cimanuk - Cisanggarung Earth Explorer States Geological (USGS) |
| Slope         | SRTM Data             | Geospatial Information Agency 2018 scale 1:25000 |
| Land use      | Shapefile             | Geospatial Information Agency 2018 scale 1:25000 |
| Type of Soil  | Shapefile             | Bappelitbangda Majalengka scale 1:250000        |
| Soil sample   | Tabular               | Field Survey                                    |

2.3. Data Processing and Analysis

Erosion that occurs is influenced by several kinds of factors such as rainfall, soil physical characteristics, slopes, land use, and soil conservation measures or management and management of the soil. These factors determine the amount of erosion. The distribution of erosion areas can be seen from the characteristic pattern of erosion distribution in Ci Lutung watershed. To calculate the total amount of soil erosion with conservation measures requires almost the same variable when calculating total erosion without conservation, which requires the variable erosivity of rainfall (R), erodibility (K), slope (LS) and land use (C), and conservation variables land is always worth 1 which means there is no conservation of land. In calculating the total amount of soil erosion with soil conservation measures, the value of soil management and management (P) obtained from the weighting of 3 soil conservation parameters in Ci Lutung watershed, namely planting plants according to contour, bench terrace and no tillage system (TOT). The data processing and analysis process is shown in Figure 2.

So that the large results of total erosion on the calculation without conservation and with conservation per land use have been obtained. The result of the difference in the total amount of erosion of the two calculations will produce a total amount of erosion that can be reduced per land use due to soil conservation. The amount of total erosion that can be reduced due to soil conservation is used to see the level of effectiveness of soil conservation per land use in Ci Lutung watershed (how much total erosion can be reduced and the percentage of total erosion that can be reduced due to soil conservation).

3. Result and Discussion

3.1. Soil Conservation (P)

The index value of soil conservation in the Ci Lutung watershed is dominated by an index value of 0.001 which is spread in the northwest, southwest and east (figure 3 and table 2). The least value of the soil conservation index in the Ci Lutung watershed is 0.1 which extends from north to south. This is because the majority of forests and plantations in Majalengka pay attention to soil conservation such as building bench terraces and planting plants following the contour and conducting a no tillage system (TOT). Many people of the Ci Lutung watershed, especially farmers, use the TOT system for planting. The implementation of TOT planting system in rainfed lowland and mixed dryland farming (PLKC), such as maize, has the function of accelerating planting time as well as low production costs and avoiding soil damage and reducing the erosion of upper nutrient layers due to the tillage process.
Figure 2. Data Processing and Analysis.

Table 2. Land Area and Percentage of Soil Conservation Index Value.

| No. | P Value | Land Areas (Ha) | Percentage (%) |
|-----|---------|-----------------|----------------|
| 1   | 0.001   | 16797.70        | 27.09          |
| 2   | 0.010   | 297.06          | 0.48           |
| 3   | 0.100   | 93.37           | 0.15           |
| 4   | 0.200   | 8700.18         | 14.03          |
| 5   | 0.400   | 14157.00        | 22.83          |
| 6   | 0.500   | 5059.55         | 8.16           |
| 7   | 0.750   | 3625.19         | 5.85           |
| 8   | 0.900   | 9462.43         | 15.26          |
| 9   | 1.000   | 3807.30         | 6.14           |
|     |         | 61999.78        | 100            |

(Source: Data Processing, 2019)
3.2. Soil Erosion Area Without Conservation

Based on Table 3 and Figure 4, the area of soil erosion without conservation in the Ci Lutung watershed is dominated by very low erosion which is 29,021.52 Ha and with a percentage of almost 46.81%. This very low erosion is almost spread throughout the Ci Lutung watershed, precisely to the north, northwest, southwest, south and east of the Ci Lutung watershed. The second largest soil erosion in the Ci Lutung watershed is moderate erosion which has an area of 14,837.92 Ha or 23.93% of the total area of the Ci Lutung watershed. This erosion is located in the northern, eastern, southeast and southwest areas of the Ci Lutung River Basin. Very heavy erosion also occurred in various places in the Ci Lutung watershed of 3,105.47 Ha or as much as 5% of the total area of the Ci Lutung watershed. Erosion which dominates the Ci Lutung watershed is very low erosion, but this erosion can disrupt economic activities and development development in the area. because if a productive land occurs very heavy erosion, the productivity in the land will decrease or even disappear and this will disrupt the development of the area. According to the Agriculture and Forestry Service, Majalengka Regency erosion that occurred in Ci Lutung watershed usually occurs in rivers which cause sedimentation in rivers so that the volume of water that should still be accommodated in the river overflows. This resulted in water overflowing into the fields and residents' settlements which resulted in crop failures and caused farmers to suffer losses.
Figure 4. Soil Erosion Area Without Conservation.

Table 3. Land Areas dan Percentage Soil Erosion Areas Without Conservation.

| No. | Soil Areas   | Erosion (Ha) | Land Areas (%) |
|-----|--------------|--------------|----------------|
| 1   | Very Low     | 29021.52     | 46.81          |
| 2   | Low          | 8204.3       | 13.23          |
| 3   | Moderate     | 14837.92     | 23.93          |
| 4   | Heavy        | 5168.49      | 8.34           |
| 5   | Very Heavy   | 4767.55      | 7.69           |
|     | **Total**    | **61999.78** | **100.00**     |

3.3. Soil Erosion Areas with Conservation

Based on Figure 5, the area of soil erosion with conservation is dominated by very low soil erosion. This is the same as the area of soil erosion without conservation which dominates soil erosion which is also very low. Even so, land area and a large percentage of moderate erosion are decreasing due to soil conservation measures in the Ci Lutung watershed (can be seen in Table 4) ie from 23.93% reduced to 13.22%. Erosion is experiencing a decrease in percentage of 9.63% due to conservation measures. This indicates that the conservation carried out by the Ci Lutung watershed community is quite effective. The effectiveness of soil conservation in reducing the amount of erosion can also be seen from the area of land and the large percentage of very low erosion is higher, that is 32,684.03 Ha and the percentage of 52.72% which initially before conservation has an area of only 29,021.52 Ha or 46.81%. There is a 2.52% large increase in erosion very low in the Ci Lutung watershed. This means that soil conservation carried out by the community in the Ci Lutung watershed bore fruit. This can also be seen from the area of land at a very heavy erosion that was reduced from 3105.47 Ha (5.01%) to 2348 Ha (3.79%). This indicates that soil conservation carried out by the community in the Ci Lutung watershed such as planting plants following contours and bench terraces has succeeded in at least reducing the occurrence of very heavy erosion.
3.4. Effectiveness of Soil Conservation

Based on Table 5, soil conservation in Ci Lutung watershed is carried out in 3 types of land use, namely plantations, mixed dryland agriculture (PLKC) and rice fields. The effectiveness of soil conservation is taken from the percentage difference between total erosion without conservation and total erosion using conservation, so that a total erosion can be obtained which can be reduced due to soil conservation in each district and in each landuse carried out by the soil conservation process. The more effective the conservation value is close to 1%, the smaller the conservation can reduce the erosion. The more effective the conservation value is close to 100%, the higher the conservation can reduce the erosion.

Based on table 8, the lowest value of conservation land use is in Cikijing District, which is 42.22%. The highest value of conservation effectiveness in the use of plantation land is located in Talaga District, which is 45.80%. In the use of mixed dryland agricultural land (PLKC) the lowest conservation value is located in Argapura District, which is 23.23%. The highest value of conservation effectiveness in the use of mixed dryland (PLKC) agricultural land is located in Maja Subdistrict, which is 58.58%. In the low land use value, the effectiveness of conservation is located in the Argapura District, which is 22.02%. The highest value of conservation effectiveness in wetland land use is located in Batarujeg District, which is 76.94%.
Table 5. Soil Conservation Effectiveness Matrix.

| No. | Land Use | District   | Erosion without Conservation (tons/year) | Land Area (Ha) | Erosion with Conservation (tons/year) | Land Area (Ha) | Total Erosion reduced | Conservation Effectiveness (%) |
|-----|----------|------------|------------------------------------------|----------------|--------------------------------------|----------------|-----------------------|-------------------------------|
| 1   | Plantation | Cikijing   | 8403.91                                  | 100.06         | 4800.49                              | 100.06         | 3603.42               | 34.97                         |
|     |          | Talaga     | 5875.43                                  | 58.22           | 3257.68                              | 58.22           | 2617.80               | 44.89                         |
|     |          | Lemahsugih | 30504.54                                 | 3298.78         | 18499.91                            | 2288.78         | 9999.53               | 49.35                         |
| 2   | PLKC      | Lemahsugih | 640343.25                                | 3007.45         | 380177.11                           | 3007.45         | 261226.14            | 53.38                         |
|     |          | Cikijing   | 192956.36                                | 3878.52         | 158988.64                           | 3878.52         | 78968.52             | 40.33                         |
|     |          | Talaga     | 402564.23                                | 3738.38         | 26875.04                            | 3738.38         | 23038.37            | 57.76                         |
|     |          | Argapura   | 57783.93                                 | 1447.85         | 44856.24                            | 1447.85         | 12926.69            | 22.60                         |
|     |          | Bantarujeg | 1687540.14                               | 3345.74         | 511767.22                           | 3345.74         | 356693.42            | 44.08                         |
|     |          | Argapura   | 98418.98                                 | 1104.63         | 80681.24                            | 1104.63         | 17826.79            | 47.42                         |
|     |          | Cikijing   | 16389.17                                 | 387.85          | 12409.40                            | 387.85          | 3980.75             | 27.75                         |
|     |          | Talaga     | 532448.52                                | 2755.89         | 50615.95                            | 2755.89         | 25503.84            | 59.60                         |
|     |          | Lemahsugih | 59764.05                                 | 902.17          | 52789.09                            | 902.17          | 6985.83             | 13.46                         |
|     |          | Argapura   | 49261.20                                 | 826.41          | 31832.08                            | 826.41          | 17429.17            | 35.33                         |
|     |          | Argapura   | 5887.49                                  | 391.50          | 5193.89                            | 391.50          | 693.52              | 14.07                         |
| 3   | Rice Fields | Lemahsugih | 39004.54                                 | 2288.78         | 18499.91                            | 2288.78         | 12094.63            | 33.75                         |
|     |          | Cikijing   | 27994.42                                 | 1616.23         | 17281.44                            | 1616.23         | 11013.07            | 40.37                         |
|     |          | Talaga     | 3465.30                                  | 204.96          | 227.53                              | 204.96          | 76.49               | 32.93                         |
|     |          | Bantarujeg | 59861.42                                 | 3898.55         | 35431.04                            | 3898.55         | 25930.43            | 52.51                         |
|     |          | Argapura   | 92.90                                    | 76.99           | 63.75                               | 76.99           | 30.17               | 36.65                         |
|     |          | Kadipaten  | 4905.82                                  | 962.92          | 5145.77                            | 962.92          | 1301.85             | 33.20                         |
|     |          | Majalengka | 5413.77                                  | 1234.62         | 2881.08                            | 1234.62         | 2592.75             | 56.98                         |
|     |          | Majalengka | 12198.47                                 | 1289.76         | 5017.94                            | 1289.76         | 4029.60             | 57.57                         |
|     |          | Wado       | 3839.78                                  | 908.08          | 2931.70                            | 908.08          | 900.63              | 22.87                         |
|     |          | Tomo       | 12893.60                                 | 1447.85         | 12409.40                            | 1447.85         | 494.25              | 37.22                         |

4. Conclusions
The erosion area that occurred in DA Ci Lutung without conservation was dominated by large erosion events which were very mild and the erosion parameter index also tended to be low so that the total amount of erosion in DA Ci Lutung was very mild. Areas of moderate, severe and very heavy soil erosion have decreased their land area due to conservation measures. This indicates that the soil conservation action undertaken by the DA Ci Lutung community is quite effective by using plant planting following the contour, bench terrace, and no tillage system (TOT).

In the use of plantation land the lowest value of conservation effectiveness is located in Cikijing District. The highest value of conservation effectiveness in plantation land use is located in Talaga District. In the use of mixed dry land farming (PLKC) the lowest conservation value is located in Argapura District. The highest value of conservation effectiveness in mixed dryland agricultural land use (PLKC) is located in Maja District. In the low land use value, the effectiveness of conservation is located in the Argapura District. The highest value of conservation effectiveness in wetland land use is located in the District of Batarujeg.

5. References
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