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MAP ANALYSIS OF LAND USE IN KHILAU SUB-SUB WATERSHED, WAY BULOK SUB-WATERSHED, WAY SEKAMPUNG WATERSHED, LAMPUNG PROVINCE

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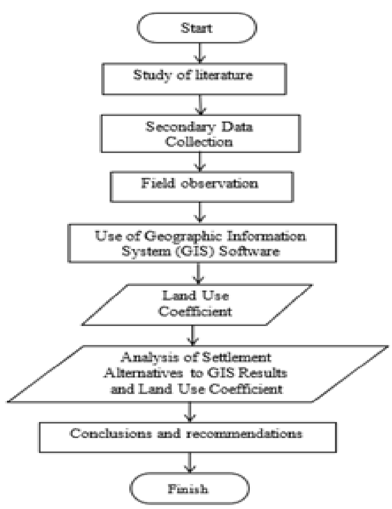
Graphical abstract



Abstract

An increase in population impacts conditions of forest, soil, and water resources in watersheds through land use change. One of the hydrological components in the watershed influenced by this change is the surface flow coefficient (C). This study aimed to analyze the land characteristics of the Khilau Sub-Sub Watershed, Bulok Sub-Watershed, Sekampung Watershed, Lampung Province. The research methods involved taking aerial photos and field observation with an application called ArcView GIS MAP as the research tool. The analysis results signify that the land use in the watershed was divided into 6 main types with a total area of 671.6776 Ha. The surface flow coefficient value (C_{total}) was 0.1412, which indicates that all rainwater falling into the watershed was well infiltrated into the soil so that the land use was categorized as good. It was found out that, with the use of the GIS application, the land use in the Khilau Sub-Sub Watershed comprises 6 main types, i.e. mixed gardens, forests, annuals, shrubs, settlements, and rice fields. The mixed garden type of land use has the highest coefficient (C) value of surface flow runoff, so it affects the C total value the most. Therefore, the rainwater in the watershed area is well infiltrated into the soil so that it is safe to categorize the land use as good.

Keywords: ArcView GIS MAP, Surface flow coefficient, Khilau Sub-Sub Watershed, Land Use, Watershed.

1.0 INTRODUCTION

Activities carried out by humans on the earth encompass agriculture, settlements, plantations, farming, and so on. In relation to use land to meet their living needs, humans mobilize from one area of land to another, like from settlements to markets or to plantations and vice versa (Damayanti et al., 2015; Wibiyanto et al., 2021). It is a fact that land use mapping is closely related to various purposes, including watershed management, forestry technicalities, soil and water conservation, residential architecture, road networking for reclamation of degraded lands, and many more activities for which information on land use is highly required.

Resident settlement patterns in an area are greatly influenced by the physical conditions of the area, in other words, the topography of the area. Residential areas are highly dependent on such environmental conditions as the lengths of river flows, roads, and railways, which is in accordance with the concept of geography, i.e. the concept of patterns closely related to the arrangement of shapes or distribution of phenomena in earthly space, both natural and physical phenomena (Hakki et al., 2015; Roslinda, et al., 2021). These patterns encompass river flow, vegetation distribution, soil type, and rainfall patterns in certain areas or such socio-cultural phenomena as settlement, population distribution, income, livelihood, residential house type patterns and so on. So, the increase in population affects the conditions of forest, soil, and water resources in watersheds. The existence of residential land in the watershed generates multifaceted problems, from floods, reduced water availability as a result of narrower rivers, to water pollution leading to the degrading quality of river water (Donoriyanto, 2017), while most of the river water is used to support residents' lives around the watershed. As the water quality debases, the usability, usefulness, productivity, support, and capacity of the water resources fade away. In order to keep it in its natural state, it is essential to maintain a good level of sanitation and control water pollution properly so that the watershed ecosystem, especially the headwaters, remains at a good level.

Ideally, riverbanks as conservation lands aim to prevent, maintain, and protect river bodies from avalanches and erosion due to natural disasters or human behavior disruption and serve as water catchment areas when water discharge is excessive. Riverbanks naturally preserved as conservation lands provide such benefits as oxygen producers (O2), the absorbers of air pollution (CO2) and other pollutants (heavy metal, dust, and sulfur), noise suppression, wind and sun shields (Salmah, 2018). Thus, it means protected and maintained natural riverbanks benefit the life processes of both land and water biota.

A fast-growing population potentially has serious repercussions on the availability of natural resources. Consumption increases as the population swells. Every individual has their own variety of needs, ranging from basic to complementary ones, while human needs are numerous and unlimited and when it comes to the needs for essentials, they will only be met if the reserves of natural resources are still sufficient. If a population rate outgrows the natural resources for the individuals' needs, there will soon be a crisis (Ehrlich and Holdren, 1971; Hardati and Setyowati, 2019). Rapid population growth leads to a higher demand for natural resources.

Land cover changes can be studied through watershed boundaries since they have their own unique ecosystem shapes and compositions (Agung et al., 2020). Land use changes are basically inevitable in the implementation of development. Residents' land demand often produces conflicts of interest in land use and the discrepancy between land use and its allotment plan (Fahmi et al., 2016; Nurdin, 2016). Therefore, the use of land must be regulated. Massive loss of forest vegetation area can decrease evapotranspiration, soil moisture, infiltration, and magnify surface runoff. As a result, it affects hydrological conditions in a watershed, causing an influence on the characteristics of highly fluctuated river flow discharge (Juliana, 2016). So, it is of paramount importance to figure out a surface runoff flow value (C) so as to determine the state of forest vegetation land cover.

Changes in environmental functions are influenced by the complexity of problems in the watershed (Asrida, 2016). The hydrological component affected by land use change in the watershed is the surface flow coefficient (C). The rainwater surface flow heading into a river or channel, lake, or sea is in the form of an aboveground flow or a sub-surface flow entering the saturated soil and then coming out back to the surface and heading into a lake, river, or lower place (Asrida, 2016). The value of C is a number expressing the ratio between the magnitude of the surface flow and the amount of precipitation. A low value indicates that the state in the watershed is still good and vice versa. The higher the value, the more damage the watershed receives (Barus and Wiradisastra, 2020). The coefficient value of runoff water is one of the indicators for the determination of whether a watershed has been physically harmed and is also one aspect which can be involved in the study of changes of the hydrological functions of the watershed area.

This study employed a program called The ArcGIS Program. The application of this program in the Khilau Sub-SubWatershed was required to establish a database for portraying the land use in the form of a map containing the results of the assessment by looking at the potential where such factors as biophysical, economic, and social conditions were the bases for land planning to achieve environmental sustainability and productivity enhancement (Femeira, 2022).

The Khilau Sub-Watershed has an area of 671.6667 Ha or 6.7167 Km2 or about 0.5721% of Pesawaran District, which is a region of 1174 Km2. The Khilau Sub-Sub Watershed itself often floods at several locations when it rains, like in 4 hamlets in Mada Jaya Village, i.e. the hamlets of Mada Tengah, Tepok Kadu, Umbul Baru, and Mada Hilir, as well as the upstream area of the Sekampung Watershed so that it impacts the river mouth. This study was aimed at analyzing the characteristics of land use and the value of the flow surface runoff coefficient (C) in the Khilau Sub-Sub Watershed, Bulok Sub-Watershed, Sekampung Watershed, Lampung Province.

2.0 METHODOLOGY

2.1 Materials

This research was conducted in the Khilau Sub-Sub Watershed, Bulok Sub-Watershed, Sekampung Watershed, Lampung Province. This location covers 2 districts, i.e. Pesawaran and Pringsewu Districts (see Figure 1).

2.2 Data and Tools

2.2.1. Research Data

The data in this study is the secondary data obtained from related agencies. The following are the secondary data of this study:

1) The land use digital map obtained from the Digital Elevation Model (DEM) of Pesawaran and Pringsewu Districts.
2) The basic map of the earth (RBI) obtained from Ina Geoportal BIG (Geospatial Information Agency).
3) The data between the secondary data and field observation was nonetheless cross-checked.

2.2.2. Research Equipment

This research employed a program called ArcView GIS MAP License 28_17 7688. Geographic Information System (GIS) is an information system designed to work with spatially referenced or geographically coordinated data. In other words, GIS is a database system with a special ability to handle spatial data in conjunction with a set of work operations. GIS is useful for the collection, stockpiling, retrieval of desired data, and displaying of spatial data based on reality. GIS can be used for scientific investigation, resource management, cartography, and development and route planning (Astuti, 2017; Wibowo et al., 2017; Utami, 2018).

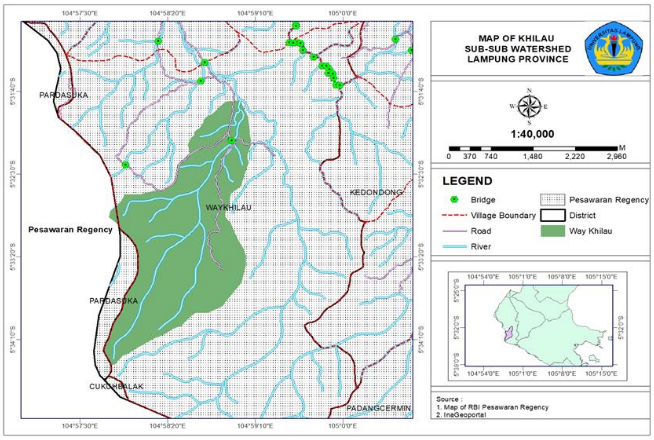


Figure 1. Research Site Map.

2.3 Research Framework

The stages of this study are shown in Figure 2. Research on the surface flow coefficient (C) of the land use changes in the Khilau Sub-Watershed was performed through data analyses, which were descriptive and quantitative analyses.

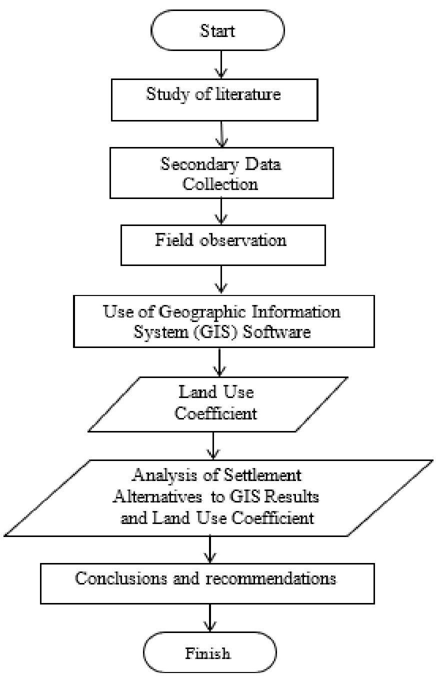


Figure 2. Research Framework.

The C value in this study was the standard runoff coefficient value (see Table 1).

Table 1. Surface Runoff Coefficient (C) Value

No	Land Use	Grade C
1	Open Ground/No Crop	1.000
2	Paddy	0.010
3	Unspecified Moor	0.700
4	Cassava	0.800
5	Corn	0.700
6	Soybeans	0.399
7	Potato	0.400
8	Peanuts	0.200
9	Rice	0.560
10	Sugar Cane	0.200
11	Bananas	0.600
12	Fragrant Roots (Citronella)	0.400
13	Bede Grass (First Year)	0.287
14	Bede Grass (Second Year)	0.002
15	Coffee with Poor Soil Cover	0.200
16	Taro	0.850
17	Mixed Gardens	
	• High Density	0.100
	• Medium Density	0.200
	• Low Density	0.500
18	Plantation	0.400
	Natural Forests:	
19	• with a lot of litter	0.001
	• with a little litter	0.005
20	Production Forests:	
	• Clearcutting	0.500
	• High Grading	0.200
21	Shrubs/Meadows	0.300
22	Cassava + Soybeans	0.181
23	Settlements	0.300
24	Cassava + Peanuts	0.195
25	Paddy – Sorghum	0.345
26	Rice – Soybeans	0.417
27	Peanuts + Pigeon Peas	0.495
28	Peanuts + Black-eyed Peas	0.571
29	Peanuts + 4 tons/ha of Straw Mulch	0.049
30	Rice + 4 tons/ha of Straw Mulch	0.096
31	Peanuts + 4 tons/ha of Corn Mulch	0.128
32	Peanuts + Crotalaria Mulch	0.136
33	Peanuts + Black-eyed Pea Mulch	0.256
34	Peanuts + 2 tons/ha of Straw Mulch	0.377
35	Rice + 3 tons/ha of Crotalaria Mulch	0.387
36	Relay Cropping Planting Pattern + Straw Mulch	0.079
37	Sequential Planting Pattern + Plant Residue Mulch	0.357
38	Fertile Pure Reed	0.001

Source: Kironoto (2003)

The calculation of the land use Ctotal value applied the following equation (1):

$$C_{total} = \sum_{i=1}^{n} \frac{Ci \ x \ Ai}{A} \quad \dots (1)$$

Where:

Ai = Land Cover Area with Type of i Land Closure
A = Entire Land Cover Area
Ci = Surface Flow Coefficient of Land Cover Types
n = Number of Land Cover Types.

The ArcView software required the following data:

1. Analysis

Analysis is one of the capabilities of GIS for obtaining new information. The first analysis is scoring. Scoring provides an assessment on each of the supporting parameters within the research sphere in the form of a number. After all the parameters are scored, an overlap analysis, which is often called an overlay, is used to produce certain results. The overlay involved in this study is called intersect. Intersection is a method of overlapping two graphic data, but if the outer boundaries of the two data are not the same, then the processing in the patched area only is carried out (Utama and Wayan, 2019). Intersect analysis was chosen as using all the intertwined information within each of the research parameters would turn into a single unit so that new information in the form of mapping units would be generated.

2. Visualization

The results in the form of a map show the areas which were part of the land cover. Table 2 contains the surface flow coefficient data of the watershed, which serves as the secondary data. . Real-world phenomena themselves, as input in GIS, can be represented in the following four kinds of models:

a) Modelling
b) Map
c) Database
d) Spatial database

3.0 RESULTS AND DISCUSSION

ArcGIS plays an important role in the process of creating land use maps. This software helped to obtain the land use values and widths of the related areas in the Khilau Sub-Watershed. The processing of the aerial photos was for the location modelling, which was reviewed through Agisoft Metashape.

The data involved in the creation of the map was obtained from Ina-Geoportal Website. Ina-Geoportal is an Indonesian geospatial website officially launched by BIG (Geospatial Information Agency) and was built with the participation of various ministries, provincial and regional institutions that are liaison partners of the National Geospatial Information Network (JIGN) node. The obtained data was then processed with Geographic Information System (GIS) to map and analyze things and events occurring on the earth. in this case, the necessary data of the land use in the Khilau Sub-Sub Watershed, which was then calculated to know the widths of the designated areas. The data was directly processed to get a complete land use map containing the bar scale, points of the compass, and other required information (see Figure 3). With the GIS software, a map planned for a variety of land activities was obtained. The land use map of the Khilau Sub-Watershed is composed of 6 main types of land use, i.e. forests, mixed gardens, settlements, rice fields, shrubs, and annuals.

Then, the coefficient values of the surface flow runoff were analyzed. The analysis of the land use map of the Khilau Sub-Sub Watershed was intended to determine the land use, the spot of each kind of land use, the coefficient values of the total runoff based on Table 1, the coefficient values of the standard runoff. The types of land use in the Khilau Sub-Watershed along with the widths of their areas are shown by Table 2.

The comparison of the areas covered by the types of land use in the Khilau Sub-Sub Watershed can be seen in the graph (see Figure 3)..

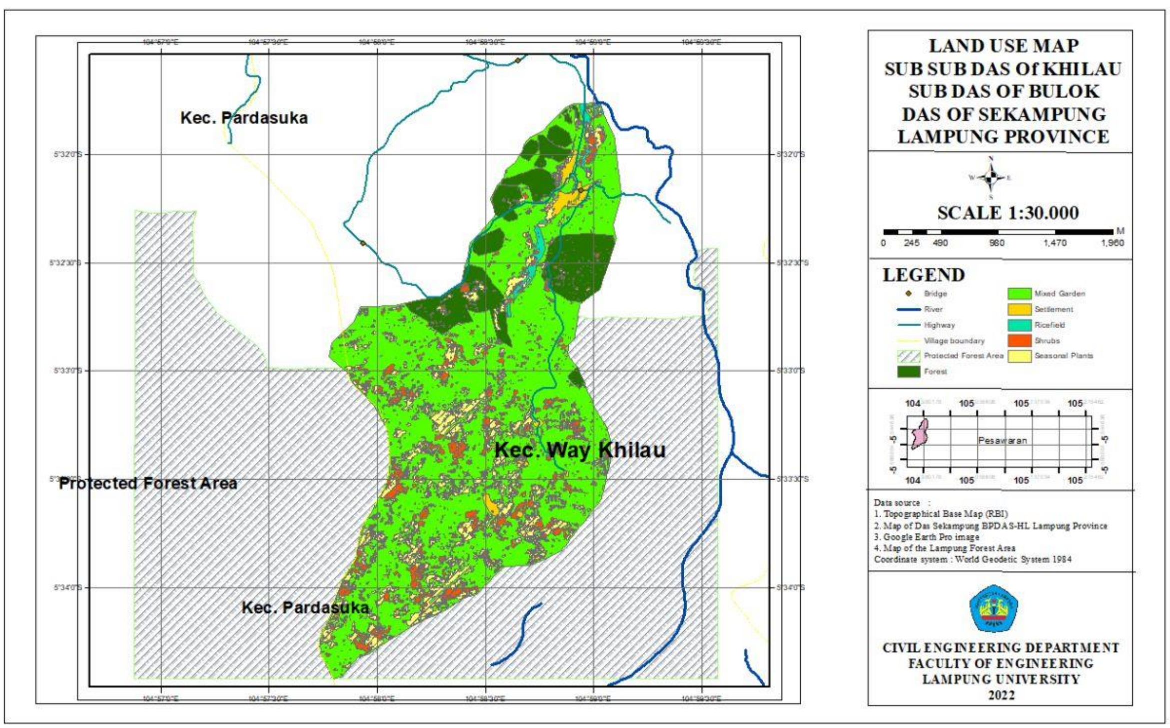


Figure 3. Khilau Sub-Sub Watershed Land Use Map.

Table 2. Coefficient Values of Surface Flow Runoff in Khilau Sub-Sub Watershed

No	Land Use	Area(Ha)	C
1	Forests	80.5327	0.1
2	Mixed Gardens	447.4284	0.001
3	Settlements	15.3667	0.4
4	Paddy	10.6307	0.3
5	Shrubs	48.4785	0.5
6	Annuals	69.2405	0.01
	Total	671.6776	0.1

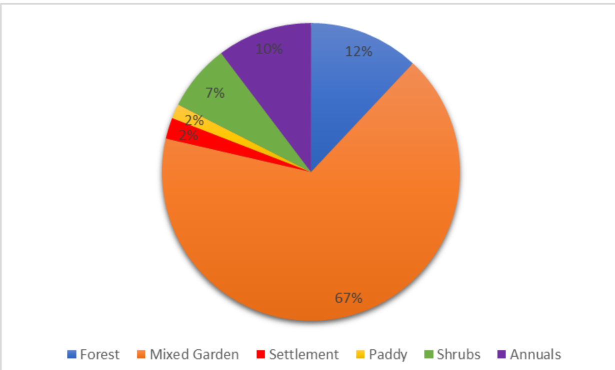


Figure 4. Comparison of Land Use Areas in Khilau Sub-Sub Watershed.

Figure 4 contains the information that the percentages of the areas of the 6 types of land use in the Khilau Sub-Sub Watershed were 12% for the forests, 67% for the mixed gardens, 2% for the settlements, 2% for the rice fields, 12% for the shrubs, and 10% for the annuals. Based on GIS analysis, the total area in Khilau Sub-watershed is 671.6667 Ha, is the same as the total area before land use analysis.

The next analysis was intended to calculate the runoff flow coefficients (C). Land use is also affected by infiltration power. For the surface flow influencing land use, a C value is a number denoting the comparison between the surface flow rate and the rainfall rate (Irmayanti, 2018). A C value ranges from 0 to 1. A value of 0 indicates that all rainwater is perfectly infiltrated into the soil, while a value of 1 indicates that all rainwater makes a surface flow. The rainwater which cannot be absorbed and, therefore, is not infiltrated into the soil forms direct runoff, while the rest becomes a basic flow (Faridah et al., 2021; Kartika et al., 2021). For a watershed, the closer a C value is to zero (0), the better, and the closer it is to 1, the worse, as it means it suffers greater damage.

For the Khilau Sub-Watershed, the C factor was analyzed based on the obtained land use map and tabled values. The data collection from the research location was performed with two methods, i.e. aerial photos and field observation.

Table 3 also presents the results of the multiplications of the flow runoff coefficient (C) values by the widths of the areas in which the kinds of land use took place.

Table 3. Results of Multiplications of Flow Runoff Coefficient Values by Widths of Areas

No	Land Use	Area (Ha)	Grade C	C x A
1	Mixed Gardens	447.4284	0.001	44.7428
2	Forests	80.5327	0.010	0.0805
3	Annuals	69.2405	0.700	27.6962
4	Shrubs	48.4785	0.800	14.5436
5	Settlements	15.3667	0.700	7.6834
6	Paddy	10.6307	0.399	0.1063
	Total	**671.667**		**94.8528**

The C_{total} value was then calculated by inserting the total of the results of the above multiplications and the total of the above area widths in equation 1. The calculation is as follows:

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

$$C_{total} = \sum_{i=1}^{n} \frac{94.8528}{671.6776}$$

$$C_{total} = 0.1412$$

The result of the calculation with equation 1 was 0.1412. This value indicates that all rainwater falling into the watershed was well infiltrated into the soil, so the land use was regarded as good.

Certain other activities also support regional growth, population growth, and economic expansion and affect land use changes, which, in turn, influence a Ctotal value. The increase of the population and economic expansion has an impact on the rise of regional function complexity. From the data of this research, it is reasonable to infer that the total population in the watershed is very small. The total space of the land use for settlements was only 15.3667 Ha out of a total area of 671.6667 Ha. The land use was dominated by agrarian activities, as seen from the data. The activities took the largest percentage through mixed gardens with an area of 447.4284 Ha, rice fields with an area of 10.6307 Ha, and annuals with an area of 69.2405 Ha. When compared to urban areas, the population is very large, so it is forced to be efficient in land use by carrying out various kinds of economic activities. In urban areas, the possibility of carrying out agrarian activities is very small as the available land for them is highly limited. The land is mostly used for industrial areas, various kinds of trade centers, schools, and offices, whose services cover several surrounding villages. So, it is plausible to say urban areas have a higher level of complexity than rural areas.

This research should be the basis for more studies shedding light on this matter periodically so that the information on the development of land use in the Khilau Sub-Watershed will always be updated and it is hoped that the findings will underlie better land use from the perspectives of certain functions, such as supporting economic development, good distribution of land, and prevention from damage to natural resources. In addition, the further research findings are also expected to create better residential land use plans for the watershed, which will also mitigate the impacts of its population density and natural disasters.

4.0 CONCLUSIONS

The conclusion is that the use of the GIS software generated a land use map of the Khilau Sub-Watershed with 6 main kinds of land use, i.e. mixed gardens, forests, annuals, shrubs, settlements, and rice fields. Mixed gardens had the highest surface flow runoff coefficient (C) value in terms of the effect on the Ctotal value, so it is inferable that the rainwater in the watershed is well infiltrated into the soil. Taking this into account, the land use is categorized as good.

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