p-ISSN 2460-0768 e-ISSN 2597-6044
GeoEco, Vol. 10, No 2. July 2024 Page. 250-270
https://doi.org/10.20961/ge.v10i2.87132
https://jurnal.uns.ac.id/GeoEco/article/view/87132

SCS-CN MODEL FOR QUANTIFYING SURFACE RUNOFF POTENTIAL IN THE ECOREGION SEGMENTATION OF BANTUL REGENCY

Faridah Nur Isnaini[1], Alfina Lismadanti[1], Katyusha Fiore[1], Lisa Mustafidatul Fauziah[1], Michelle Ruth Boru Girsang[1], Muhammad Farhan Athaya[1], Satrio Budiman[1*], Tuhu Satrio Nugroho[1], Mohammad Pramono Hadi[2]

[1] Department of Environmental Geography, Faculty of Geography, Universitas Gadjah Mada
[2] Center for Environmental Studies, Universitas Gadjah Mada

*E-mail: satriobudiman28@mail.ugm.ac.id

ARTICLE INFO

Article History
Received : 28/05/24
Revised : 25/06/24
Accepted : 03/07/24

Citation:
Isnaini, F. N., Lismadanti, A., Fiore, K., Fauziah, L. M., Girsang, M. R. B., Athaya, M. F., Budiman, S., Nugroho, T. S., and Hadi, M. P. (2024) SCS-CN Model for Quantifying Surface Runoff Potential in the Ecoregion Segmentation of Bantul Regency. GeoEco. Vol. 10, No. 2.

ABSTRACT

The role of surface air is pivotal within the framework of human livelihoods, necessitating a thorough examination of the potentiality inherent in surface water resources. This study aims to ascertain the estimations of surface runoff potential within Bantul Regency for the year 2020, serving as a watershed area, employing the Soil Conservation Service-Curve Number (SCS-CN) model grounded in ecoregion segmentation. Empirical data pertaining to spatial distribution of rainfall, soil types, and land use are meticulously analyzed to delineate hydrological soil group (HSG) and corresponding curve numbers (CN). The geospatial integration of these datasets is overlaid, facilitating landform mapping. Notably, the CN values are predicated upon three distinct Antecedent moisture conditions (AMC), delineated as AMC I, II, III denoting dry, normal, and wet conditions, respectively. The research findings reveal that surface runoff volume within Bantul Regency is predominantly concentrated within the landform expanse characterized as F2-Qmi, registering at 119,971,277.78 m^3 during the rainy season and 376,473 m^3 during the dry season. By contrast, the lowest runoff volume is observed in M1-Qa, amounting to 126,811.85 m^3 during the rainy season and 0.61 m^3 during the dry season. To ensure the availability of potential surface runoff influenced by various ecoregions, it is essential to conduct detailed mapping, implement ecosystem conservation, construct reservoirs in dry areas, and engage communities through education and supportive zoning policies for sustainable water management.

Keywords: *curve number; landform; seasonal variations; surface runoff volume*

INTRODUCTION

Runoff constitutes an integral component within the hydrological cycle by controlling precipitation and water flow in water systems (Sitterson et. al., 2018.) Surface runoff, or overland flow, comprises rainfall that flows over the soil surface, transporting substances and soil particles (Appels et. al., 2017). Runoff

CC BY

occurs when rainfall intensity exceeds the soil's infiltration capacity (David, 2016). Upon reaching saturation, when higher infiltration water, water fills depressions on the soil surface (Zhao et. al., 2018). Once these depressions are filled with water, runoff occurs over the soil surface. Runoff water is classified into two types, sheet surface runoff and rill surface runoff. However, when this water flow enters the stream or river channel system, it is referred to as streamflow runoff (Asdak, 2020).

Over time, the dynamics of population growth have continued to unfold within Bantul Regency. The rise in population is accompanied by an increase in the demand to fulfill human needs (Hemathilake and Gunathilake, 2022). The high intensity of social and economic activities necessitates a substantial amount of water resources, especially in facing water scarcity caused by climate change (Larraz et. al., 2024). A region experiencing development tends to undergo changes in land area or land use conversion (Sitorus et al., 2011). Land use conversion impacts the low infiltration capacity of built-up areas (Permatasari et al., 2017). This will affect the availability of water in Bantul Regency in the year 2020.

Macroscopically, Bantul Regency's terrain comprises flatland areas located in the central part, hilly regions situated in the eastern and western parts, and coastal areas to the south. The topographical conditions of the region generally extend from north to south. According to Adi and Setiawan (2010), the comparison between the areas of discharge and recharge in Bantul Regency is 31,546.3 hectares and 19,887.5 hectares, respectively. This implies that a significant portion of the study area constitutes discharge areas. The predominance of discharge areas in most parts of Bantul Regency renders it suitable for agricultural purposes. Based on RBI map analysis, paddy fields notably dominate land use in Bantul Regency, although built-up areas remain the most prevalent land use type.

The availability of water represents the quantity of water reserves accessible for both domestic and non-domestic needs (Pratiknyo, 2016). Surface water availability can serve as an initial investment for development, thus underlining the importance of policy formulation aimed at better management of water availability in terms of both quality and quantity (Borisova et. al., 2020). This research aims to estimate the potential surface runoff in Bantul Regency in 2020. Analysis of surface runoff potential is conducted using the Soil Conservation Service Curve Number (SCS-CN) method based on geographic information systems (GIS) to ascertain its spatial conditions. Thus far, there has been no research conducted on surface runoff in Bantul Regency, particularly with the use of the SCS-CN method. Furthermore, investigations into surface runoff based on ecoregion segmentation remain exceedingly rare in Indonesia.

MATERIALS AND METHODS

Study Area

The study was conducted within Bantul Regency, situated in the Special Region of Yogyakarta, bordered to the north by Yogyakarta City and Sleman Regency, to the east by Gunungkidul Regency, and to the west by Kulon Progo Regency. Bantul Regency spans an area of 506.85 square kilometers. Three major rivers traverse Bantul Regency: the Opak River and Oyo River in the eastern region, and the Progo River in the western region, demarcating its boundary with Kulon Progo Regency. The topographic conditions within Bantul Regency encompass five distinct types: fluvial, solusional, marine, structural, and volcanic (see **Table 1** and **Figure 1**). The most extensive topographic feature in Bantul Regency is fluvial, characterized by flat fluvio-volcanic plains originating from recent Merapi volcanic deposits. This topography predominantly occupies the central region of Bantul Regency, exhibiting relatively flat morphography. Its existence is influenced by the presence of Mount Merapi to the north, with its materials carried by fluvial forces streaming towards the sea, traversing Bantul Regency. Solutional topography is situated in the eastern part of Bantul Regency, specifically along its border with Gunungkidul Regency, featuring solusional karst hills of the Nglanggeran and Wonosari formations. Marine topography is found in the southern part of Bantul Regency, where it meets the Indian Ocean, with marine forces contributing to the formation of alluvial sand dunes and alluvial marine plains.

Table 1. Landforms code

Code	Landform
F2-Qmi	Volcanic Fluvio Plain of Younger Merapi Volcanic Deposits
K-Tmng	Karst Solutional Hills of Nglanggeran Formation
K-Tmwl	Karst Solutional Hills of Wonosari Formation
M1-Qa	Alluvium Sand Dunes

Code	Landform
M2-Qa	Alluvium Marin Plain
S2L-Tmps	Structural Hills Folds of Sentolo Formation
S2P-Qa	Alluvium Fault Structural Hills
S2P-Tmng	Structural Fault Hills of Nglanggeran Formation
S2P-Tms	Structural Fault Hills of Semilir Formation
S2P-Tmss	Structural Fault Hills of Sambipitu Formation
S2P-Tmwl	Structural Fault Hills of Wonosari Formation
V3-Qmi	Volcanic Deposits of Younger Merapi Volcanic Plains

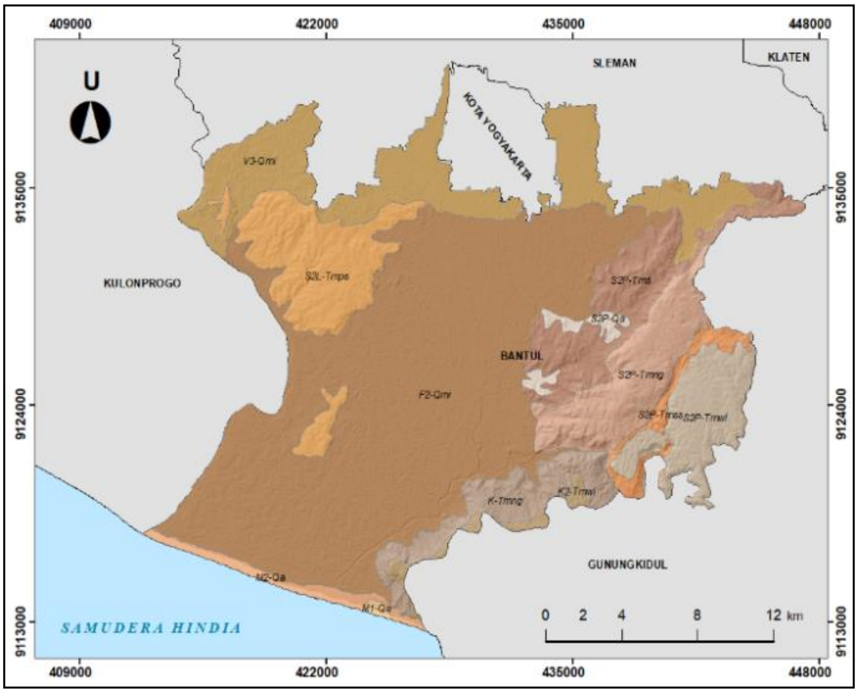


Figure 1. Landform types in Bantul Regency

Data Acquisition

The data utilized in this study pertains to the year 2020. The selection of data from this specific timeframe was predicated upon considerations regarding the availability of requisite data sets to comprehensively support this research endeavor. It is worth noting that more recent data for subsequent years may not have been updated at the onset of this research, potentially rendering them incomplete or unavailable for analysis.

The instruments employed in this study primarily revolve around data processing, interpretation, and analysis activities. Specifically, the utilized tools encompass Microsoft Excel software for data processing, image data processing tools, and the aid of image data processing software for identifying precipitation (CHIRPS data), namely GNU Octave-

CC BY

5.2.0, serving as the medium for spatial and temporal data processing and analysis. The data utilized originates from secondary sources obtained through data requests from relevant parties. The detailed data specifications and sources within this study are as follows.

Table 2. Data acquisition and source

No.	Data Acquisition	Source
1.	Daily rainfall from CHIRPS	https://earlywarning.usgs.gov/fews
2.	Observed daily rainfall from rainfall station in Bantul Regency	Central Region River Serayu Opak (BBWS Serayu Opak)
4.	Ecoregion segmentation of Bantul Regency	Data processing and analysis
5.	Land use in Bantul Regency	Regional Development Planning Agency of Bantul (Bappeda Kabupaten Bantul)
6.	Soil types of Bantul Regency	Regional Development Planning Agency of Bantul (Bappeda Kabupaten Bantul)

Data Analysis

The data analysis (**Figure 2.)** phase commences with the computation of correlation between daily rainfall data from CHIRPS for Bantul Regency and daily rainfall measurements from the Barongan Station for the year 2020. This process is undertaken to acquire accurate daily rainfall data. When the coefficient correlation value (R) approaches 1, the correlation relationship becomes stronger or more accurate (Motovilov et al., 1999). The rainfall data necessary for calculating the potential surface runoff volume is the average rainfall of the region obtained using the Thiessen polygon method with the assistance of image data processing software, specifically GNU Octave-5.2.0.

The SCS-CN method fundamentally correlates soil characteristics, vegetation, and land use with the CN, which represents the potential for runoff formation in response to specific rainfall events (Asdak, 2020). The determination of CN involves overlaying land use maps with hydrological soil group (HSG). HSG is based on soil texture, which affects the soil's infiltration capacity. Soil infiltration capacity decreases from class A to D (Wang et al., 2017). The determination of CN for calculation begins with values representing normal AMC based on **Table 3**. Subsequently, the CN corresponding to the AMC condition of each unit can be determined by referencing CN for normal conditions.

cc BY

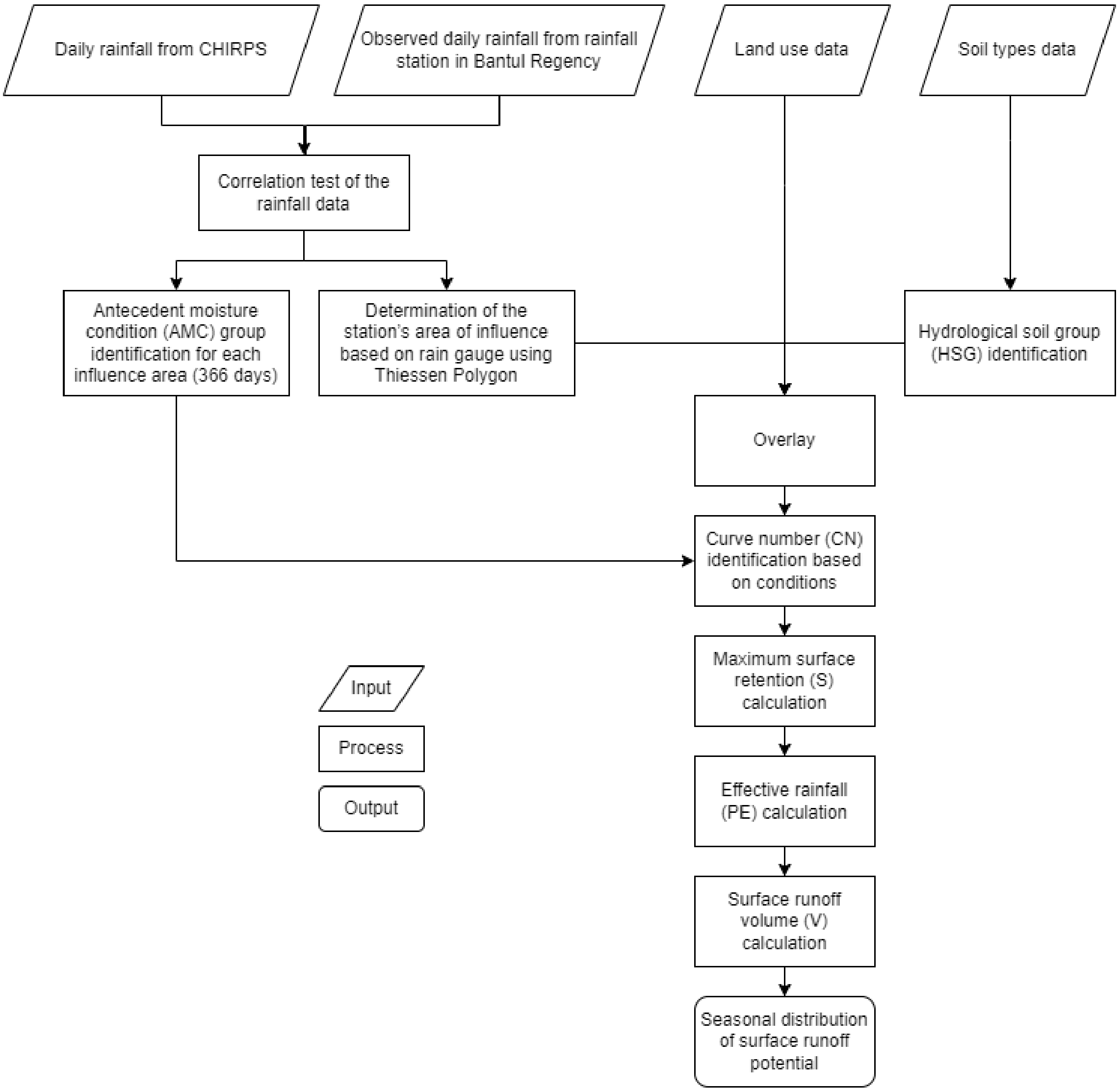


Figure 2. Research flowchart

Table 3. HSG classification

No.	Land Use Type	HSG			
		A	**B**	**C**	**D**
1.	Mixed cropland	45	53	67	72
2.	Scrub and abandoned land	36	60	73	79
3.	Forest	25	55	70	77
4.	Grassland	39	61	74	80
5.	Settlement	57	72	81	86
6.	River	97	97	97	97
7.	Retention pond	100	100	100	100

Source: Prabhu, et. al., 2020

The AMC or initial soil moisture state serves as a crucial indicator in surface runoff volume. The determination of CN in the SCS-CN method relies on the cumulative precipitation over the preceding five days, with AMC I designated for dry conditions, AMC II for normal conditions, and AMC III for wet conditions (**Table 4**).

Table 4. Determination of AMC conditions

AMC	Previous 5 days rainfall accumulation (cm)
I (dry)	<3.6
II (normal)	3.6–5.3
III (wet)	>5.3

Source: McCuen, 1998

The formula for CN under dry conditions (CN I).

$$\mathrm{CN\ (I)} = \frac{4.3\ \mathrm{CN\ (II)}}{10 - 0.0058\ \mathrm{CN\ (II)}}$$

The formula for CN under wet conditions (CN III).

$$\mathrm{CN\ (I)} = \frac{23\ \mathrm{CN\ (II)}}{10 + 0.13\ \mathrm{CN\ (II)}}$$

The estimation of surface runoff volume is computed based on the maximum surface retention (S) and effective rainfall (PE) values. The parameter S delineates the maximum volume of water that can be retained by the soil profile (Kang and Yoo, 2020), as determined through the following calculation.

$$\mathrm{S} = \frac{25{,}400}{\mathrm{CN}} - 254$$

Furthermore, the determination of the PE value is predicated upon equation (4) when the precipitation value (P) exceeds 0.2S. Conversely, if the precipitation value (P) is less than 0.2S, the PE value is set to 0. Consequently, the surface runoff volume (V) can be computed by multiplying the PE value with the area of the mapping unit resulting from the overlay of regional rainfall maps (**Figure 4**), land use (**Figure 3a**), HSG, and landforms.

$$PE = \frac{(P - 0.2S)^2}{P + 0.8S}$$

$$V = PE\ x\ A$$

RESULTS AND DISCUSSION

Land Use and Hydrological Soil Group (HSG)

The land use conditions were derived from the RBI Map data of Bantul Regency, which were subsequently integrated with spatial data on HSG to analyze the characteristics of the CN within each unit of analysis. The distribution of land use in Bantul Regency is illustrated in **Figure 3a**. This map reveals that the flatlands of Bantul Regency are predominantly occupied by built-up areas (residential, commercial, and industrial zones) as well as paddy fields. In the hilly regions to the west, land use is dominated by plantations and orchards, while in the eastern hilly areas, paddy fields along with fallow and cultivated land are prevalent. The depressions or flatter areas in Bantul

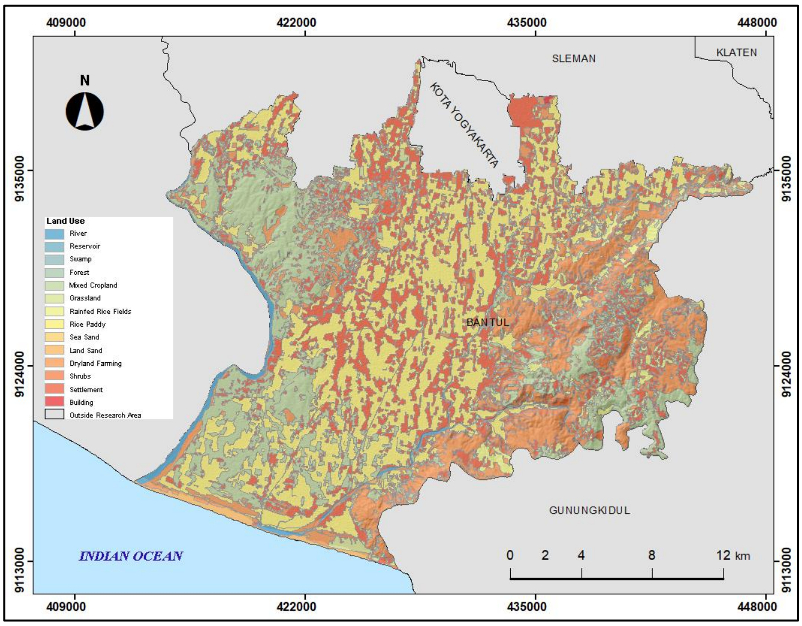
CC BY

Regency are identified as fluvio-volcanic mountainous deposits of young Merapi volcanic sediments with the code F2-Qmi. The results indicate that these landforms exhibit the highest surface runoff potential compared to other landform units, both during the dry and rainy seasons. Consequently, the predominant land use in the F2-Qmi landform, such as paddy fields, aligns well with the surface runoff potential of Bantul Regency.

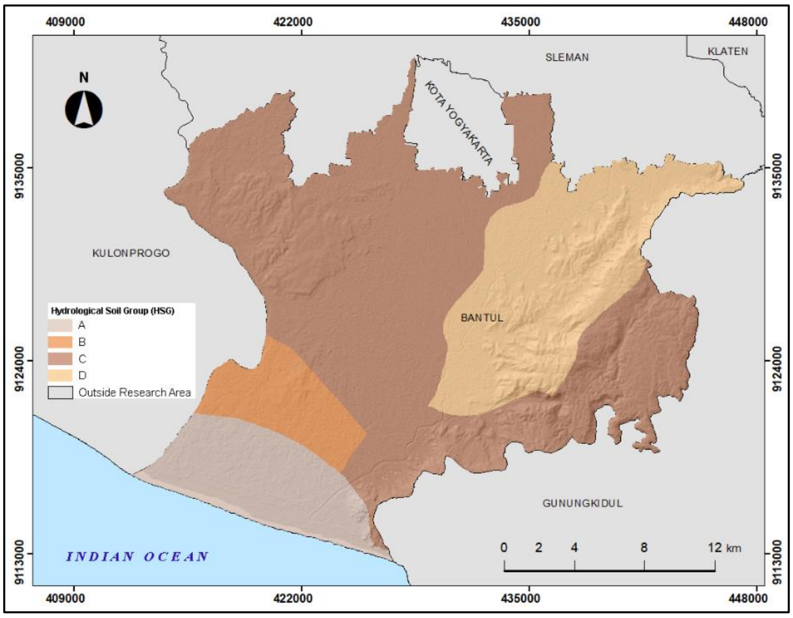
The outcomes of the analysis concerning HSG at the study site are depicted on **Figure 3b**. These classes are determined based on the soil types present within each analytical unit, sourced from the soil data provided by the Regional Development Planning Agency (Bappeda) of Bantul Regency. The soil types identified within Bantul Regency include Udipsamments, Haplustepts, Endiaquepts, Haplustolls, and Haplusterts. These soil types are classified into HSG based on their textural characteristics, which are closely linked to the soil's effective water capacity and its influence on infiltration processes. HSG are categorized into four classes, denoted as A, B, C, and D (McCuen, 1998). Bantul Regency is predominantly characterized by Haplustepts soils, classified as Class C, characterized by clay loam texture and low organic matter content. Along the coastal areas, Udipsamments soils are predominant, classified as Class A, characterized by gravel and sandy textures, resulting in faster infiltration rates and minimal runoff compared to other soil classes.

The CN has difference values each land use caused by combination of the land use and HSG in simulating hydrological processes (Hu et. al., 2020). The study site employs landform as the unit of analysis, which subsequently yields varying runoff potentials commensurate with the topographical features and CN values associated with each.

Calculation using the SCS-CN method elucidates that rainfall-induced runoff is a function of land use, HSG, moisture content determined by AMC, and cumulative rainfall (Kim et al., 2018). Consequently, the spatial distribution of land use and HSG significantly contributes to determining CN values within each analysis unit by landforms. HSG exhibits an order in generating runoff potential, with Class A exhibiting progressively smaller potential, while towards Class D, runoff potential escalates. Generally, land uses such as built-up areas with HSG C and D tend to have higher CN values.



(a)



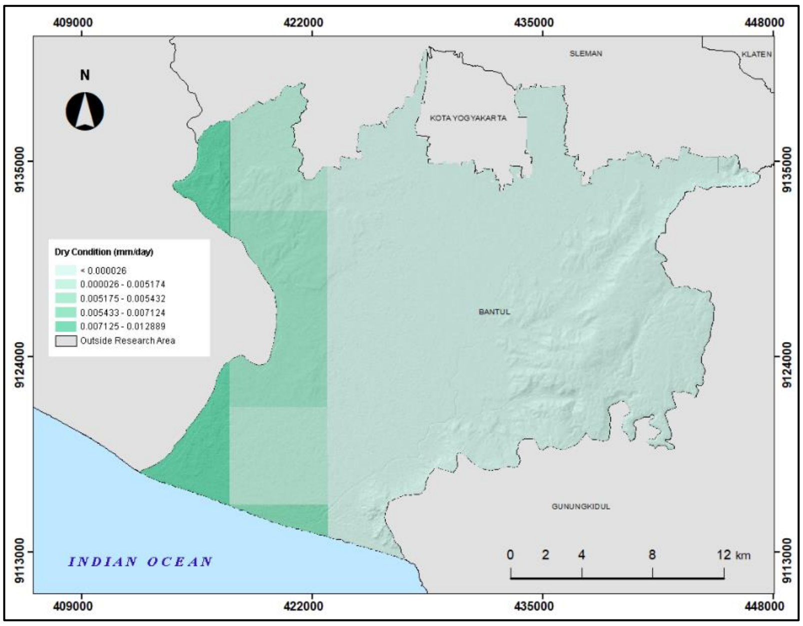
(b)

Figure 3. (a) Land use map of Bantul and (b) HSG map of Bantul

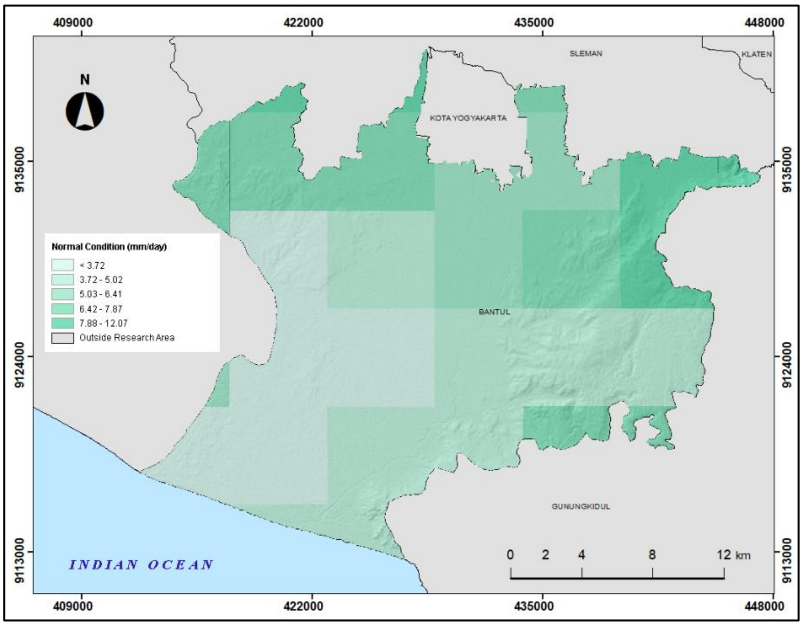
F2-Qmi is predominantly characterized by built-up land use (impermeable surfaces), residential areas, and agricultural land. This landform unit is dominated by hydrological class C, resulting in higher CN values compared to other landform units (see **Figure 5**). Bulit up areas are non-vegetated land. The absence of vegetation results in nothing that can reduce the velocity of

p-ISSN 2460-0768 e-ISSN 2597-6044
https://doi.org/10.20961/ge.v10i2.87132

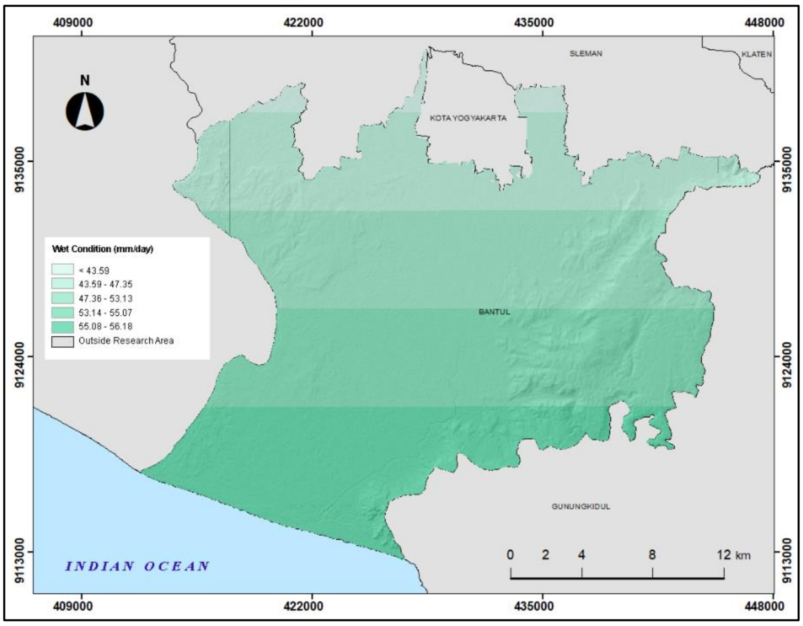
surface runoff on the ground (Hidayah et al., 2022). As a result, the CN value is classified at the high value. This supports the assertion that F2-Qmi possesses the highest runoff potential across all seasons caused by built up area (Shrestha et. al., 2021).



(a)

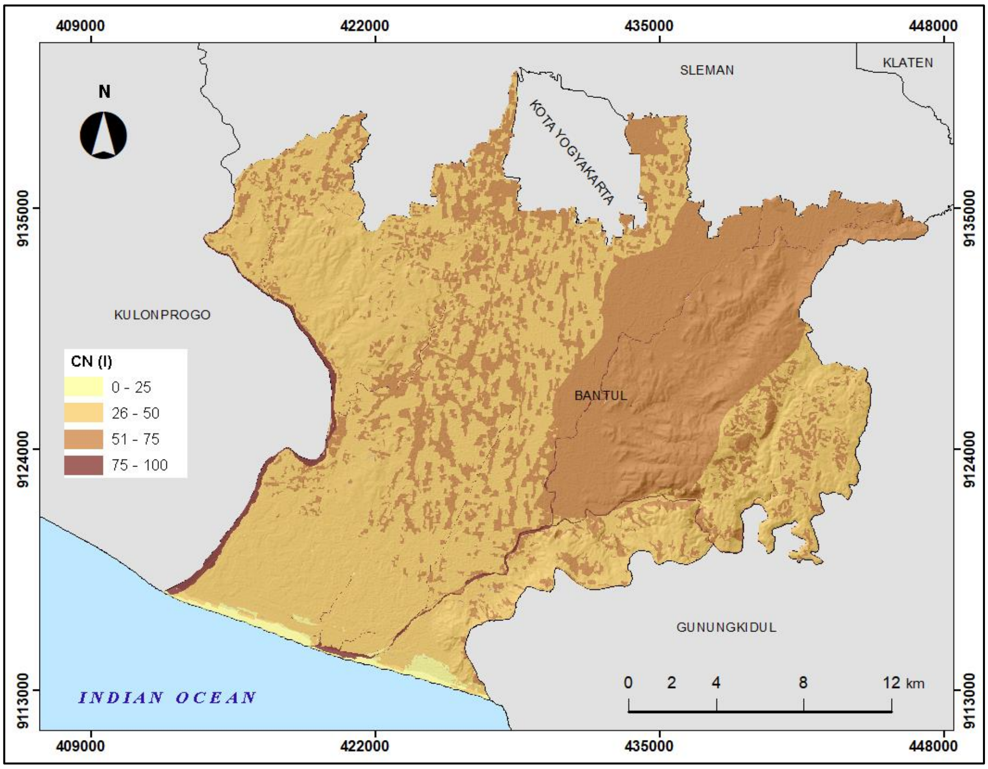


(b)

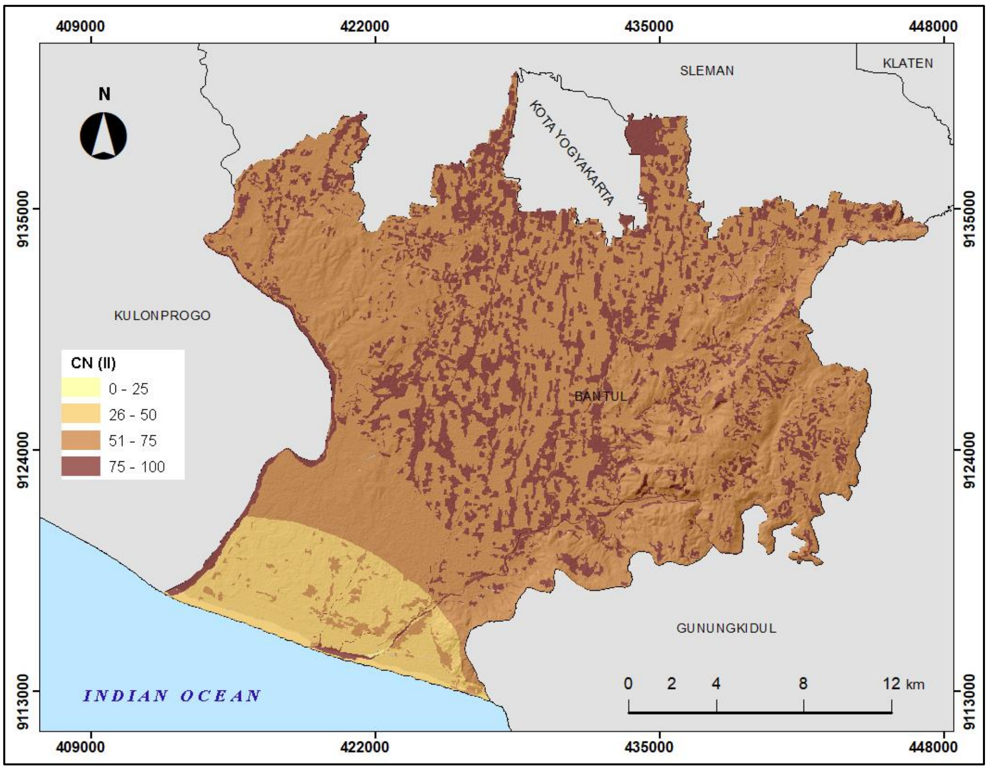


(c)

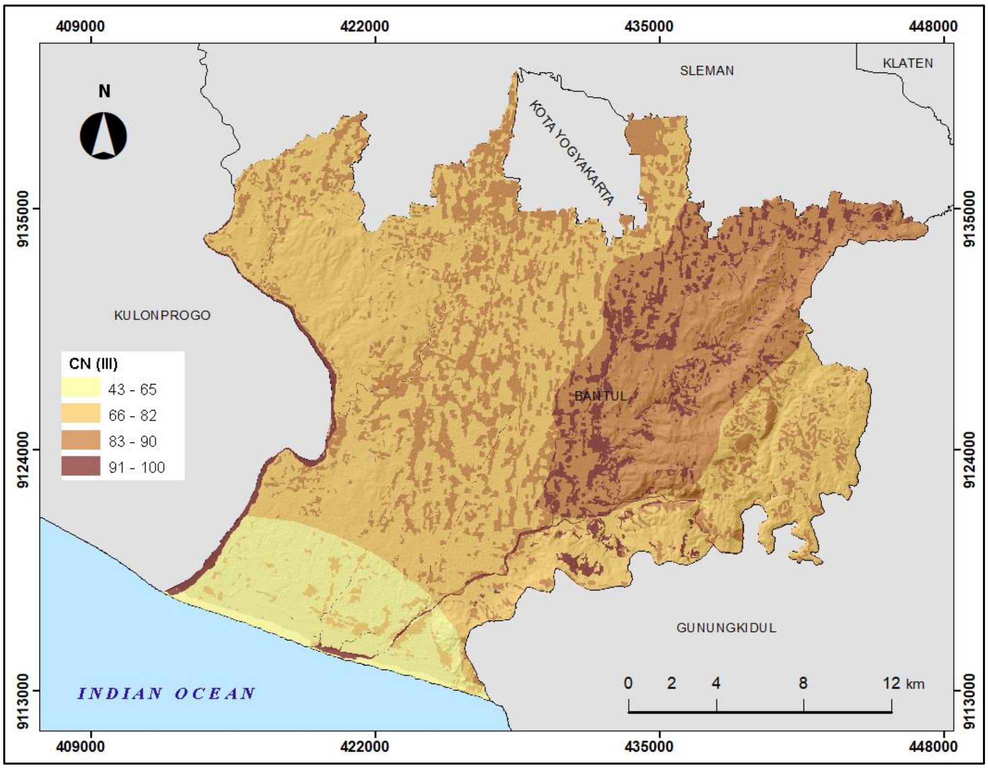
Figure 4. Example of rainfall distribution: (a) dry condition (March 4, 2020), (b) normal condition (September 18, 2020), and (c) wet condition (November 2, 2020).



(a)



(b)



(c)

Figure 5. Example of CN distribution: (a) dry condition (March 4, 2020), (b) normal condition (September 18, 2020), and (c) wet condition (November 2, 2020).

CC BY

The Potential Volume of Surface Runoff

The potential volume of surface runoff, as quantified, is predicated upon the magnitude of precipitation, soil type, and land use. The cumulative surface runoff volumes presented herein are categorized in accordance with the respective landforms.

Annual Potential

The largest runoff volume predominates in the central region of Bantul Regency, characterized by the F2-Qmi, amounting to 120,347,749.8 m^3 (**Table 5**). The distribution of runoff volume is shown in **Figure 6**. The expansive nature of this landform exerts a significant influence on the accumulation of runoff volume. The B-type exhibits the largest area within this landform, indicating a comparatively greater infiltration capacity than types C and D. However, the predominant land use, primarily comprising settlements and irrigated paddy fields, significantly contributes to the high CN values within this landform. The CN values associated with this land use are notably high, thereby indicating a substantial potential for runoff, given the substantial amount of rainfall onto the soil surface.

The landform with the smallest runoff volume is identified as M1-Qa, with a volume of 126,812.466 m^3. The area of this landform is exceedingly diminutive, resulting in its minimal contribution to the accumulation of surface runoff volume. Additionally, this landform is predominantly composed of sandy-textured soil. Sandy soils typically exhibit high infiltration rates because of its large pore size (Haghnazari et. al., 2015), thereby limiting the amount of water runoff. Consequently, the CN assigned to this landform is low, reflecting its HSG of type A, which is characterized by low runoff production. This phenomenon is attributable to the rapid drainage capacity of sandy soils, facilitating efficient percolation of water into the subsurface.

Similarly, areas exhibiting minimal surface runoff volume are found in the southeast and east, characterized by landforms designated as K-Tmng and K-Tmwl. These landforms yield limited surface runoff volume due to karst formations, characterized by materials with high porosity resulting from dissolution processes, thereby facilitating substantial infiltration (Munawir et al., 2019).

The potential for large surface runoff volumes can yield both advantages and disadvantages. Areas exhibiting significant surface runoff volumes are suitable for sustainable agriculture development (Mohamed et. al., 2020) due to their indication of consistently moist soil throughout the year. This aligns with land use in the central regions of Bantul Regency, where irrigated rice fields predominate. However, the potential for flooding in these areas poses a significant drawback. Land use dominated by settlements exacerbates surface runoff, resulting in a greater volume of water runoff compared to infiltration into the soil (Erena & Worku, 2019). The risk of flooding escalates if the channel capacity is smaller than the maximum discharge that occurs. Conversely, areas with low surface runoff volumes offer the advantage of a minimal probability of flood disasters, rendering them suitable for cultivation or crop fields that require less water. Nevertheless, the downside is the susceptibility to drought, as seen in karst regions where surface water is scarce due to substantial infiltration into groundwater.

Table 5. The potential volume of surface runoff in 2020

Landform	Volume of Surface Runoff (m^3)
F2-Qmi	120,347,749.78
K-Tmng	8,516,717.67
K-Tmwl	1,930,599.79
M1-Qa	126,812.47
M2-Qa	6,833,488.65
S2L-Tmps	13,306,486.12
S2P-Qa	1,831,505.26
S2P-Tmng	12,691,173.87
S2P-Tms	13,332,225.88
S2P-Tmss	2,983,191.6
S2P-Tmwl	8,387,741.46
V3-Qmi	24,811,100.25
Total	**215,098,792.78**

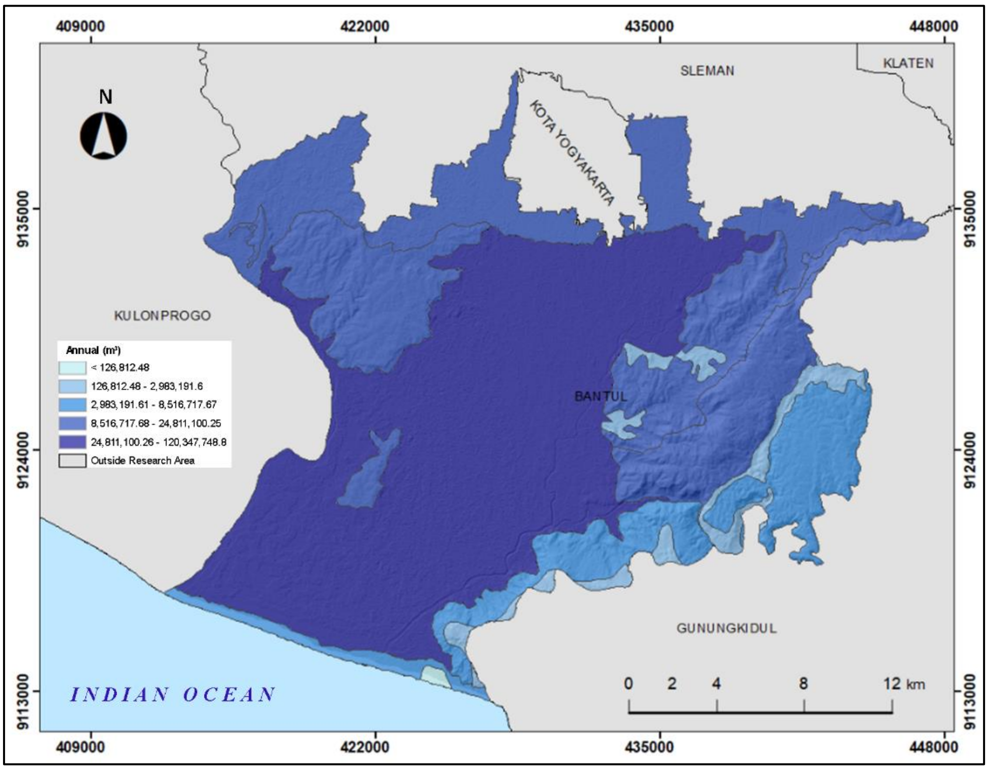


Figure 6. The potetial volume of surface runoff map in 2020

Potential in Dry Season

The dry season, or drought period, in Bantul Regency during 2020, persisted for a duration of four months, spanning from June to September. The dry season in Bantul Regency manifested adverse impacts on the potential volume of surface runoff, governed by soil types, landform, and precipitation patterns. The potential volume of surface runoff in Bantul Regency amounted to merely 639,800.68 m^3 during the dry season (see **Table 6**).

Figure 7 illustrates the spatial distribution of potential surface runoff volumes in Bantul Regency in the dry season. Areas with substantial potential surface runoff volumes tend to be concentrated in the central region of Bantul, characterized by F2-Qmi. The potential surface runoff volume associated with this landform reaches 376,472 m^3. Conversely, the smallest potential surface runoff volumes are observed in the southern part of Bantul Regency, where the landform is classified as M1-Qa. The potential surface runoff volume in this landform is only 0.61 m^3. The diminutive nature of potential surface runoff volumes during the dry season is significantly influenced by precipitation patterns and CN values during this season, as these two variables are controlled by seasonal dynamics. The

CC BY

potential surface runoff volumes during the dry season can impact agricultural practices in Bantul Regency, influencing cropping patterns that align with seasonal variations.

Table 6. The potential volume of surface runoff in 2020 (dry season)

Landform	Volume of Surface Runoff (m^3)
F2-Qmi	376,472
K-Tmng	6,839.91
K-Tmwl	806.77
M1-Qa	0.61
M2-Qa	27,677.28
S2L-Tmps	25,114.63
S2P-Qa	5,260.91
S2P-Tmng	23,075.01
S2P-Tms	38,444.65
S2P-Tmss	4,553.18
S2P-Tmwl	14,255.24
V3-Qmi	117,300.48
Total	639,800.68

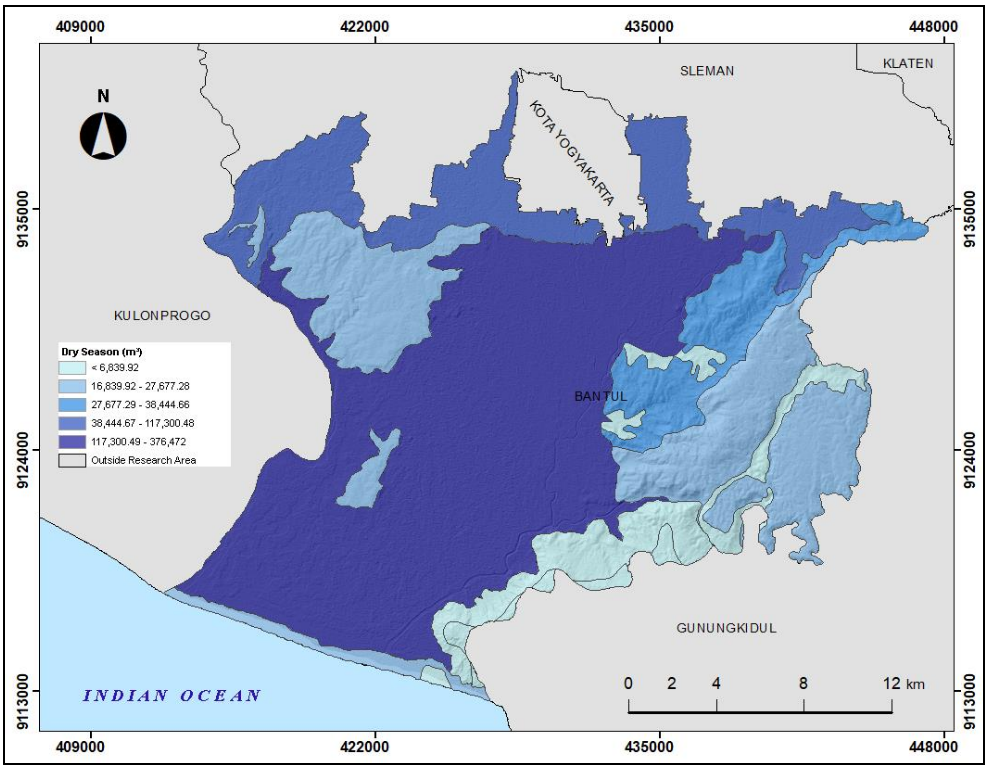


Figure 7. The potetial volume of surface runoff map in 2020 (dry season)

cc BY

Potential in Rainy Season

The magnitude of surface runoff volume in Bantul Regency during the rainy season exhibits a notably significant disparity compared to that during the dry season. The rainy season in Bantul Regency spanned from January to May and October to December. Effective rainfall emerges as a primary determinant influencing the magnitude of surface runoff, alongside land usage patterns and soil characteristics. Rainfall during the wet months predominantly contributes to effective rainfall when its value exceeds 0.2S or initial abstraction (Krajewski et al., 2020). The analysis results reveal that the cumulative surface runoff volume accumulation in Bantul Regency during the 2020 rainy season amounted to 214,458,992.1 m^3, with a breakdown of runoff volumes per landform type presented in **Table 7**. The spatial distribution of surface runoff volumes during the rainy season is visualized in **Figure 8**.

The map illustrates that the M1-Qa exhibits the lowest surface runoff volume compared to other landforms, measuring at 126,811 m^3. Conversely, the F2-Qmi displays the highest surface runoff volume, amounting to 119,971,277.78 m^3. The respective areas of each landform significantly influence the magnitude of surface runoff volume in Bantul Regency, as the volume within a landform is an accumulation of volumes from various land uses with specific soil characteristics.

Surface runoff volume during the rainy season significantly contributes to the annual runoff volume in Bantul Regency in 2020. While large runoff volumes are advantageous for numerous activities, particularly agriculture, which heavily relies on surface water sources, excessive runoff, especially during the rainy season, can lead to flood disasters, especially if drainage systems such as rivers and irrigation channels are unable to accommodate the peak flow resulting from intense rainfall.

Table 7. The potential volume of surface runoff in 2020 (wet season)

Landform	Volume of Surface Runoff (m^3)
F2-Qmi	119,971,277.8
K-Tmng	8,509,877.75
K-Tmwl	1,929,793.02
M1-Qa	126,811.85
M2-Qa	6,805,811.37

Landform	Volume of Surface Runoff (m^3)
S2L-Tmps	13,281,371.49
S2P-Qa	1,826,244.35
S2P-Tmng	12,668,098.86
S2P-Tms	13,293,781.22
S2P-Tmss	2,978,638.42
S2P-Tmwl	8,373,486.22
V3-Qmi	24,693,799.77
Total	**214,458,992.1**

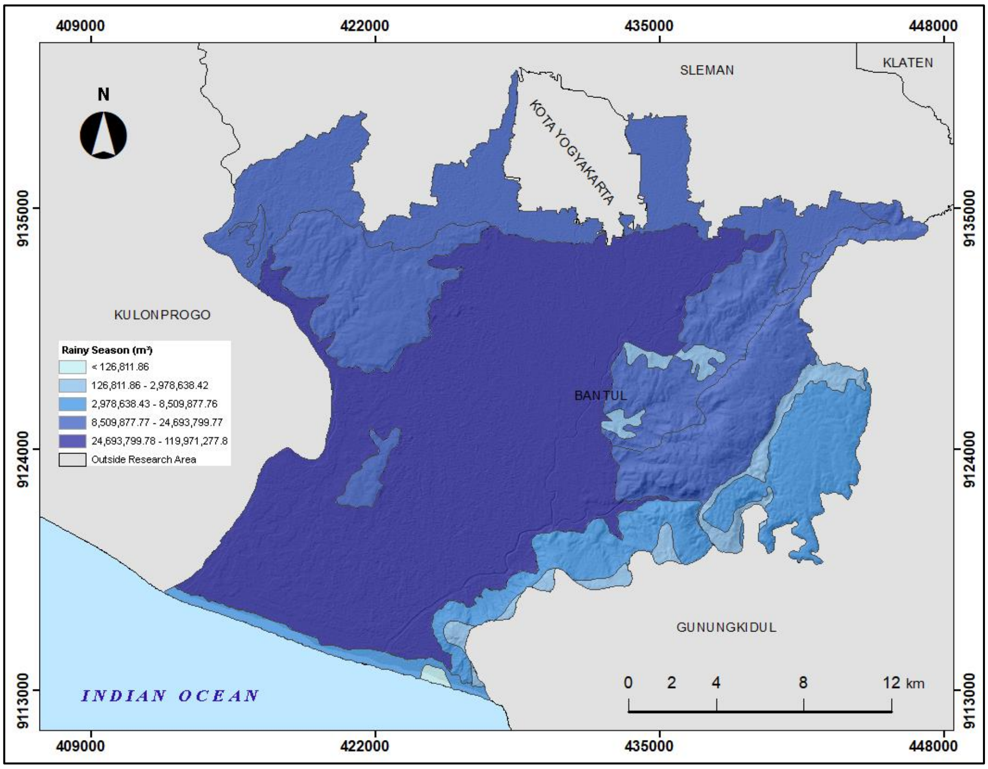


Figure 8. The potetial volume of surface runoff map in 2020 (rainy season)

CONCLUSIONS

The estimation of surface runoff volume potential in Bantul Regency in 2020 utilizing the SCS-CN method yields surface runoff volume potentials that are comparatively lower during the dry season than during the rainy season. Ecoregion segmentation led to understand more regarding the influence of landforms and antrophogenic activity on land use towards the amount of surface runoff. The distribution of surface runoff volume potentials is categorized based on volume potential levels, with significant distributions of surface runoff volume potentials observed predominantly in the

F2-Qmi, while areas with lower surface runoff volume potentials tend to correspond to the M1-Qa. A recommendation stemming from this study involves the necessity for field validation of measurement outcomes to ascertain actual conditions. To maintain the availability of potential surface runoff volume influenced by ecoregions (volcanic, fluvial, marine, and structural) for domestic and non-domestic needs, detailed mapping or zoning and ecosystem conservation based on ecoregion characteristics are required. One approach is the construction of water reservoirs in dry areas to ensure water availability during the dry season. Additionally, it is important to involve the community through education and zoning policies that support sustainable water management.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Mohammad Pramono Hadi, M.Sc. (deceased) as the supervisor of Field Work Lecture 3 (KKL 3) for the surface hydrology group, you meant a lot to us for always being genuine. The authors would also like to thank the anonymous reviewers for their invaluable comments and feedback to improve the quality of this article.

REFERENCES

Adi, R. N., & Setiawan, O. (2010). Penentuan Zonasi Tataguna Air Tanah di Kabupaten Bantul, Daerah Istimewa Yogyakarta. Jurnal Penelitian Hutan dan Konservasi Alam, 7(4): 315-339. doi: 10.20886/jphka.2010.7.4.315-339

Adji, T. N. (2006). Peranan Geomorfologi dalam Kajian Kerentanan Air Bawah Tanah Karst. Indonesian Cave and Karst Journal, 2(1), 64–74. doi: 10.31227/osf.io/zancv

Appels, W. M., Bogaart, P. W., & van der Zee, S. E. A. T. M. (2017). Feedbacks Between Shallow Groundwater Dynamics and Surface Topography on Runoff Generation in Flat Fields. Water Resources Research, 53(12), 10336–10353. doi: 10.1002/2017WR020727

Asdak, C. (2020). Hidrologi dan Pengelolaan Daerah Aliran Air Sungai: Edisi Revisi Kelima. Yogyakarta: Gadjah Mada University Press.

Borisova, T., Cutillo, M., Beggs, K., & Hoenstine, K. (2020). Addressing the Scarcity of Traditional Water Sources through Investments in Alternative Water Supplies: Case Study from Florida. Water, 12(8), 2089. doi:10.3390/w12082089

David, D. (2016). An Approach to Analysing Plot Scale Infiltration and Runoff Responses to Rainfall of Fluctuating Intensity. Hydrological Processes, 31(1), 191–206. doi: 10.1002/hyp.10990

Erena, S. H. & Worku, H. (2019). Dynamics of Land Use Land Cover and Resulting Surface Runoff Management for Environmental Flood Hazard Mitigation: The Case of Dire Daw City, Ethiopia. Journal of Hydrology: Regional Studies, 22, 1–10. doi: 10.1016/j.ejrh.2019.100598

Haghnazari, F., Shahgholi, H., & Feizi, M. (2015). Factors Affecting the Infiltration of Agricultural Soils: Review. International Journal of Agronomy and Agricultural Research (IJAAR), 6(5), 21–35.

Hemathilake, D. M. K. S & Gunathilake, D. M. C. C. (2022). Agricultural Productivity and Food Supply to Meet Increased Demands. Future Foods: Global Trends, Opportunities, and Sustainability Challenges, 539–553. doi: 10.1016/B978-0-323-91001-9.00016-5

Hidayah, E., Widiarti, W. Y., & Ammarulsyah, A. R. (2022). Zonasi Tingkat Kerawanan Banjir Bandang dengan Sistem Informasi Geografis di Sub-DAS Kaliputih Kabupaten Jember. Jurnal Teknik Pengairan, 13(2), 273–282. doi: 10.21776/ub.pengairan.2022.013.02.12

Hu, S., Fan, Y., & Zhang, T. (2020). Assessing the Effect of Land Use Change on Surface Runoff in a Rapidly Urbanized City: A Case Study of the Central Area of Beijing. Land, 9(1), 17. doi: 10.3390/land9010017

Kang, M., & Yoo, C. (2020). Application of the SCS–CN Method To the Hancheon Basin On The Volcanic Jeju Island, Korea. Water, 12(12), 3350. doi: 10.3390/w12123350

Kim, J., Johnson, L. E., Cifelli, R., Choi, Jeongho., & Chandrasekar, V. (2018). Derivation of Soil Moisture Recovery Relation Using Soil Conservation Service (SCS) Curve Number Method. Water, 10(7), 833. doi: 10.3390/w10070833

Krajewski, A., Sikorska-Senoner, A. E., Hejduk, A., & Hejduk, L. (2020). Variability of the Initial Abstraction Ratio in an Urban and an Agroforested Catchment. Water (Switzerland), 12(2), 1-15. doi: 10.3390/w12020415

Larraz, B., Rubio, N. G., Gamez, M., Sauvage, S., Cakir, R., Raimonet, M., & Perez, J. M. S. (2024). Socio-Economic Indicators for Water Management in the South-West Europe Territory: Sectorial Water Productivity and Intensity in Employment. Water, 16(7), 959. doi: 10.3390/w16070959

McCuen, R. H. (1998). Hydrologic Analysis and Design: 2nd edition. New Jersey, Prentice Hall.

Mohamed E. S., Abdellatif, M. A., Sameh, K. A. E., & Khalil, M. M. N. (2020). Estimation of Surface Runoff Using NRCS Curve Number in Some Areas in Northwest Coast, Egypt. E3S Web of Conferences 167, 02002. doi: 10.1051/e3sconf/202016702002

Motovilov, Y. G., Gottschalk, L., Engeland, K., & Rodhe, A. (1999). Validation of A Distributed Hydrological Model Against Spatial Observations. Agricultural and Forest Meteorology, 98, 257–277. doi: 10.1016/S0168-1923(99)00102-1

Munawir, A., Jauhari A., Kurniawan, M. O., & Muhammad, A. N. (2019). Analisis Akuifer Anggota Batugamping Lam Kabeu-Pidie dengan Metode Porositas Sekunder. Prosiding Seminar Nasional Manajemen Bencana di Era Revolusi Industri 5.0, 10 Agustus 2019, Fakultas Geografi UMP.

Permatasari, R., Arwin, & Natakusumah, D. K. (2017). Pengaruh Perubahan Penggunaan Lahan terhadap Rezim Hidrologi DAS (Studi Kasus: DAS Komering). Jurnal Teknik Sipil, 24(1): 91-98. doi: 10.5614/jts.2017.24.1.11

Prabhu, N., Kumar, T.M., & Inayathulla, M. (2020). Runoff Estimation for Arkavathi Valley, Hebbala Valley, Kc Valley, South Pennar Valley, Vrishabhavathi Valley by Using Soil Conservation Services Curve Number Method (SCS-CN). Water Energy International, 63(2), 57-66.

Pratiknyo, P. (2016). Proyeksi Ketersediaan dan Kebutuhan Air Industri di Kab. Tangerang. Seminar Nasional Kebumian XI, 3-4 November 2016, Fakultas Teknologi Mineral, UPN ”Veteran” Yogyakarta, Yogyakarta.

Shrestha, S., Cui, S., Xu, L., Wang, L., Manadhar, B., & Ding, S. (2021). Impact of Land Use Change Due to Urbanisation on Surface Runoff Using GIS-Based SCS–CN Method: A Case Study of Xiamen City, China. Land, 10(8), 839. doi: 10.3390/land10080839

Sitorus, S. R. P., Mulyani, M., & Panuju, D. R. (2011). Konversi Lahan Pertanian dan Keterkaitannya dengan Kelas Kemampuan Lahan serta Hirarki Wilayah di Kabupaten Bandung Barat. Jurnal Tanah Lingkungan, 13(2), 49-57. doi: 10.29244/jitl.13.2.49-57

Sitterson, J., Knightes, C., Parmar, R., Wolfe, K., Muche, M., & Avant, B. (2018). An Overview of Rainfall-Runoff Model Types. International Congress on Environmental Modelling and Software, 27 Juni 2018, Brigham Young University

Wang, J. J., Ding, J. L., Zhang, Z., & Chen, W. Q. (2017). Improved Algorithm of SCS-CN Model Parameters in Typical Inland River Basin in Central Asia. In IOP Conference Series: Earth and Environmental Science, 57(1), 012051. doi: 10.1088/1755-1315/57/1/012051

Zhao, L., Hou, R., Wu, F., & Keesstra, S. (2018). Effect of Soil Surface Roughness on Infiltration Water, Ponding and Runoff on Tilled Soils Under Rainfall Simulation Experiments. Soil and Tillage Research, 179, 47–53. doi: 10.1016/j.still.2018.01.009