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Surface Runoff Analysis Using SCS-CN Method in Summarecon Serpong Area

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ABSTRACT

The increasing population is definitely in line with the rising demand for housing. One area with many residents is Tangerang Regency, Banten, with a population growth rate of 5.85% per year. PT. Summarecon Agung Tbk. becomes one of the developers of an integrated area in Tangerang Regency in fulfilling housing needs. However, the wider the development of an area, it is parallel with the changes in land cover that significantly impact surface runoff. Therefore, determining surface runoff in the Summarecon Serpong area is essential to predict the inundation potential. The method used is the Secondary Data Analysis (SDA) approach which requires several data: rainfall, land cover, and soil type. These data were processed using Frequency Analysis to obtain design rainfall and continued to the SCS-CN Method to obtain surface runoff with the return period at two years, five years, ten years, 20 years, and 100 years. Most of The Summarecon Serpong area was covered by buildings with Hydrologic Soil Groups C and D. Based on the analysis result, the Composite Curve Number (CNk) for this area is 88,89. While the calculation of direct runoff using the SCS CN Method with a return period of two years, five years, ten years, 20 years, and 100 years respectively, were 77 mm, 121 mm, 154 mm, 188 mm, and 275 mm. The lowest surface runoff occurred on land cover in the form of green open land with Hydrologic Soil Group C, and the highest surface runoff occurred on land cover in the form of water bodies. This analysis indicates that focusing on the green open land in the Summarecon Serpong area can reduce surface runoff while increasing infiltration to maintain the hydrologic sustainability system.

1. Introduction

Tangerang Regency is one part of the satellite city of the Special Capital District of Jakarta, which is administratively located in Banten Province. This district is located in the west of Jakarta and has an area of ± 959.61 km^2 [1]. Based on statistical data from 2020, Tangerang Regency has a population growth rate of 5.85%; this value is classified as high because from 2010 to 2020, the average population growth rate of Indonesia was only 1.25% per year, influenced by factors of birth, death, and migration [2].

One of the reasons for the high rate of population growth in Tangerang Regency is its strategic location and as a buffer zone for DKI Jakarta. The rapid increase in population will lead to increased development activities in various sectors, accompanied by increased land demand [3]. The increasing land demand makes the Tangerang Regency Government need to develop land use planning to anticipate a significant increase in land clearing. The amount is for a specific purpose, but it can be utilized to the maximum extent possible to use the existing land in order to be able to create a safe and comfortable area for the community.

In land use planning in an area, it is necessary to use surface runoff with a return period as a consideration. Surface runoff determines the percentage of water that runs off in an area. The amount of surface runoff can be a parameter in optimizing soil absorption. Surface runoff is rainfall that is not retained on the surface or absorbed into

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the ground or can also be interpreted as rainwater that directly overflows [4].

Surface runoff is part of the rainfall that flows over the land to rivers, lakes, and oceans. In general, rainwater that falls to the ground surface can be divided into two where the first is rainwater that is directly absorbed into the soil or called infiltration, and secondly, rainwater that is not absorbed into the ground will flow over the ground to a lower elevation or trapped in the ground which is called surface runoff. [5].

Since 2004, PT. Summarecon Agung Tbk. has participated in developing an integrated area in Tangerang Regency by combining residential and business concepts in one integrated area. The concept of an integrated area is made to combine certain functions needed in one area so that it can make it easier for people living in the area to carry out activities and activities. The integrated area developed by PT. Summarecon Agung Tbk. in Tangerang Regency is called the Summarecon Serpong area, located in Kelapa Dua District. Based on the Tangerang Regency population data in 2020, 160,803 people lived in the sub-district, the highest population among the districts in Tangerang Regency.

To answer the need for housing and the times' development, Summarecon Serpong continues to develop by utilizing the available land. Until now, Summarecon Serpong is still in the development stage of the residential and industrial areas. Land use management and planning need to be considered because the Summarecon Serpong area is planned to be an independent city where there are residential and industrial areas that are combined and integrated.

Research on surface runoff with a specific return period has never been carried out in the Summarecon Serpong area. Surface runoff with a specific return period is needed in planning land use to maximize the future area's development in Summarecon Serpong.

This study aimed to determine the distribution of surface runoff that occurred in the Summarecon Serpong area. In addition, the results of this study can be used as a reference value in the design of regional expansion plans in the Summarecon Serpong area to help optimize the future development of the Summarecon Serpong area.

2. Method

The research method used to determine the value of surface runoff in the Summarecon Serpong area is the Descriptive Quantitative Method using a Secondary Data Analysis approach, which is a research method with analysis results based on processed secondary data. Primary data is not used as part of the analysis because it does not require directly experimental in the laboratory.

This study uses secondary rainfall data from Serpong Station, Summarecon Serpong Masterplan, Google Earth, and soil types data in the Summarecon Serpong area. The rainfall data used in this study is 31 years of maximum daily rainfall data at Serpong Station. Meanwhile, the Masterplan and Summarecon Serpong soil type data were obtained directly from PT. Summarecon Agung Tbk., which is located in Serpong. The master plan contains the Summarecon Serpong development area, covering several land covers, such as housing, water bodies, and others. As for the Google Earth data obtained from internet searches.

After secondary data collection, then the data is processed for further analysis. The initial analysis contained in this study is Frequency Analysis, with the main secondary data used is rain data from Serpong Station. The rainfall data is useful for knowing the design rainfall with a specific return period that can be found in the Frequency Analysis process. The direct runoff value requires the value of the periodic redesign of rainfall and the value of the Curve Number (CN). The CN value is commonly calculated using effective rainfall method. This method relies on heavy rainfall data at the closest station to the area to be studied, namely the Soil Conservation Service Curve Number (SCS-CN) Method.

The SCS-CN Method is generally used to calculate surface runoff, influenced by several variables, such as land use change, with the analysis using monthly and daily rainfall data [6]. This method calculates the surface runoff by the Curve Number map based on the secondary data that has been collected and then the determination of design rainfall with a return period of 2 years, 5 years, 10 years, 20 years, and 100 years through Frequency Analysis. The flow chart in this study can be seen in Figure 1.

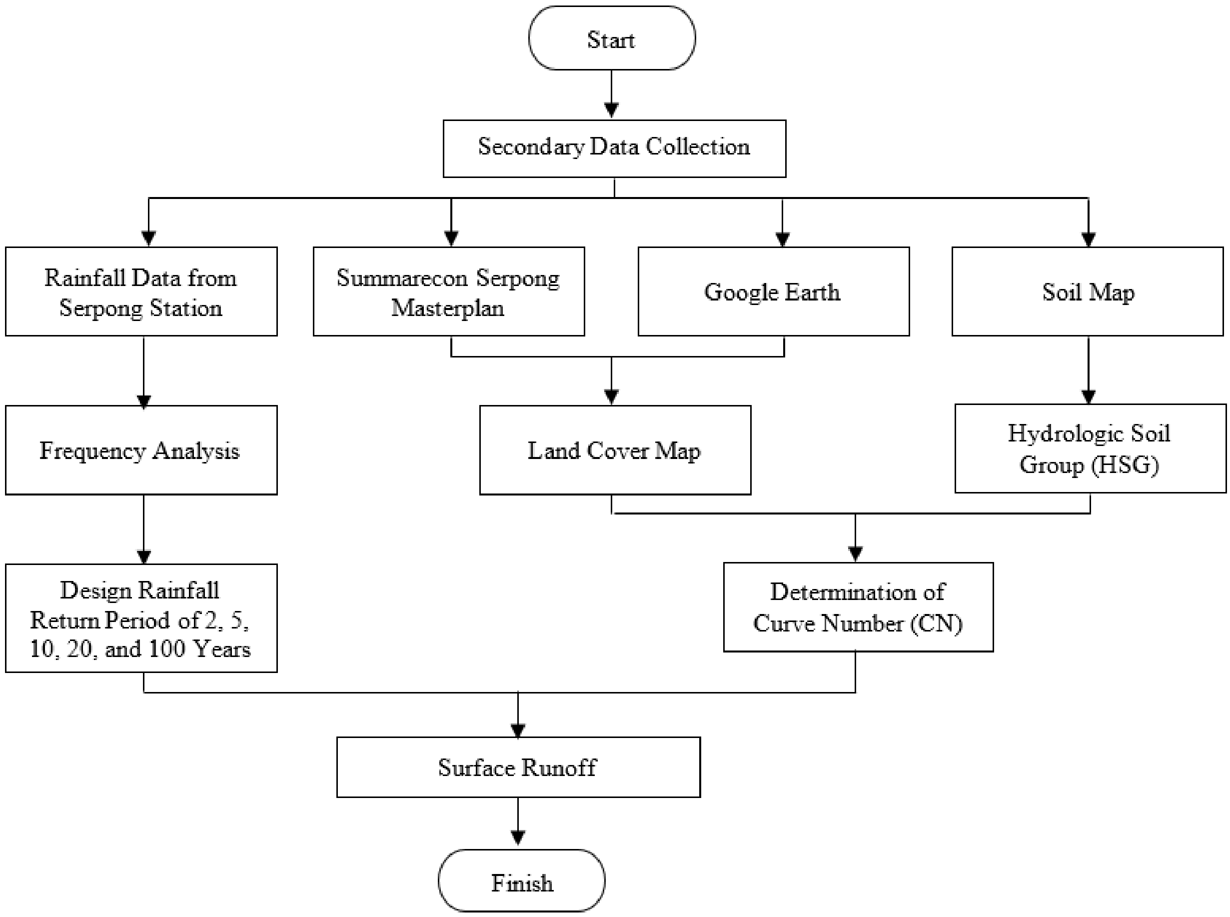

Figure 1. Research Flow Chart

2.1 Research Location

This research takes a case study in the Summarecon Serpong area, developed by PT. Summarecon Agung Tbk. This area is administratively located in Tangerang Regency, Banten Province, with UTM coordinate boundaries X: 676481-682689 m and Y: 9311341-9304525 m (Zone 48S). PT Summarecon Agung Tbk, participated in developing several integrated cities as satellite cities that will support the development of the Special Capital District of Jakarta. Located about 21 kilometers west of Jakarta, Summarecon developed an area of 750 hectares previously known as Gading Serpong.

Since 2004, Summarecon Serpong has successfully developed over 50 residential and commercial development clusters on approximately 350 hectares. Summarecon Serpong has succeeded in building more than 15,000 housing units, 1,100 apartment units, 2,000 shop houses, a shopping center covering an area of 100,000 m^2, a modern market, an open-air dining center, an automotive buying and selling center, an office tower, a golf course, recreation club, the green educational park and facilities, and hospital with the best standard and covered with technological features as well as the development of a beautiful and nature-oriented area.

The population growth in Tangerang Regency, especially in the Summarecon Serpong area, is increasing yearly. Therefore, the necessity of living and commercial areas to support living is increasing rapidly, resulting in changes in land use which can affect surface runoff. This research focuses on several development areas of Summarecon Serpong, with most land use in residential areas (clusters). The research location can be seen in Figure 2.

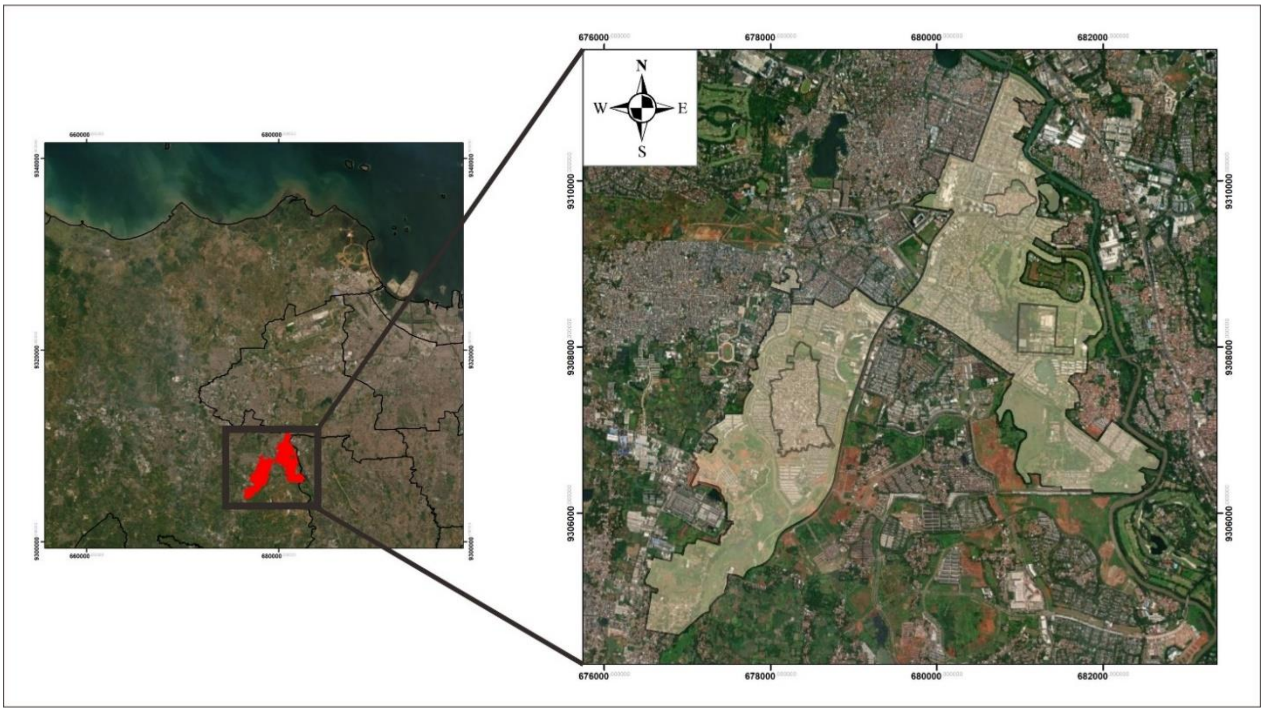

Figure 2. Research Location

2.2 Frequency Analysis

Frequency Analysis in this study is needed in the process of processing data from maximum daily rainfall to design rainfall using a probability distribution. Frequency Analysis produces design rainfall values with certain return periods ranging from 2 years to 100 years.

The return period used in the Frequency Analysis estimates the amount of discharge or design rainfall that will be equaled or exceeded once in the selected time during the return period. This return period is not related to the resulting discharge. It will be repeated in each period to show the probability of discharge or rainfall generated in the calculated return period.

The return period that has been determined in the Frequency Analysis shows the time interval between rain events based on the rain series data that has been taken. The return period is related to the probability, so the return period in relation to probability is an event or events that will occur in one year by using Equation 1 [7].

$$P(Q \geq QT) = 1/T \tag{1}$$

where P is the probability, Q is the discharge, and QT is the discharge with return period of T years.

The rainfall data is processed into a data arrangement by producing several statistical parameters, such as the mean value, standard deviation value, variance value, and coefficient of variance, which can be seen in Equation 2 to Equation 6.

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x \tag{2}$$

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(xi - x)^2} \tag{3}$$

$$Cv = \frac{s}{\overline{x}} \tag{4}$$

$$Cs = \frac{\frac{n}{(n-1)(n-2)}\sum_{i=1}^{n}(xi-\overline{x})^3}{s^3} \tag{5}$$

$$Ck = \frac{n^2}{(n-1)(n-2)(n-3)s^4}\sum_{i=1}^{n}(xi - \overline{x})^4 \tag{6}$$

where $\overline{x}$ is the mean value (mm), xi is data *i*, *S* is standard deviation, *Cv* is the coefficient of variation, *Cs* is the coefficient of skewness, *Ck* is the coefficient of kurtosis, and *n* is total data.

After all the statistical parameters have been calculated, the probability distribution can be determined. There are several distributions to choose from, but the selected distribution is a distribution with properties that match the calculated statistical parameters, namely the Normal Distribution, Log-Normal Distribution, Gumbel Distribution, and Log Pearson Type III Distribution. Each distribution has its conditions to be chosen, which can be seen in Table 1 [7].

Table 1. Probability Distribution Requirements

No	Probability Distribution	Requirements Cs	Ck
1	Normal	0	3,00
2	Log-Normal	Cs = 3 Cv Cs > 0	
3	Gumbel	Cs = 1,3966	5,4002
4	Log Pearson Type III	The Cs and Ck values do not match the three distributions above	

After the statistical parameters have been calculated, it is then adjusted to the conditions of the probability distribution. The selected probability distribution must be readjusted with the hydrological data set obtained in the secondary data. Therefore, the secondary data is described in the selected distribution probability paper. The distribution of rain data points on probability paper can be ordered from the smallest to the largest value or vice versa. After the rain point is plotted on probability paper, a theoretical line can be drawn.

The selected distribution affects the calculation process for the design rainfall with a specific return period. The distribution suitability test is also carried out using the Chi-Square and Smirnov-Kolmogorov tests. The Chi-Square test is carried out by considering several parameters, such as the frequency or number of observations of the expected rain data according to the class division and the frequency of the rain data read in the same class. While the Smirnov-Kolmogorov test pays more attention to the curve of data depiction on probability paper. Because from the distribution of points on the probability paper, the distance of the largest deviation from each rain data point to the curve [7].

2.3 SCS-CN Method

The SCS-CN Method is an empirical approach to estimating runoff in an area [8]. This method considers several parameters, including rain, land cover, and soil hydrology group [9]. In [7], the CN value ranges from 0 to 100, where the higher the CN value, the location is impermeable/saturated with water which causes the higher surface runoff that occurs.

Surface runoff can be defined as the amount of rain that becomes surface runoff into rivers, which no longer considers water losses, such as evaporation and retention in basins. The calculation formula for effective rain using the SCS-CN method can be seen in the Equation 7 and Equation 8 [7].

$$Pe = \frac{(P-0,2S)^2}{P+0,8S} \quad (7)$$

$$S = \frac{25400}{CN} - 254 \quad (8)$$

where *Pe* is the depth of effective rainfall or surface runoff (mm), *P* is the total rain depth (mm), *S* is the maximum potential retention by groundwater (mm), and CN is the Curve Number.

Several parameters that are a function of watershed characteristics in calculating the CN value are soil type, cover crops, land cover [10], humidity, and soil working methods. The resulting CN value can indicate the amount of surface runoff and maximum potential water retention by the soil in the area under consideration. If the relationship between effective rainfall or direct runoff with cumulative rainfall is at various CN values, then the graph will form Equation 6. Variations in the CN value are determined from the function parameters mentioned above [7].

In addition, the SCS-CN Method has determined the CN value based on land cover and Hydrology Soil Group. The soil groups based on hydrological aspects are divided into four groups [7]:

1. Group A, soils with grain sizes of coarse sand, gravel, and little silt/clay, have high infiltration rates and low potential for surface runoff.
2. Group B, soils with medium grain size, medium infiltration rates, and a relatively low potential for surface runoff.
3. Group C, soil with fine sand grain size, silt or clay, low infiltration rate, and a relatively high potential for surface runoff.
4. Group D, soil with grain size dominated by silt or clay, has a very low infiltration rate and a high runoff potential.

Antecedent Moisture Condition (AMC) is one-factor affecting surface runoff [11]. There are three types of AMC: AMC I, AMC II, and AMC III. AMC II is for normal humidity conditions, AMC class I is for dry conditions, and AMC III is for wet conditions [12]. In this study, AMC II is used, which is normal humidity conditions.

3. Results and Discussion

3.1 Distribution of Hydrologic Soil Group

The soil type in each area will vary based on the weathering results of the rock. Soil can affect the amount of infiltration and surface water runoff. Based on grain size, coarse-grained soils tend to have better infiltration capabilities than fine-grained soils. So fine-grained soils will cause more significant surface runoff [13]. The The research area consists of two types of soil, the northern part is dominated by sandy loam and silty sand, and the southern part is silty clay. Refers to the soil hydrology group, the research area is divided into group C (sand type of clay and silty sand) and group D (type of silty clay soil). A map of soil types in the research area can be seen in Figure 3.

3.2 Land Cover

Land cover and soil type are essential parameters in determining the CN value and are used in the surface runoff calculation analysis. In this study, land cover and soil type were identified in the Summarecon Serpong area to determine the proportion of land cover and soil type in the entire area. The type of land cover for the Summarecon Serpong area can be seen in Figure 4.

Figure 4 shows that buildings dominate the land cover. The building domination is in line with the fact that Summarecon Serpong is one of the developers of the area, with the majority of its construction intended for cluster buildings or housing, shophouses, and other public places. In addition, several extensive green open lands are seen, followed by bodies of water. The parks in several Summarecon Clusters are grouped into green open land, while for water bodies, there are several retention ponds built in the campus and cluster areas. In addition to land cover, soil type and soil type also affect the calculation of effective rainfall. The percentage of area for each land cover, soil type, and soil type in the entire Summarecon Serpong area can be seen in Table 3.

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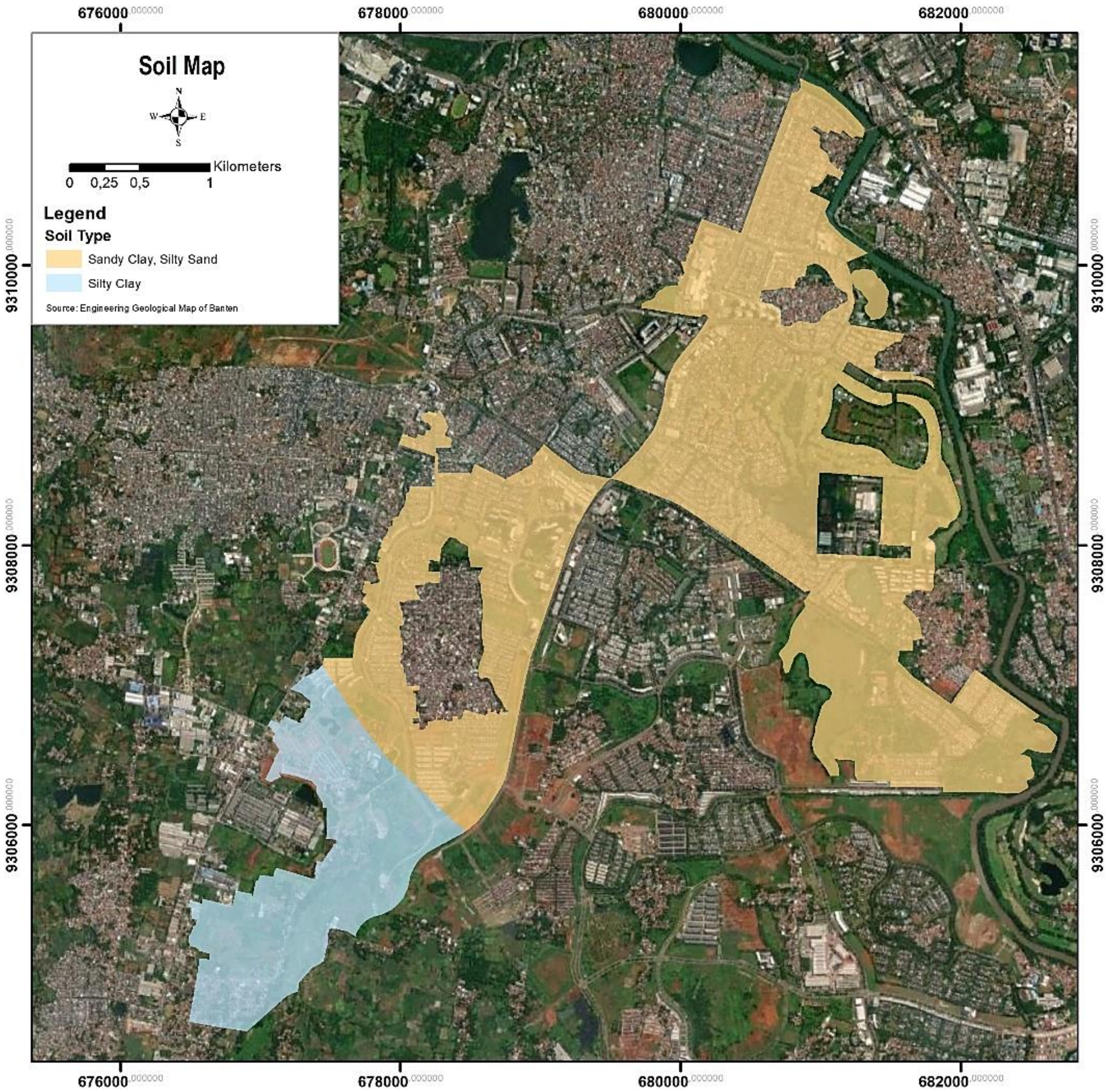

Figure 3. Soil Type Map in Summarecon Serpong Area

3.3 Curve Number Value

The composite Curve Number (CN) value in this study was influenced by land cover, hydrologic soil group, and area [10]. In determining the CN value of the Summarecon Serpong area, the CN value for each land cover and hydrologic soil group is determined according to Table 2, and then multiplied by the percentage of the area. The analysis of determining the CN value can be seen in Table 4.

Although from Figure 4, the area is dominated by building land for housing, the Summarecon Serpong area is still provided with water bodies and green areas, where the percentage of each land cover of water bodies and green areas affects the calculation of direct runoff. The proportion of land cover distribution can be seen in Table 2, while the Composite CN value calculation results can be seen in Table 3.

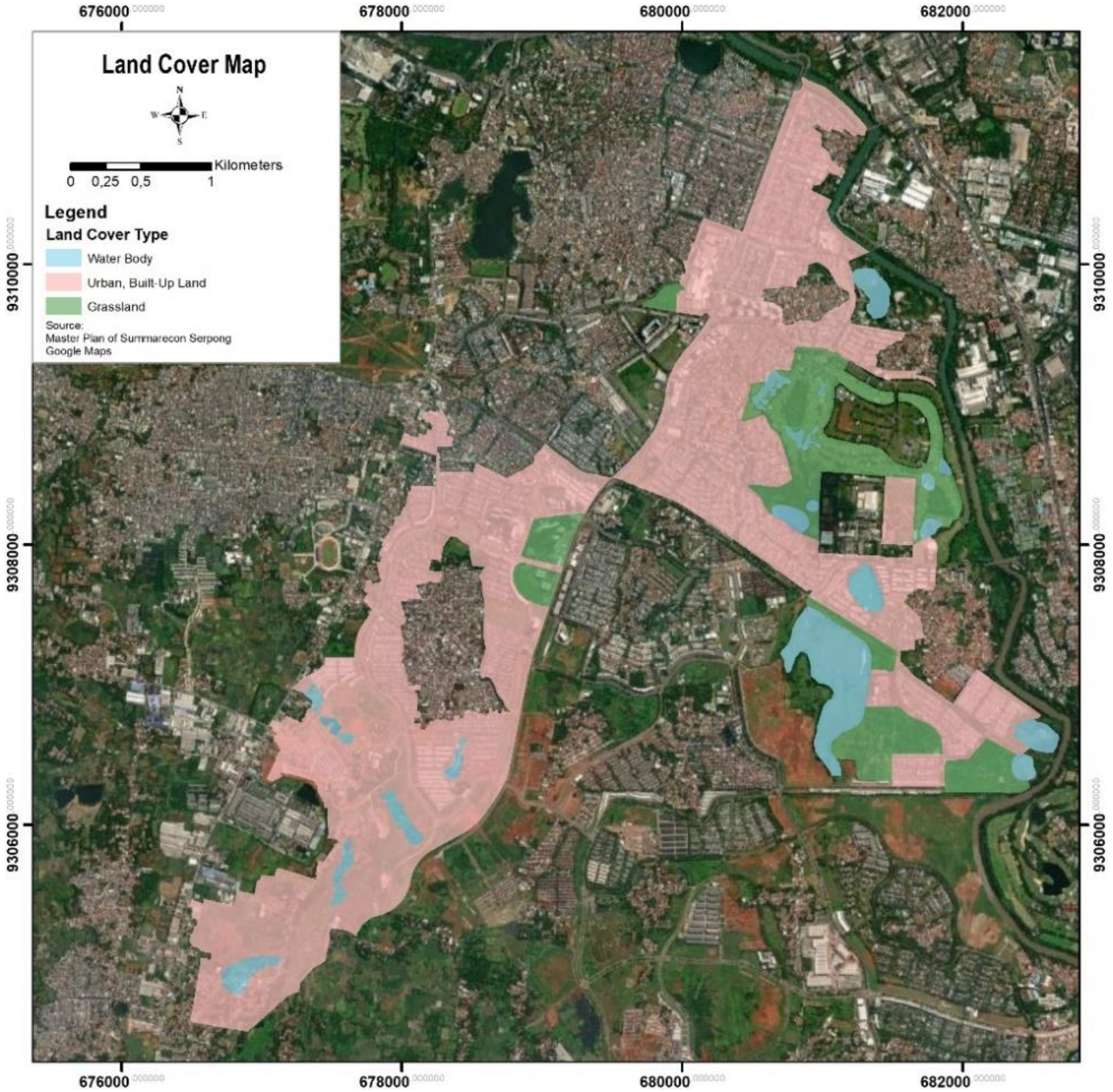

Figure 4. Land Cover Map in Summarecon Serpong Area

Table 2. Land Cover and Soil Type in Summarecon Serpong Area

No.	Land Cover	Soil Type	Hydrologic Soil Group	Area (km^2)	Area Percentage (%)
1	Water Body	Silt clay	D	0.16	1.63
2	Water Body	Sandy clay Silt sand	C	0.70	7.03
3	Building	Silt clay	D	1.82	18.37
4	Building	Sandy clay Silt sand	C	5.78	58.36
5	Green Areas	Sandy clay Silt sand	C	1.45	14.60
TOTAL				9.9	100

Table 3. CN Composite and CN Values

Hydrologic Soil Group	Land Cover	%A	CN	%CN	CN Composite
C	Waterbody	7	100	703	88.89
	Building	58	90	5253	
	Green area	15	74	1081	
D	Waterbody	2	100	163	
	Building	18	92	1690	
	Green area	0	80	0	

3.4 Design Rainfall

In this study, the calculations of the design rainfall used the maximum daily rainfall data for 31 years obtained from the Serpong Station**.** Figure 5 below shows the maximum daily rainfall for the Serpong Station. In determining the design rainfall, it is necessary to calculate the frequency analysis to determine the type of probability distribution by matching the data parameters with the conditions for each distribution. The calculation results show the Cs value of 1.77 and the Ck value of 3.45. Based on Table 1, it can be concluded that the probability distribution used is the Log Pearson III distribution. In addition, tests were also carried out using Chi-Square and Smirnov Kolmogorov.

In the Chi-Square test**,** the number of classes used is 6, and the value of degrees of freedom is 3. The Chi-Square test results show that only the Pearson III log distribution is accepted. In addition to the Smirnov Kolmogorov test, all distributions are accepted, but the best probability distribution is the Log Pearson III distribution which has the smallest maximum delta value. Design rainfall with a specific return period from the Log Pearson III distribution can be seen in Table 4.

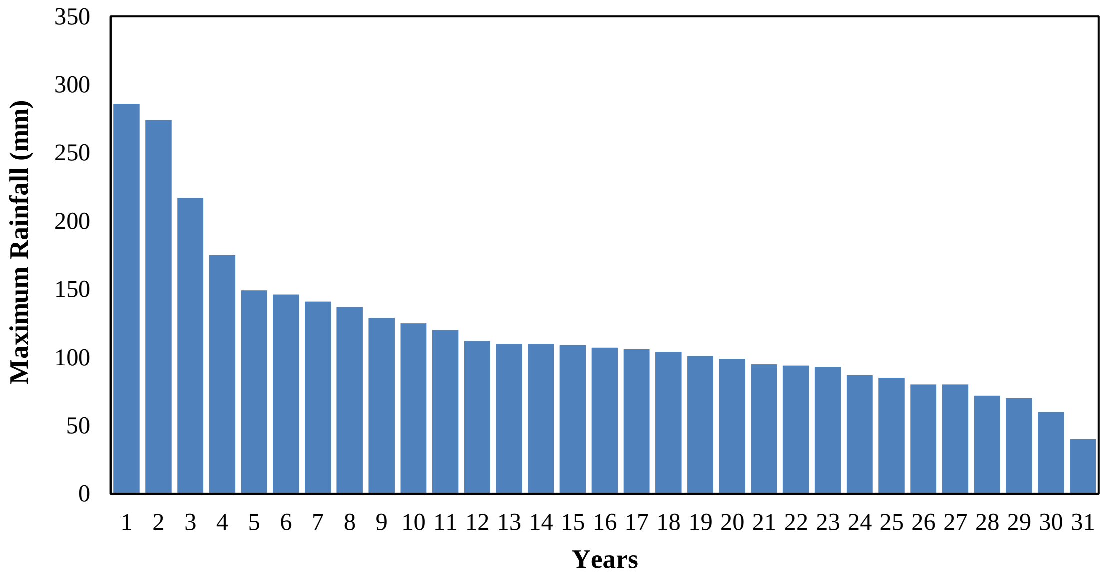

Figure 5. Secondary Data: Maximum Daily Rainfall

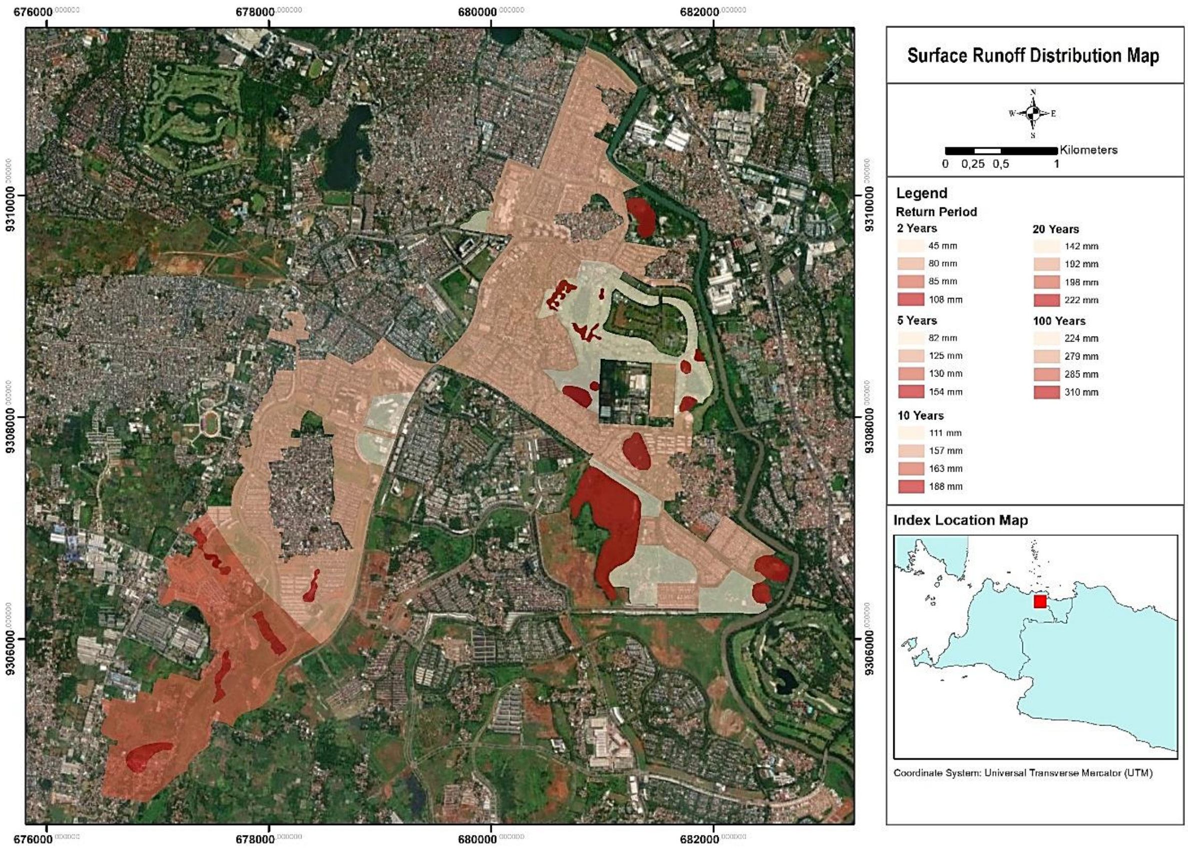

Figure 6. Surface Runoff in the Summarecon Serpong Area

Table 4. Design Rainfall

Return Period (years)	Design Rainfall (mm)
2	107.9
5	153.9
10	187.5
20	222.2
100	310.3

3.5 Surface Runoff

The results of the calculation of design rainfall with a specific return period can be seen in Table 4. The calculation of the surface runoff value for the entire Summarecon area using Equation 6 and composite CN. From the analysis results, the surface runoff height for the entire Summarecon Serpong area at the 2, 5, 10, 20, and 100 year return periods can be seen in Table 5.

Table 5. Surface Runoff

Return Period (years)	Surface Runoff (mm)
2	77
5	121
10	154
20	188
100	275

In addition, the lowest surface runoff occurred on land cover in green open land with Hydrologic Soil Group C, and the highest runoff height occurred on land cover in water bodies. The height of surface runoff on green open land is generally lower because of the ability to absorb water into the soil. The percentage of surface runoff that occurs on green open land is 38%-70%. The high percentage shows that green open land has an essential role in the development of the Summarecon area, where the land cover can reduce the runoff rate. The surface runoff height of the Summarecon Serpong area can be seen in Figure 6.

4. Conclusions

Several things can be concluded based on the analysis of surface runoff calculations in the Summarecon Serpong area. Based on the identification of soil types, there are two (2) soil groups in the Summarecon Serpong area: Group C with sandy loam and silty sand types, and Group D with silty clay soil types. Meanwhile, the types of land cover in the Summarecon Serpong area are buildings, water bodies, and green open land.

The percentage distribution for each land cover, land group, and area resulted in a Composite CN value representing all CN values at Summarecon Serpong is about 88.89. Frequency analysis shows that the type of probability used in this study is the Pearson III Log Distribution. In addition, the design rainfall values are also generated with a return period of 2 years, 5 years, 10 years, 20 years, and 100 years with values of 107.9 mm, 153.9 mm, 187.5 mm, 222.2, and 310.3 mm. Results on surface runoff value from the SCS-CN Method with a return period of 2 years, 5 years, 10 years, 20 years, and 100 years respectively, with values of 77 mm, 121 mm, 154 mm, 188 mm, and 275 mm. The distribution of surface runoff shows that the lowest runoff value occurs in the green area covered with Hydrologic Soil Group C. In contrast, the highest surface runoff value occurs in water bodies.

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