Water Absorption Zoning in Residential Areas Using a GIS Approach (Case Study: Summarecon Bandung Area)

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Abstract

Land conversion from natural to built-up areas increases surface runoff and reduces infiltration. A descriptive method with the Evaluation, Analysis, and Creation (EAC) approach was applied, using Landsat 8 imagery, rainfall data, soil type, and DEM. Rainfall was tested with RAPS and homogeneity analysis, with Log Pearson III identified as the best distribution. Runoff was estimated using the Curve Number (CN) method and simulated with the Storm Water Management Model (SWMM). The results indicate dominance of built-up land (91.584 ha), followed by open land (119.987 ha), vegetation (40.380 ha), and water bodies (6.585 ha). Eutric Fluvisols soils tend to have low infiltration, while gentle slopes (0–8%) support infiltration. The composite CN value (78.52) indicates high runoff potential. Runoff coefficients (C) show low infiltration in built-up areas and water bodies ($C > 0.60$), and moderate in open land and vegetation ($0.30 \leq C < 0.60$). Infiltration zoning highlights low capacity in built-up zones and moderate capacity in open/green areas. Conservation strategies such as infiltration wells, biopores, and retention ponds are required to maintain hydrological functions.

Keywords: Infiltration, Surface Runoff, Geographic Information System (GIS), Curve Number

1. INTRODUCTION

Rapid urban development leads to significant land use changes, reducing infiltration capacity while increasing surface runoff. This condition exacerbates the risk of urban flooding and waterlogging. Summarecon Bandung, a large-scale residential development, has undergone major conversion from agricultural land to built-up areas, which may cause hydrological imbalances.

Water absorption zoning is essential to identify areas with high, moderate, and low infiltration capacity. Geographic Information Systems (GIS) provide an effective tool to integrate spatial factors such as land use, soil type, and slope in determining absorption zones.

The objective of this study is to identify the existing land use conditions in Summarecon Bandung, to estimate the surface runoff resulting from land use changes, and to develop a water absorption zoning map using GIS. Through these objectives, the study provides insights intothe spatial distribution of infiltration capacity and serves as a basis for sustainable land management and runoff control strategies.

1.1 Land Use Change and Infiltration Capacity

Land use plays a fundamental role in determining the hydrological response of an area. Different land use types, such as built-up areas, vegetation, open fields, and water bodies, exhibit distinct infiltration capacities. Vegetated areas generally allow greater water absorption due to root systems and soil porosity, while built-up areas with impervious surfaces limit infiltration and increase surface runoff.

1.2 Metode Curve Number

The Curve Number (CN) method, developed by the United States Soil Conservation Service (SCS), is a widely applied hydrological approach for estimating direct runoff from rainfall events. The CN value represents the combined effects of land use, soil type, and hydrological conditions on runoff generation. CN values range from 30 to 100, where lower values indicate higher infiltration and water absorption capacity, while higher values reflect limited infiltration and increased runoff potential.

In residential areas, CN values are typically high due to the dominance of impervious surfaces such as rooftops, pavements, and roads. Conversely, vegetated or agricultural lands exhibit lower CN values, allowing more rainfall to infiltrate into the soil. Integrating CN analysis within GIS facilitates spatial estimation of runoff potential and the classification of water absorption zones, making it an essential tool in urban hydrology and land use planning.

1.3 Runoff Coefficient

The runoff coefficient (C) is an essential parameter for estimating surface runoff potential. It reflects the proportion of rainfall that becomes direct runoff depending on land use type, soil condition, and slope. Areas with dense vegetation typically have low runoff coefficients due to higher infiltration rates, while residential and commercial zones exhibit high runoff coefficients, indicating lower water absorption.

1.4 Geographic Information Systems (GIS)

Geographic Information Systems (GIS) have become an effective tool in hydrological studies for integrating spatial data such as land use, soil type, slope, and rainfall. By overlaying and analyzing these parameters, GIS enables the development of spatial zoning maps that identify areas with high, moderate, or low absorption capacity. This approach provides valuable insights for sustainable urban planning, flood mitigation, and water resource management.

2. METHOD

The research employed a descriptive method with an Evaluation, Analysis, and Creation (EAC) approach to identify existing conditions, evaluate water infiltration capacity based on hydrological parameters, and develop water infiltration zoning using GIS.

2.1 Research Object

The object of this research is the Summarecon Bandung residential area, located in Gedebage District, Bandung City, Indonesia. The study area covers approximately 258 hectares, which includes various land use categories such as residential areas, open land, vegetation, commercial facilities, and water bodies. The soil type in this area is dominated by Eutric Fluvisols, and the topography is relatively flat with a slope range of 0–8%.

2.2 Research Stage

The research was carried out in several stages:

1) Preliminary Study: collection of relevant literature, previous research, and hydrological theories related to land use, runoff coefficient, and curve number (CN).
2) Data Collection: compilation of spatial and non-spatial data including land use, slope, soil type, and rainfall.
3) Data Processing: classification of land use, overlay with soil and slope maps, calculation of CN values, and estimation of runoff coefficients.
4) Water Absorption Zoning: determination of infiltration capacity zones (high, moderate, low) using GIS overlay analysis based on the runoff coefficient.
5) Analysis and Interpretation: evaluation of spatial patterns of absorption capacity and their relation to land use distribution.

2.3 Data Inventory

The data used in this study include spatial, climatological, and hydrological datasets. Table 1 summarize the types and sources of data

Table 1. Data Source

No	Primary Data Type	Data Source	Year
1	Land Cover Data	Earth Explorer USGS	2025
2	Rinfall Data	NASA - Giovanni	2005-2025
3	Soil Type Data	WARUNGMAPPING.ID (shp)	2020
4	ElevationData (DEM)	DEMNAS	2024

3. RESULTS AND DISCUSSION

3.1 Land Use in Summarecon Bandung

Table 2. Land Use Class

No	Land Use Class	Area (ha)	Area (km2)
1	Water Body	6,585083	0,06585083
2	Built-up Area	91,584577	0,91584577
3	Open Land	119,987857	1,19987857
4	Vegetation	40,38012	0,4038012

Table 2 presents the land use classification within the Summarecon Bandung residential area. The largest land use type is open land, covering an area of approximately 119.99 hectares (1.20 km²), followed by built-up areas at 91.58 hectares (0.92 km²). Vegetation occupies 40.38 hectares (0.40 km²), while water bodies cover the smallest portion of the study area, with 6.59

hectares (0.07 km^2). This distribution indicates that although the built-up area is dominant, a significant proportion of the study area is still composed of open land and vegetation, which play an important role in water absorption capacity.

3.2 Surface Runoff

In this study, land use classification is grouped into four main classes, namely built-up land, open land, vegetation, and water body. Hydrological analysis using the CN method indicates that surface runoff is significantly higher in residential and road areas.

Table 3. CN Composite Value

No	Land Cover Type	Hydrology Class	Area (Ha)	CN	CN (Weighted)
1	Water Body	B	6,59	98	645,34
2	Built-up Area	B	91,58	61	5586,66
3	Open Land	B	119,99	77	9239,06
4	Vegetation	B	40,38	57	2301,67
CN Composite = 20300,93/258,54 = 78,52					

Table 3 shows the Curve Number (CN) values assigned to each land cover type in the study area based on the SCS-CN method. The highest CN value is found in water bodies (CN = 98), which indicates very limited infiltration capacity and high runoff potential. Built-up areas also show relatively high CN values (61), reflecting the dominance of impervious surfaces such as rooftops and pavements. Open land has a CN of 77, representing moderate infiltration capacity, while vegetation has the lowest CN value (57), indicating the highest potential for water absorption.

The weighted CN values were calculated by multiplying each CN with its corresponding land cover area. The results show that open land contributes the largest portion of the composite CN (9,239.06), followed by built-up areas (5,586.66), vegetation (2,301.67), and water bodies (645.34). From the overall calculation, the Composite Curve Number (CN Composite) for the study area is 78.52.

This composite CN value suggests that the Summarecon Bandung residential area generally has moderate runoff potential, with a balance between impermeable built-up surfaces and permeable open land and vegetation. However, the increasing proportion of built-up areas may shift the hydrological response towards higher runoff and lower infiltration if not managed properly.

Table 4. Runoff Coefficient

No	**Land Cover Type**	**Runoff (mm)**	**Effective Rainfall (mm)**	**Runoff Coefficient**	**Composite Runoff Coefficient**
1	Water Body	60,123	63,626	0,945	0,646
2	Built-up Area	55,269		0,869	
3	Open Land	35,972		0,565	
4	Vegetation	21,194		0,333	

Table 4 presents the calculation results of runoff depth and runoff coefficients for each land cover type in the study area, based on the effective rainfall of 63.626 mm. The highest runoffis observed in water bodies (60.12 mm), followed by built-up areas (55.27 mm). These land cover types also exhibit the highest runoff coefficients, 0.945 and 0.869, respectively, reflecting their very limited infiltration capacity.

Open land shows a lower runoff depth of 35.97 mm with a runoff coefficient of 0.565, indicating moderate infiltration potential. Meanwhile, vegetation contributes the lowest runoff (21.19 mm) and the lowest runoff coefficient (0.333), confirming its role as the most effective land cover type for water absorption.

The overall compound runoff coefficient for the Summarecon Bandung study area is calculated at 0.646. This value indicates that nearly two-thirds of the effective rainfall becomes surface runoff, while only about one-third infiltrates into the soil. This condition emphasizes the hydrological consequences of urban land use, where the dominance of built-up areas significantly reduces infiltration and increases surface runoff.

3.3 Water Absorption Zoning

The water absorption zoning map generated from GIS overlay analysis is presented in Figure X. The classification is divided into two categories: moderate absorption (0.3–0.6) and low absorption (0.6–1.0). The spatial distribution shows that most of the study area falls under the moderate absorption zone, while low absorption zones are concentrated in built-up clusters and commercial areas where impervious surfaces dominate.

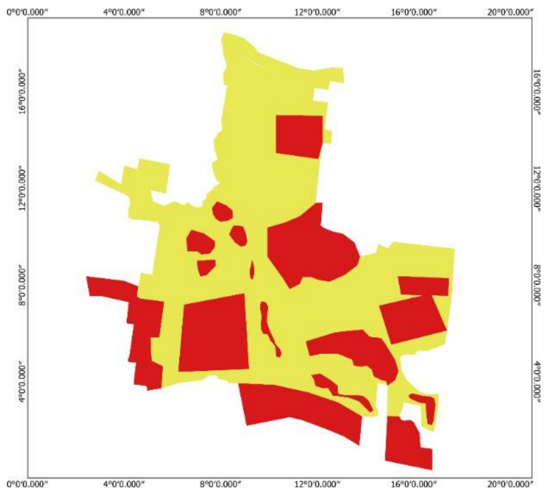

Figure 1. Water Absorption Zonation

Table 5. Absorption Class

No	Absorption Class	Percentage
1	Moderate absorption	80%
2	Low absorption	20%

As summarized in Table 5, approximately 80% of the study area belongs to the moderate absorption class, while the remaining 20% is categorized as low absorption. The dominance of moderate absorption indicates that a significant portion of the land still retains the potential to infiltrate rainfall, primarily due to the presence of open land and vegetation. However, the low absorption zones highlight critical areas with limited infiltration capacity, which could contribute to increased surface runoff and potential drainage problems if urban expansion continues.

These results underline the importance of preserving and managing open land and vegetation to maintain natural infiltration processes. At the same time, low absorption zones require special attention through the implementation of green infrastructure, such as permeable pavements, infiltration wells, and green open spaces, to mitigate runoff and improve hydrological balance in the residential area.

3.4 Implications for Urban Drainage and Planning

The findings of this study have several implications for water resource management and urban planning in the Summarecon Bandung residential area. The relatively high composite CN value (78.52) and compound runoff coefficient (0.646) indicate that a significant portion of rainfall is converted into surface runoff. Built-up areas and water bodies, with runoff coefficients of 0.869 and 0.945 respectively, contribute most to the low absorption zones, which occupy approximately 20% of the total area.

These low absorption zones represent critical areas that are highly vulnerable to surface runoff accumulation and potential flooding, particularly during extreme rainfall events. Without adequate drainage infrastructure, the expansion of built-up land could further increase the volume of runoff and reduce infiltration capacity. On the other hand, open land and vegetation, which cover about 62% of the study area and have relatively lower runoff coefficients (0.565 and 0.333), provide moderate absorption potential that should be preserved and enhanced.

From an urban planning perspective, maintaining and expanding green areas, applying low-impact development (LID) strategies, and promoting the use of green infrastructure (such as permeable pavements, infiltration wells, and rain gardens) are crucial to mitigate the hydrological impact of urbanization. Integrating water absorption zoning into drainage system design will help ensure that stormwater is managed sustainably, reducing flood risk while maintaining groundwater recharge.

Thus, the water absorption zoning developed in this study can serve as a decision-support tool for policymakers, urban planners, and developers in designing sustainable residential areas that balance urban growth with hydrological resilience.

4. CONCLUSIONS

1) Land use in the Summarecon Bandung residential area is dominated by built-up areas (91.58 ha), followed by open land (119.99 ha), vegetation (40.38 ha), and water bodies (6.59 ha). The soil type across the area is classified as Eutric Fluvisols with a sandy clay texture, while the slope is relatively flat.

2) The analysis using the Curve Number (CN) method shows that the study area has a relatively high composite CN value of 78.52. The calculated runoff depth is 55.27 mm for built-up areas, 35.97 mm for open land, 21.19 mm for vegetation, and 60.12 mm for water bodies.

3) The runoff coefficients indicate that built-up areas (C = 0.869) and water bodies (C = 0.945) fall into the low absorption zone. Open land (C = 0.565) and vegetation (C = 0.333) belong to the moderate absorption zone. The overall compound runoff coefficient of the area is 0.464, which classifies the study area as having moderate water absorption potential, though urban development increases the risk of reduced infiltration and higher surface runoff.

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