**PLANNING MALAYSIA:**
*Journal of the Malaysian Institute of Planners*
**VOLUME 23 ISSUE 1** (2025), Page 187 – 201

# THE IMPACT OF THE SURFACE RUNOFF COEFFICIENT (C) ON LAND UTILIZATION

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## Abstract

Transformations in land use from undeveloped to built-up land can increase large surface runoff. This research aims to assess runoff coefficient (C) on changes in land utilization over various periods and times. The method used in this research involves analyzing changes in land use to determine the area of each type of land use over a specific period and then analyze the C value due to land changes. The results reveal that land use in the Way Pubian sub-watershed consists of pond, forest, open land, settlements, plantations, and rice fields area. In certain periods, land use changes, so that different C total value results are obtained in 2012, 2017 and 2022 periods. The C value is significantly affected by the type of land use, because the type of particular land use has different surface runoff coefficient values. The C value obtained from the 2012, 2017 and 2022 periods are close to 0, indicating that all rainwater that falls in the sub-watershed area are infiltrating the soil properly and therefore, land use is classified as good. It can be concluded that the value of the surface runoff coefficient (C) affects the magnitude of changes in land use within a certain period of time.

***Keywords***: Land usage, Runoff coefficient (C), Way Pubian watershed, Central Lampung, GIS

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## INTRODUCTION

Land usage is a quite complex study of the appearance (surface) of the earth influenced by numerous determining or changing factors (Ilmi, 2019). Land use is all types of land use by humans, including use for agriculture, sports fields, residential areas, restaurants, hospitals, and cemeteries (Rianasari et al., 2013; Lindgren, 1985; Purwadhi, 2008). Basically, land is a finite natural resource that forms naturally and can be damaged due to human activities (Romdania and Herison, 2023). Therefore, it can be interpreted that the type of land use in an area is seen based on the results of community activities. Transformations in land use will directly and indirectly affect the condition of areas where land changes occur, such as hydrological conditions which include changes in runoff, decreased water quality, changes in river hydrological characteristics, and decreased rainwater infiltration capacity compared to before the changes (Tanuma et al., 2015; Mariati et al., 2022). Transformations in land use from undeveloped to built-up land can increase large surface runoff, where if surface runoff increases it will affect the peak discharge at the watershed outlet (Irmayanti, 2018). This can be interpreted that changes in land use have an impact on the hydrological conditions of a watershed (DAS) and influence the water infiltration capacity. As the infiltration rate decreases, the amount of surface runoff increases, this results in less infiltration into groundwater, and has an impact on decreasing groundwater and surface water supplies (Purwantara, 2013).

The rate at which surface water infiltrates affect land use, namely the surface flow runoff coefficient (C), a number that indicates the comparison between the load of surface flow and the load of rainfall. The C coefficient value ranges from 0–1, with a close to zero (0) C value indicates as good, while a watershed is said to be increasingly damaged if the C value is closer to one (Irmayanti, 2018; Abinowo, 2018; Verrina et al., 2013). The key factors that influence the C coefficient value include soil infiltration rate, land steepness, ground cover plants, and rain intensity. The C value varies over time according to surface flow in the river, especially soil moisture. The runoff coefficient (C) value can be estimated by reviewing land use (Setiawan, 2020). So, a land use map is needed in an area to obtain the coefficient C value. Searching for land use information can also be done directly in the field. However, this activity requires a lot of time, energy, and costs, making periodic monitoring difficult (Sari, 2011; Razak et al., 2015). Thus, remote sensing technology is essential to be able to describe earth objects and monitor changes in land use in an area periodically (Niagara et al, 2020). For this reason, remote sensing research is necessary to obtain information about the shape of the earth's surface and support the search for information on land use in a region.

The use of land use maps of an area provides insights into the conditions of land use. An area that experiences changes affects the infiltration power conditions of a watershed. The problem is that land use mapping for sub-watershed areas in Lampung Province has not been carried out thoroughly, so research was carried out regarding the C value to see how much land use change has occurred. Although research on the influence of the C value on land use have been carried out in various regions, they were never carried out in the Way Pubian Sub-watershed on a regular basis. Therefore, it is necessary to conduct a land use review to determine the C value on the extent of land use.

This research aims to assess runoff coefficient (C) on changes in land utilization over various periods and times. Through this analysis, we can obtain the surface runoff coefficient (C) value and its effect caused by the size of land use changes.

# METHODOLOGY

## The Location of the Research

The location of the research is in Way Pubian Sub-watershed, Central Lampung Regency. Geographically it is located at 5°04'24" South Latitude - 104°54'22" East Longitude. Administratively, it covers several sub-districts, including Pubian, Selagai Lingga, Sendang Agung and Padang Ratu sub-districts. See Figure 1.

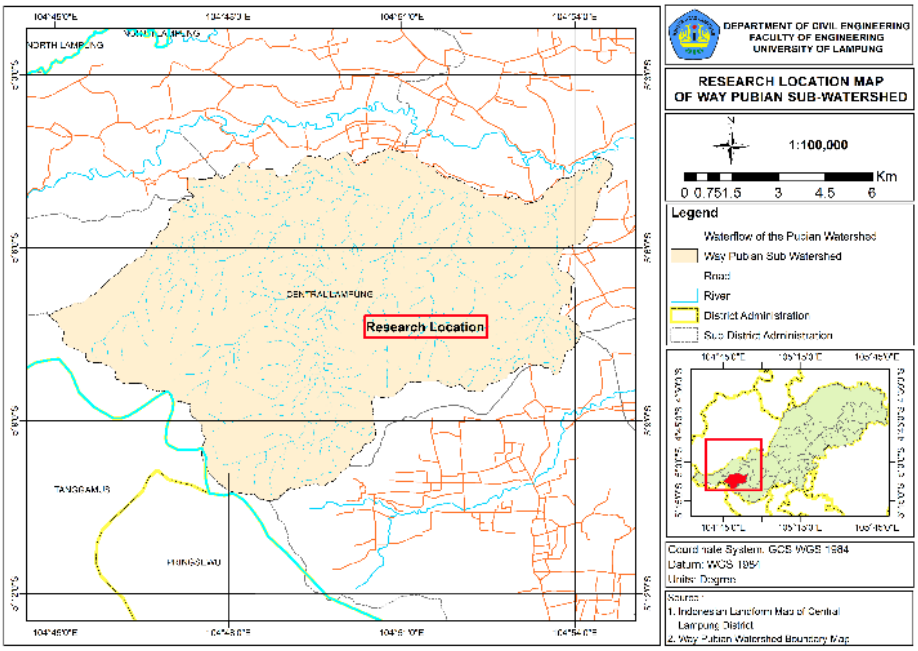


**Figure 1:** Location Map

 

**Tools and Materials**

In this research, the tools used are as follows:

a. Computer
b. ArcGIS 10.2 Software with Concurrent Use License code EFL123456789.
c. Camera

Materials used in this research:

a. Image map on 2012, 2017 dan 2022 period from Google Earth
b. Indonesian Earth Map of Central Lampung regency, scaled on 1: 50.000
c. Border map of Way Pubian sub-watershed, Central Lampung regency
d. Documentation of field observer

**Data Collection Method**

In this research, the types of data used are as follows:

1. Primary Data

A collection of data directly from the research location and obtained through documentation. Primary data can be obtained from either direct observation or interview. See table 1.

**Table 1:** Primary Data

| No | Data | Source |
|---|---|---|
| 1 | Documentation | Collection by visiting the research location and document the condition of the research location |

2. Secondary data

Secondary data is a data regarding the research location that can be obtained indirectly. See table 2.

**Data Processing Method**

The geographic information system method is employed in spatial data processing. Geographic Information Systems (GIS) is utilizedd in various studies and applications, including transportation network analysis (Ya'acob, 2016). The steps of processing are as follows (Kholisa, 2022):

a. Data Input
   Identification process and data collection necessary for the research.
b. Analysis
   Analysis using guided classification method.
c. Visualisation

**Table 2:** Secondary Data

| No | Data | Source |
|---|---|---|
| 1 | Literature Study | Data can be obtained from sources such as previous research and articles regarding land use |
| 2 | Sub Watershed Border | Secondary data collection by proposing data request to Protected Forest Watershed Management Agency (Badan Pengelola Daerah Aliran Sungai Hutan Lindung (BPDASHL)) Way Seputih Way Sekampung |
| 3 | Indonesian Earth Map | Data collection by downloading Indonesian Earth Map of Central Lampung regency from Geospatial Information Agency (Badan Informasi Geospasial (BIG)) on Ina-Geoportal website |
| 4 | Satelite Image Map | Image data collection from Google Earth by downloading high resolution map on website https://earth.google.com on recorded year 2012, 2017, and 2022 |

Results presentasion in map form, showing regions that has land use.
There are two methods of processing data, they are:

1. Image Interpretation
   ArcGIS software is used to carry out the interpretation method. The 2012, 2017 and 2022 high quality satellite image data used in this method is digitally processed.

   The steps to interpret image digitally are (Lestari et al., 2021):
   a. Import image data
   b. Correct the geometrics
   c. Image cutting
   d. Image classification

2. Guided Classification
   The supervised analysis is used for guided classification, where the classification criteria are established based on the class signature that is produced by creating a training sample area (Riswanto, 2009; Khairussidqih et al., 2021).

   The process for classification is as follows (Riswanto, 20099):
   1) Training sample stage: construct an "interpretation key" and numerically develop the spectra for each feature.
   2) Classification stage: determine the value of unknown and most similar pixels of the same category

3) Output stage: the areas of various forms of land use in the image are then produced as a matrix table, giving a summary of the matrix in the form of a land use map.
4) Overlay: To view the differences between two maps of the location, the overlapping method was described as one of the features of the ArcGIS software. The land use maps from 2012, 2017 and 2022 were used for the overlay.

**Data Analysis**

***Land Use Change Analysis***

Analyzing changes in land use using high-resolution data Google Earth satellite image are as follows (Kelly-Fair et al., 2022):

a. Classification and Post Processing
b. Identify drivers of change based on descriptive methods of process results.

The analysis was performed by comparing land use maps over a duration of five years for 2 periods in 2012, 2017 and 2022. A reasonably lengthy time period was taken in order that significant comparisons can be visible.

***Surface Runoff Voefficient Value (C) Analysis***

From the analysis results of changes in land use, the effect on runoff coefficient value (C) was analyzed. To calculate the surface runoff coefficient (C) value from the land use map, the C total equation was used, as follow (Kironoto et al., 2000; Herison & Romdania, 2023):

$$C\ total = \sum_{i=1}^{n} \frac{Ci\ x\ Ai}{A}$$

Where:
Ai= Area of land cover with land cover type i
A= Area of the whole land coverage
Ci= Coefficient of the surface runoff land cover type
N= Land cover types amount

## RESULTS AND DISCUSSION

**Land Use Map Processing Result**

The results of the processed land use maps for 2012, 2017 and 2022 are obtained based on the results of data processing using image interpretation and guided classification methods. Figure 2, 3 and 4 shows these results.

 

From the map of land use above, it can be implied that the Way Pubian sub-watershed features 6 types of land use, specifically ponds, forests, open land, settlements, plantations and rice fields. In Figure 2 which depicts the year 2012, it can be seen that the land use area was dominated by forest land with minimum of open land. Meanwhile, for the 2017 map period, there was an increase in land use such as open land and residential areas. The land use map for 2022 reveals a decline in forest land compared to the previous 2 years.

Using ArcGIS program to process land use maps, the area for every type of land use can be calculated with the assist of calculate geometry system. Changes in land use over the three years can be seen in table 3.

Table 3 indicates that there has been changes in land use for the last three years. Notable reduction can be seen in the utilization of forest land. The percentage of land use changes is more detailed in results of the analysis of differences in the region of land use types from the three years, see table 4.

**Table 3:** Land Use Change

| No | Land Use | Land Area Each Year (Ha) | | |
|---|---|---|---|---|
| | | 2012 | 2017 | 2022 |
| 1 | Pond | 3.45 | 2.66 | 1.57 |
| 2 | Forest | 8091.36 | 7342.89 | 6719.14 |
| 3 | Open Land | 14.41 | 62.13 | 122.58 |
| 4 | Residential Area | 681.18 | 763.92 | 823.2 |
| 5 | Plantation | 2026.2 | 2414.05 | 2783.11 |
| 6 | Rice Field | 802.34 | 1033.29 | 1169.34 |
| | Total | 11618.94 | 11618.9 | 11618.94 |

From table 4, it is revealed that in 2012 and 2017, several changes that occurred included ponds decreasing by 0.01% from an area of 3.45 to 2.46, forests decreasing by 6.44% from an area of 8091.36 Ha to 7342.89 Ha, open land increased 0.41% from an area of 14.41 Ha to 62.13 Ha, residential areas increased 0.71% from an area of 681.18 to 763.92 Ha, plantations increased 3.34% from an area of 681.18 to 763.92 Ha and rice fields also increased by 1.99% from 802.34 to 1033.29 Ha. From 2017 to 2022, there are changes in land use, including ponds decreasing by 0.01% from an area of 2.66 to 1.57 Ha, forests decreasing by 5.37% from an area of 7342.89 to 6719.14 Ha, open land increasing by 0, 52% from an area of 62.13 to 122.58, residential areas increased by 0.51% from an area of 763.92 to 823.2 Ha, plantations increased by 3.18% from 2414.05 to 2783.11 Ha.

 

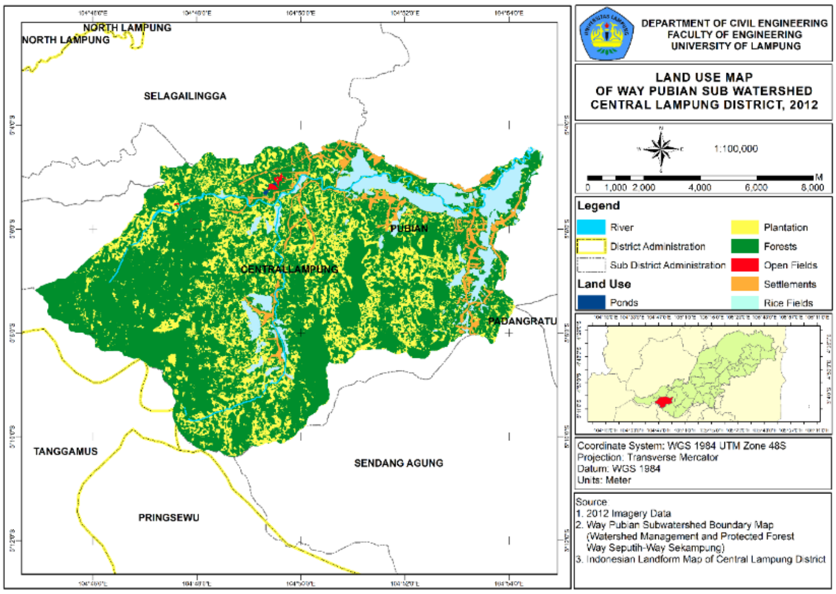


**Figure 2:** Map of Land Use Year 2012

Changes in land use in this sub-watershed are influenced by several factors, which can be seen in table 5. Changes in land use can be seen from the overlay results of land use maps for 2012, 2017 and 2022, see figure 5.

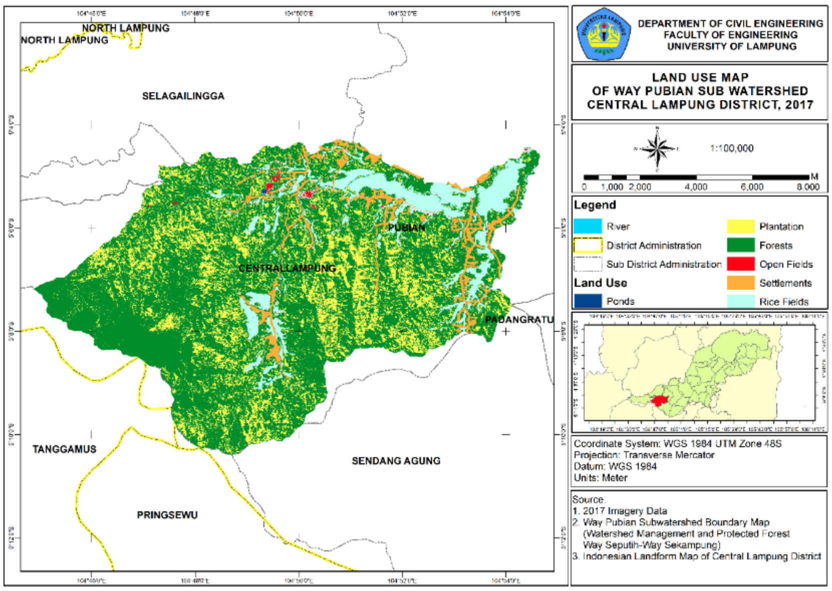


**Figure 3:** Map of Land Use Year 2017

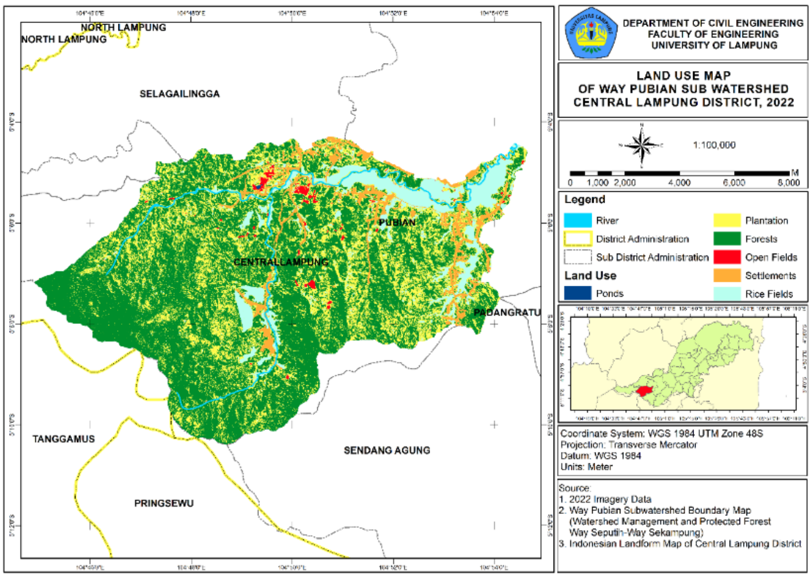


**Figure 4:** Map of Land Use Year 2022

**Table 4:** The percentage of land use change in year 2012, 2017, and 2022

| No | Land Use | 2012 Area (Ha) | 2012 Percentage (%) | 2017 Area (Ha) | 2017 Percentage (%) | Land Use Change | 2017 Area (Ha) | 2017 Percentage (%) | 2022 Area (Ha) | 2022 Percentage (%) | Land Use Change |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pond | 3.45 | 0.03% | 2.66 | 0.02% | -0.01% | 2.66 | 0.02% | 1.57 | 0.01% | -0.01% |
| 2 | Forest | 8091.36 | 69.64% | 7342.89 | 63.20% | -6.44% | 7342.89 | 63.20% | 6719.14 | 57.83% | -5.37% |
| 3 | Open Land | 14.41 | 0.12% | 62.13 | 0.53% | +0.41% | 62.13 | 0.53% | 122.58 | 1.06% | +0.52% |
| 4 | Residential Area | 681.18 | 5.86% | 763.92 | 6.57% | +0.71% | 763.92 | 6.57% | 823.2 | 7.08% | +0.51% |
| 5 | Plantation | 2026.2 | 17.44% | 2414.05 | 20.78% | +3.34% | 2414.05 | 20.78% | 2783.11 | 23.95% | +3.18% |
| 6 | Rice Field | 802.34 | 6.91% | 1033.29 | 8.89% | +1.99% | 1033.29 | 8.89% | 1169.34 | 10.06% | +1.17% |
| | Total | 11618.94 | 100.00% | 11618.94 | 100.00% | | 11618.94 | 100.00% | 11618.94 | 100.00% | |

**Table 5:** Land Use Change Factor

| No | Land Use | Changes | Reason |
|---|---|---|---|
| 1 | Pond | Declining | The degree of absorption of water assets is very high due to the expansion in vegetation from the expansion in plantation so the plant's requirement for water increases. Therefore, the land that function as pond turned dry. |
| 2 | Forest | Declining | The cooperation between the government and the community in utilizing protected forest land turned them into plantation lands. |
| 3 | Open Land | Increasing | There were lands that was not maintained and cared to by the owner, so that the land is neglected and broken. The planted land became dry and no plantation was placed and therefore it becomes open land. |
| 4 | Residential Area | Increasing | Population continues to rise, so that residential land increases due to the increase in housing and other buildings to satisfy community desires. |
| 5 | Plantation | Increasing | The cooperation between the government and the community in utilizing protected forest land turned them into plantation lands. |
| 6 | Ricefield | Increasing | The government regulation supports in utilizing rice field expansion so that rice fields increase as the means to fullfill the needs of the community. |

Figure 5 presents the result of spatial land use analysis adjusted to the results of area observations and interviews with the community within the Pubian District region. Judging from the results, the greatest change is in the decline of land use of forest which were caused by an increase in population.

Population growth is summarized in statistical data on population growth projections in Central Lampung Regency, accessible through the Central Lampung Regency Central Statistics Agency (BPS) website. Statistical data regarding population growth in Pubian District, Central Lampung Regency, one of the sub-districts within Way Pubian Sub-Watershed, shows that in 2012 there were 21,059 people. By 2017, there was an increase in population growth of 21,580 people. Finally, a drastic surge was recorded in 2021 of 54,494 people (Central Lampung Regency Central Statistics Agency, 2023a; 2023b). This data is in accordance with information from local officials about the number of new arrivals moving to the area around the Way Pubian Sub-watershed.

As the population rises, so do their basic needs. With the basic need for rice consumption and their selling price soared, people are prompted to plant and use rice fields as a supply of livelihood. This is reflected with the outcomes of land use analysis, where the area of rice fields has multiplied within the last 10 years. However, land that lacks water tends to be used for palm oil plantations. Unlike rice fields which yield harvests annually, palm oil requires longer timeframe from the start of planting.

The changes in land use that occur can be considered normal. This is due to the fact that some of the forest land is included in protected forest areas.

To support this, refer to the map of the central Lampung Regency Forest area from the Bappeda of Lampung Province (Lampung Province Regional Development Planning Agency, 2021).

This aligns with the use of forest land in the Way Pubian Sub-watershed, which has been excessive due to continuous protection and designation as a conservation area for the government. However, it remains imperative to cautiously pay attention so that changes in land use does not increase, as this could pose unfavourable risks and has the potential to harm the condition of a watershed.

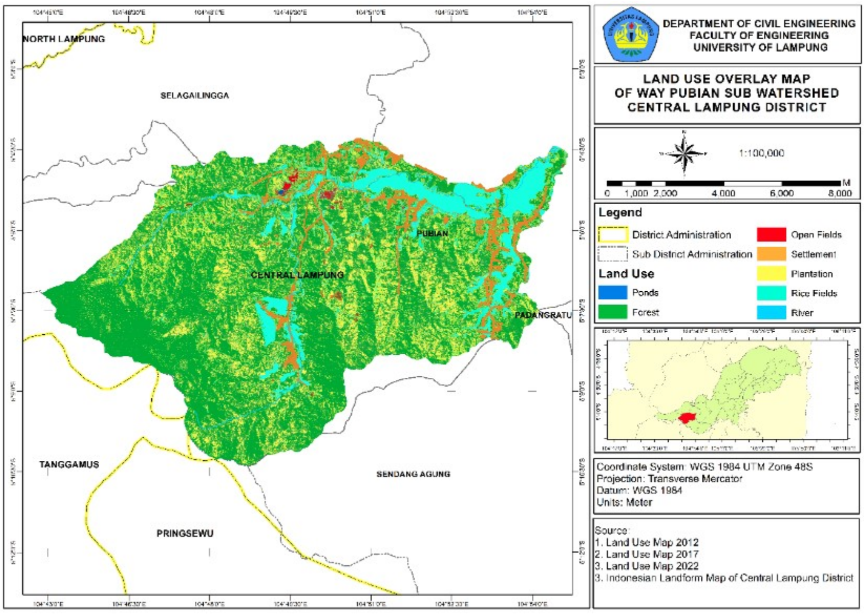


**Figure 5:** Land Use Overlay Map

**Surface Runoff Coefficient Value (C) Analysis**

Accoding to Kironoto (2003), the C coefficient value for land use types in the Way Pubian sub-watershed were 0.7 with the type of use obtained were ponds, forest with a C value of 0.001, open land with a C value of 1, residential area with a C value of 0.3, plantations with a C value of 0.1 and rice fields with a C value of 0.01 (Kironoto et al., 2000). Then, the C value is multiplied by the area of land use in the Way Pubian Sub-watershed. The calculation results obtained by the total C value in 2012, 2017 and 2022 are presented in Table 6.

**Table 6:** Total C Value Year 2012, 2017, and 2022

| No | Calculation Year | C total |
|---|---|---|
| 1 | Year 2012 | 0.0379 |
| 2 | Year 2017 | 0.0475 |
| 3 | Year 2022 | 0.0574 |

Calculation of the largest area value with a surface runoff coefficient value of 0.001 significantly impacts the results of the total surface runoff coefficient value, specifically on forest land use. The total C value suggests that changes in land use that took place in 2012, 2017 and 2022 influenced the results of the coefficient value (C) in that area. This is because when the land area was utilized in calculating the C value, the C value results from year to year also change.

The change in the C value from 2012 to 2017 obtained a difference of 0.0096 (11.24%), while from 2017 to 2022 the difference in the C value became 0.0099 (9.44%). If we examine the distinction in changes in the C value, bigger changes occurred from 2017 to 2022. These changes were affected by the magnitude of changes in land use. Based on the calculation results, the value of the runoff coefficient (C) that is closest to 0 is in 2012, while the value of C that is near 1 is the value of C in 2022. All the results in 2012, 2017 and 2022 if seen comprehensively were nonetheless near number 0. This result suggests that all rainwater that falls is properly infiltrating the soil and therefore, land use is classified as good. This result is in line with the percentage level of forest and plantation land use which continues to be excessive.

Similar study was carried out in other areas in Lampung Province. The study is an analysis of land use in the Khilau sub-watershed area, Way Khilau District, Pesawaran Regency in 2022 (Herison & Romdania, 2023). Land use in the Khilau Sub-Watershed is highly occupied by plantation land due to land use changes from forest into plantation. Changes in land function occur due to government cooperation with the community as a form of land use Therefore, these changes affect the value of (C) in the Khilau Sub-Watershed. In the Khilau Sub-Watershed, a total C value of 0.1412 was obtained. In this calculation, the largest area value is 447.4284 ha with a surface runoff coefficient value of 0.1, which greatly impacts the results of the total surface runoff coefficient value, namely for mixed plantation land use (Kironoto et al., 2000). Meanwhile, in 2022 in the Way Pubian Sub-Watershed, the C value obtained was lower, which were 0.0574. These results affect the results of the total C value calculation for forest land use. Therefore, the size of the C value is significantly influenced by the type of land use, because the type of particular land use has different surface runoff coefficient values.

## CONCLUSION

It can be concluded that the surface runoff coefficient (C) value influences the changes value in land use within a certain time frame. In the Way Pubian Sub-Watershed in 2012, 2017, and 2022, the total C value was near zero due to all the rainwater in the watershed was properly properly infiltrating the soil and therefore, land use is classified as good.

## ACKNOWLEDGEMENT

The author would like to thank Way Seputih, Way Sekampung Watershed and Protected Forest Management Agency (Badan Pengelola Daerah Aliran Sungai dan Hutan Lindung (BPDASHL)) Lampung province that has provided the data necessary for research needs.

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Received: 8th June 2024. Accepted: 29th November 2024

 