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IMPACT OF LAND-USE CHANGES OF WATERSHED KRUKUT ON RUNOFF

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ABSTRACT

Changes in land use from undeveloped land covers, such as rice fields, ponds, and fields to open building spaces, increase the inundation. Therefore, its management in urban areas is vital to suppress the runoff rate the larger the building's open space, the greater the runoff coefficient. As a result, the local government must pay attention to many things to overcome the problem of land-use change in the Krukut watershed. This review is based on an overview of satellite imagery in 2010 and 2019 to estimate land area and calculate differences in runoff coefficients between the two periods, using a Geographic Information System (GIS) spatial analysis. The result, which shows the coefficient of 0.79 and 0.89, proves that the changes have an impact. Then, based on the runoff coefficient, planned rainfall intensity, and watershed area, the researchers found that the 25-year return period discharge for the Hydrograph Soil Conversion Service (SCS) increased by 25.42 m^3/second, from 302.19 m3/second to 327.61 m^3/sec.

Keywords: Rainfall, Land Use, Runoff, Geographic Information System

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1. INTRODUCTION

A Watershed is a land area of a unitary river ecosystem and its branches. It is useful for collecting, storing, and draining water from rainfall to a lake or sea. The land boundary is a topographical separator from the sea line to the irrigation area, which is still affected by land activities (Law No. 7/2004 concerning water resources).

The occurrence of inundation is one of the problems in urban areas, especially the Krukut watershed in DKI Jakarta Province.

The incident was caused by extreme rains, increased land use conversion into watertight open spaces, narrowing of river borders, and reduced rainwater catchment areas. This inundation event was felt in the last ten years, from 2010 to 2020. There are 30 inundation points from 11 sub-districts along the river.

For this reason, it is necessary to research whether land-use changes significantly affect the incidence of inundation along the watershed. This analysis aims to define its impact on runoff rates in 2010 and 2019.

The benefits of this study are information material and local government considerations for planning urban land use based on runoff rates and for future research.

The data used is sourced from satellite image monitoring in 2010 and 2019. While the rainfall data used are sourced from the UI campus station recording for 16 years from 2003 to 2018. The amount of discharge plan for the 25-year return period compares the Nakayasu Hydrograph and the Soil Conversion Hydrograph. Services (SCS).

2. LITERATURE REVIEW

Land Use

Changes in land use occur in their uses and functions in an area at different times. The transformation of land cover functions from forest or green land into built-up areas increases the rate of erosion and sedimentation in the area, which makes inundation in the surrounding area also known as flooding (Alimin, Wicaksono, et al., 2017).

According to Arsyad (1989), land use results from every form of intervention by dynamic human activities on land to meet the needs of life, both material and spiritual.

Determination of Land Cover Classification by comparing Image classification aims to group or segment homogeneous features using quantitative techniques.

Rainfall and Runoff

Rainfall is measured in an area at a certain time. It is very influential for life on earth, expressed in inches or millimeters (1 inch = 25.4 mm). The number of 1 mm indicates the height that covers the surface 1 mm if the water does not seep or evaporate into the atmosphere. The Agency for Climatology and Geophysics Methodology (BMKG) states that the height of rainwater collected on a fairly flat surface does not evaporate, does not seep, and is difficult to drain into the ground. The number of time units can also be referred to as rainfall intensity, where the unit is mm/hour.

Soewarno (2000) states that rain is a form of water droplets with a diameter of more than 0.5 mm or smaller and falls scattered over an area. Meanwhile, rainfall is the amount of water that falls to the earth's surface, which is considered flat and waterproof, does not experience evaporation, is evenly distributed, and is expressed as the thickness of the water.

Ministry of Public Works, SK SNI M-18-1989-F (1989) explained that the Rational method can be used for drainage area sizes < 5000 Ha.

Researchers use the mononobe formula below to calculate the intensity of rain in determining peak discharge with the Rational method:

$$Q = 0{,}278\ C\ I\ A$$

where:

Q: The runoff water discharge (m3/s).

C: The Runoff Coefficient/flow coefficient.

I: Rain intensity (mm/hour).

A: The area of the drainage area was obtained from the watershed area map (km2).

The runoff coefficient is the percentage of the amount of water that can flow through the soil surface from the total rainwater that falls on an area. The more impenetrable a soil surface, the higher the coefficient value of C.

$$C = C\ rata - rata\ = \frac{\Sigma\ C\ i\ A\ i}{\Sigma\ A\ i}$$

Table 1. Runoff coefficient for the rational method

No	Land description/surface character		Flow Coefficient, C
1	Business		
		urban	0.70 – 0.95
		periphery	0.5 – 0.70
2	Housing		
		Residential home	0.30 – 0.50
		Multiunit, separated	0.40 – 0.60
		Multiunit, merged	0.60 – 0.75
		Village	0.25 – 0.40
		Apartment	0.50 – 0.70
3	Industry		
		Heavy	0.50 – 0.80
		Light	0.60 – 0.90
	Hardening		
		Asphalt dan Concrete	0.70 – 0.95
		Bricks, Paving	0.50 – 0.70
	Roof		0.75 – 0.95
	Sandy Yard		
		Flat 2%	0.05 – 0.10
		Average 2-7 %	0.10 – 0.015
		Steep 7%	0.15 – 0.20
	Heavy Soil Yard		
		Flat 2%	0.13 – 0.17
		Average 2-7 %	0.18 – 0.22
		Steep 7%	0.25 – 0.35
	Train Yard		
		Park, Playground	0.20 – 0.35
		Plantation Garden	0.10 – 0.25
		Flat 0-5%	0.10 – 0.40
		Wavy 5-10%	0.25 – 0.50
		Hilly 10-30%	0.30 – 0.60

Source: McCuen, (1989)

The Nakayasu Hydrograph Synthetic Unit Method

The Nakayasu HSU is a way to obtain a design flood hydrograph of a watershed. It is necessary to look for the characteristics or parameters of the drainage area to create a flood hydrograph on the river, such as time to peak magnitude, time log, the time base of the hydrograph, drainage area, and length of the longest channel.

SCS-CN Method

Pakasi (2006) said that one of the bases in the concept of developing a watershed hydrological model is the Runoff Curve Number (CN) method. The prediction model is simple and accurate, using easily available rain data and watershed characteristics. It can be used to predict small to large watershed runoff. The Soil Conversion Service (SCS, 1972) has developed a procedure for estimating runoff in a small watershed called the Curve Number.

The basis is the relationship of the infiltration of each soil type to the amount of rainfall that falls. The total rainfall that falls on every rain (P) on the ground with the maximum potential of the soil to hold certain water (S) will be divided into three components: Runoff water (Q), Infiltration (F), and initial abstraction (Initial). Abstraction: Ia) (Chow, 1988:148).

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S}$$

with:

Q: Surface Runoff Volume (mm).

Ia: Initial abstraction (initial abstraction).

Q: Daily rain (mm).

S: Volume of retention parameter (mm).

The above equation shows how to determine the depth of the depth excess rainfall or surface runoff, where the correlation between Ia and S values is: (Chow, 1988:148).

$$Ia = 0.2\ S$$

US SCS determines the amount of S in facilitating the calculation of the antecedent moisture condition of land use and soil conservation as follows:

$$S = 25.4\left(\frac{1000}{CN} - 10\right)$$

with:

CN: Running water curve number varies from 0 to 100

CN can be determined by plotting the values of P and Q on the SCS curve. The SCS method categorizes soil types into four types based on soil type and land use (hydrology soil group). In the initial abstraction, he usually uses the 0.2 S approximation so that the equation becomes:

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

Determination of the Curve Number of SCS-CN

It is determined by considering the Soil Hydrological Group, AMC, and Land use. The SHG consists of four groups given the symbols A, B, C, and D; the soil properties associated with these groups and their relationship to the minimum infiltration rate are presented in Table 2. Vertical Drainage Study and Mapping in DKI Jakarta Province (2020) shows the Hydrological group. The soil in the Krukut watershed is Group C.

The equation for the Curve Number (CN) is as follows:

$$CN = \frac{CNi\,.Ai + CN\,i + 1 + \cdots + CN\,n\,.An}{\Sigma\,Ai}$$

where:

CN: Curve Number.

A: Area Size.

CN is obtained by overlaying land use maps with soil hydrological group maps. The result is a map of the distribution of CN values in the watershed with land use of the soil hydrology group, where its attribute is matched with the CN attribute. After each CN is determined, the weighted average CN value is sought.

Table 2. Curve Number

No	Land Use	Soil Category/Hydrology Class			
		A	B	C	D
1	Primary Dryland Forest	30	55	70	77
2	Settlement	61	75	83	87
3	Dryland farming	45	66	77	83
4	Mixed Shrub Dry Land Agriculture	35	56	70	77
5	Ricefield	62	71	78	81
6	Shrubs	30	48	65	73
7	Industrial forest	57	73	82	86
8	Plantation	57	73	82	86
9	Secondary Dryland Forest	45	66	77	83
10	Grass/Open Ground	68	79	86	89
11	Water Body	98	98	98	98

Source: McCuen, (1989) dan *US SCS* (1972)

Geographic Information System

It is a component consisting of hardware, software, geographic data, and human resources that work together to enter, store, improve, update, manages, manipulate, integrate, analyze, and display data in geographic-based information (Nurhamidah, 2011 Junaidi et al. 2016).

The process of input data in (GIS) is a facility to enter and change the form of data that can be accepted and used. The entry is done in 3 ways. Scanning converts continuous graphic data into one consisting of constituent image cells (pixels) using portable scanning, storing data in raster form. Digitization is converting analog graphic data into digital in a vector structure. In this structure, the data is mathematically stored in the form of points, segments, or polygon data—rows of data in a GIS consist of graphics and attributes.

Data processing. Data processing includes storing, activating, restoring, and printing all data obtained from data input. Data settings, improvements, subtractions, and additions are also carried out. The function of this subsystem is to differentiate the data to be processed in the GIS, change the data format, get parameters, and manage the process. Efforts to evaluate this subsystem need to be continued because it is a central GIS system, where new information that will be generated is processed.

Output (output). This subsystem shows new information and quantitative and qualitative geographic data analysis. The output can be in the form of maps, tables, or archives, which can then be presented in hardcopy or printed form.

3. RESEARCH METHODOLOGY

The researchers use a qualitative approach to prepare land-use change and visualize the results in Story Maps. Then, the topographic map data for the watershed, land use maps, and rainfall data are used to determine the planned rainfall and the planned flood discharge.

The data analysis method is carried out by comparing land use by digitizing maps for 2010 and 2019. Here, researchers use the ArcGIS program to obtain land cover classifications from RBI maps of the Geospatial Information Agency.

4. RESULTS AND DISCUSSIONS

Land Use

Landsat 8 image interpretation, using a combination of the best bands for land cover classification, and observing the correctness of land cover objects visually in the field, identifies five land cover classes: water open space (blue), buildings (yellow), bush grass (light green), soil (light brown), and vegetation (dark green).

Changes in land use and cover are the main elements to determine the level of vulnerability to inundation. The information is obtained from the results of the interpretation/interpretation of Ikonos images in 2010 and 2019 through GIS. Then, based on the above interpretation, the researchers conducted a Ground Check on all types of land use and land cover in the Krukut Catchment Area, presented in table 3 and Figure 1.

The highest percentage of total land use in 2010 was open space for buildings 78.44%, vegetation at 8.72%, land at 5.70%, grass at 5.16%, and the last one was water at 1.98%.

The highest percentage of total land use in 2019 was building open space at 92.54%, vegetation at 5.79%, soil at 0%, grass bushes at 0%, and water at 1.67%.

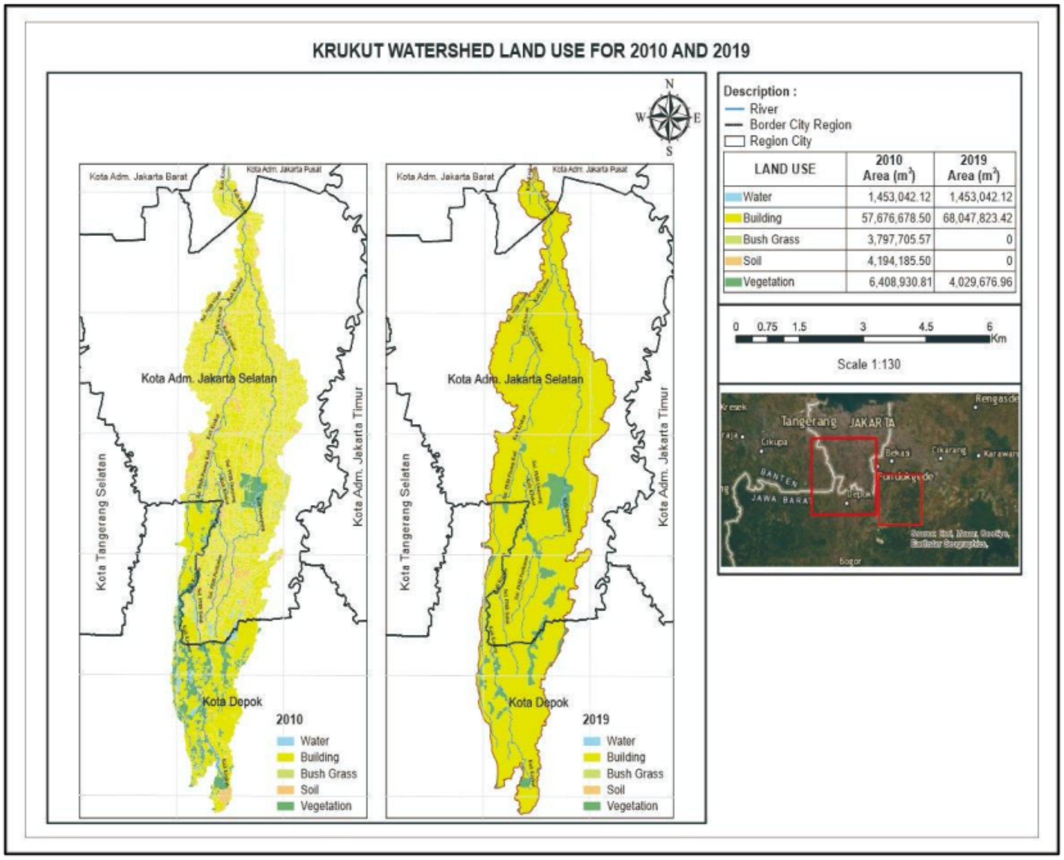


Figure 1. Land cover and use maps for 2010 and 2019, Source: Analysis (2022).

Table 3. Krukut watershed land use and cover in 2010 and 2019

Land cover class	2010 Land Cover		2019 Land Cover	
	Size (Km^2)	Percentage (%)	Size (Km^2)	Percentage (%)
Water	1.45	1.98	1.45	1.67
Building	57.68	78.44	68.05	92.54
Bush grass	3.80	5.16	0	0
Soil	4.19	5.7	0	0
Vegetation	6.41	8.72	4.03	5.79
Amount	73.53	100	73.53	100

Source: Analysis (2022)

Table 4. Determination of CN and C values (flow coefficient)

Krukut Watershed									
No	Land cover class	Coef. CN	Coef. C	Size (Km^2)		*CN*		*C*	
				2010	2019	2010	2019	2010	2019
1	Water	98	0	1,453	1,453	142.40	142.40	0.00	0.00
2	Building	83	0,95	57,677	68,048	4,787.16	5,647.97	54.79	64.65
3	Bush grass	65	0,2	3,798	0,000	246.85	0.00	0.76	0.00
4	Soil	86	0,4	4,194	0,000	360,70	0.00	1.68	0.00
5	Vegetation	70	0,15	6,409	4,029	448.63	282.08	0.96	0.60
	Total			73,53	73,53	5,985.74	6,072.44	58.19	65.25
	Weighted					81.40	82.58	0.79	0.89

Source: Analysis (2022)

Rain Intensity

The amount of rainfall per unit period is needed to facilitate the calculation of the design flood hydrograph. It is necessary to know the value of the planned rain for a certain period to determine the value of the intensity of rainfall, which is sought using the Mononobe method as follows:

$$I_T = \frac{R_{24}}{t}\left(\frac{t}{T}\right)^{2/3}$$

Note:

I_T: Rain Intensity at T (mm/hour)

R_{24}: Planned rainfall in 24 hours (mm)

t: time from rain to T (hours)

T: Concentration time (hour)

Table 5. Rainfall intensity values for various return periods in 24 hours

Time		Tmax	Watershed rain intensity (mm/hour)						
Minute	Hour	24.000	T_R=2	T_R=5	T_R=10	T_R=25	T_R=50	T_R=100	TR24 150mm BMKG
5	0.083	1.817	209.9	247.0	270.8	300.3	322.0	343.5	272.6
10	0.167	1.145	132.2	155.6	170.6	189.2	202.8	216.4	171.7
15	0.250	0.874	100.9	118.8	130.2	144.4	154.8	165.1	131.0
30	0.500	0.550	63.6	74.8	82.0	90.9	97.5	104.0	82.5
50	0.833	0.391	45.2	53.2	58.3	64.7	69.4	74.0	58.7
70	1.167	0.313	36.1	42.5	46.6	51.7	55.4	59.1	46.9
90	1.500	0.265	30.6	36.0	39.4	43.7	46.9	50.0	39.7
110	1.833	0.231	26.7	31.5	34.5	38.2	41.0	43.7	34.7
130	2.167	0.207	23.9	28.1	30.9	34.2	36.7	39.1	31.1
150	2.500	0.188	21.7	25.6	28.0	31.1	33.3	35.6	28.2
170	2.833	0.173	20.0	23.5	25.8	28.6	30.7	32.7	26.0
190	3.167	0.161	18.6	21.9	24.0	26.6	28.5	30.4	24.1
210	3.500	0.150	17.4	20.4	22.4	24.9	26.6	28.4	22.6
230	3.833	0.142	16.4	19.2	21.1	23.4	25.1	26.8	21.2
250	4.167	0.134	15.5	18.2	20.0	22.1	23.7	25.3	20.1
270	4.500	0.127	14.7	17.3	19.0	21.0	22.5	24.0	19.1
360	6.000	0.105	12.1	14.3	15.6	17.4	18.6	19.8	15.7
1200	20.000	0.047	5.4	6.4	7.0	7.8	8.3	8.9	7.1
1440	24.000	0.042	4.8	5.7	6.2	6.9	7.4	7.9	6.3

Source: Calculation (2022)

Rain Distribution

The selection and distribution pattern influences the calculated design flood results. The same rainfall distributed with the long one will result in a lower flood peak than that distributed with a short duration. There are various methods available for estimating rainfall intensity. The method consists of two approaches: rainfall intensity data recorded in a short time and maximum daily rainfall for various return periods as a database.

In calculating this design flood, the data available is only the maximum daily rainfall (mm/24 hours) in one year of observation, so the Mononobe formula approach is used in the analysis. As for the design of the flood calculation, the rainfall hydrograph for the flood calculation station is distributed for 6 hours to get a critical one.

Table 6. Mononobe method rain distribution table (within 6 hours)

Mononobe	Tr=2	Tr=5	Tr=10	Tr=25	Tr=50	Tr=100	Tr 150mm
	115.52	135.94	149.03	165.25	177.18	189.02	150.00
0.067	7.79	9.17	10.05	11.15	11.95	12.75	10.12
0.100	11.59	13.64	14.95	16.58	17.78	18.97	15.05
0.550	63.57	74.81	82.01	90.94	97.51	104.02	82.55
0.143	16.52	19.44	21.32	23.64	25.34	27.04	21.46
0.080	9.23	10.86	11.90	13.20	14.15	15.10	11.98
0.059	6.81	8.02	8.79	9.74	10.45	11.15	8.84

Source: Calculation (2022)

Table 7. Rainfall plan on return of UI campus station

Return Period	Normal	Log Normal	Pearson III	**Log Pearson III**	Gumbel
100	171.17	179.73	179.70	**189.02**	189.44
50	165.03	170.89	171.10	**177.18**	177.18
25	158.20	161.57	161.94	**165.25**	164.82
10	147.64	148.13	148.57	**149.03**	148.16
5	137.72	136.54	136.90	**135.94**	134.98
2	118.77	116.85	116.83	**115.52**	115.07

Source: Calculation (2022)

Nakayasu dan *Soil Conservation Service (SCS) Hydrograph Results*

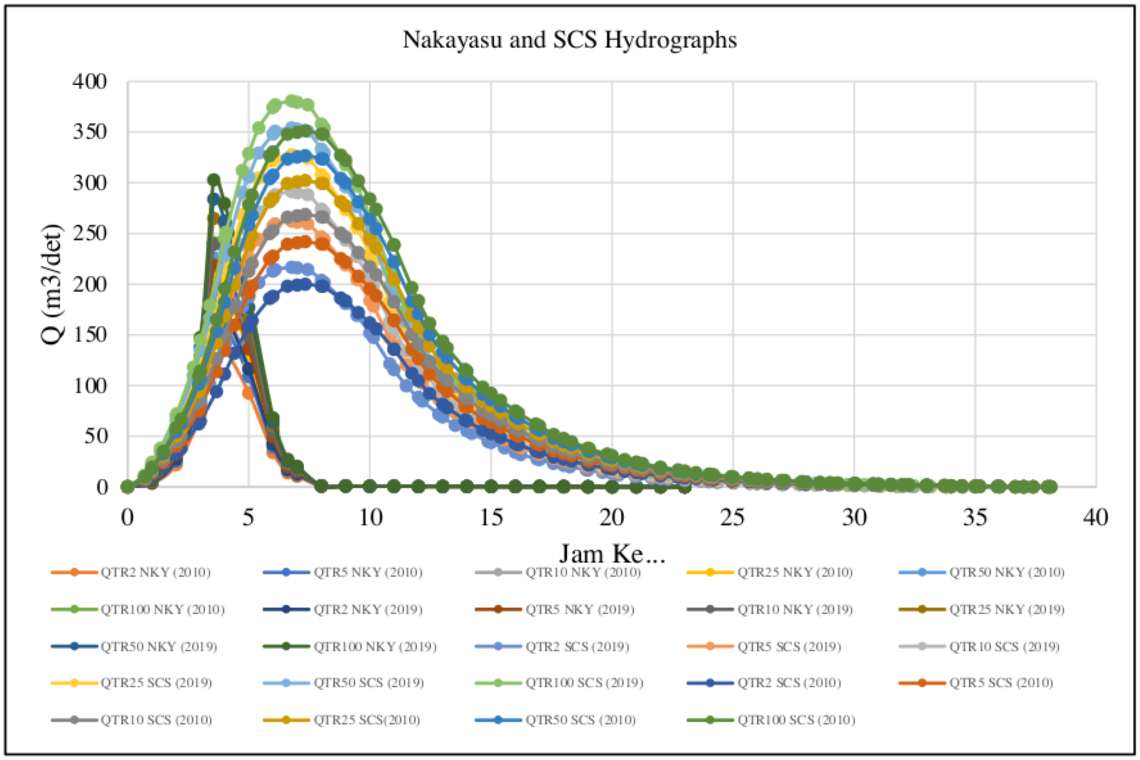


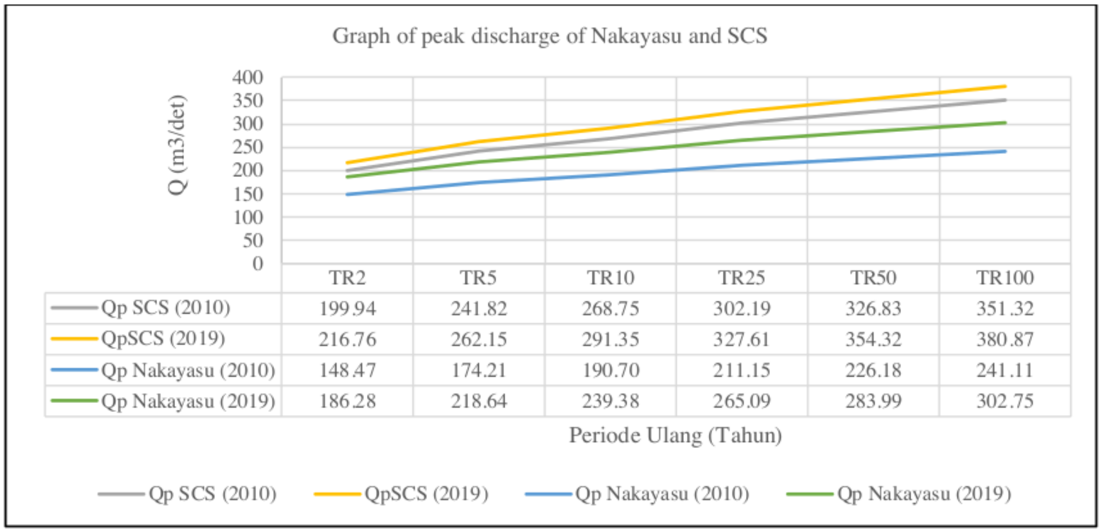
Figure 2. Nakayasu and SCS Hydrographs Based on Land Cover in 2010 and 2019

Source: Analysis (2022)

Table 8. Peak discharge of Nakayasu and SCS methods based on 2010 and 2019 land cover

Hydrograph	Tp (Jam)		Qp TR2		Qp TR5		Qp TR10		Qp TR25	
	2010	2010	2010	2019	2010	2019	2010	2019	2010	2019
Nakayasu	3.55	3.55	148.47	186.28	174.21	218.64	190.70	239.38	211.15	265.09
SCS	7.33	6.76	199.94	216.76	241.82	262.15	268.75	291.35	302.19	327.61

Source: Calculation (2022)



	TR2	TR5	TR10	TR25	TR50	TR100
Qp SCS (2010)	199.94	241.82	268.75	302.19	326.83	351.32
QpSCS (2019)	216.76	262.15	291.35	327.61	354.32	380.87
Qp Nakayasu (2010)	148.47	174.21	190.70	211.15	226.18	241.11
Qp Nakayasu (2019)	186.28	218.64	239.38	265.09	283.99	302.75

Figure 3. Graph of peak discharge of Nakayasu and SCS based on Land Cover 2010 and 2019

Source: Analysis (2022)

5. CONCLUSIONS AND SUGGESTIONS

Conclusions

The digitized maps of the Krukut watershed land use in 2010 and 2019 show changes. Here, the percentage of building open space from 78.44% to 92.54%, and the runoff coefficient value from 0.79% to 0.89. Meanwhile, open water space decreased from 1.98% to 1.67% in 2019. The discharge calculation uses the SCS Hydrograph to produce the maximum discharge value. Here, the calculation is on the 25-year return period. The results of the Q25 calculation in 2010 of 302.19 m3/second increased to 327.61 m3/second in 2019. We can see that the change in the discharge value from 2010 to 2019 in the Krukut watershed is 25.42 m3/second.

Suggestion

Reducing the open building space and increasing the rainwater catchment area on built-up land with the Low Impact Development (LID) concept can be used to suppress the increase in runoff.

REFERENCES

[1] Arsyad, S, (1989), Konservasi Tanah dan Air. IPB, Press, Bogor.

[2] Asdak, C. (2007). Hidrologi dan Pengelolaan Daerah Aliran Sungai. Cetakan Keempat (revisi). Gajah Mada University Press.Yogyakarta.

[3] A. Halim Hasmar, (2002). "Drainase Perkotaan", UII Press, Yogyakarta.

[4] Alimin, M., Wicaksono, K.S. & Sudarto. (2015). "Estimasi Limpasan Permukaan DAS Mikro Brantas Hulu Kecamatan Bumiaji kota Batu menggunakan Penginderaan Jauh dan Sistem Informasi Grafis". Jurnal Tanah dan Sumberdaya Lahan, Vol.2(2), 171-177.

[5] Ashley, R., Lundy, L., Ward, S et al. (6 more authors). (2013).” Water-sensitive urban design: opportunities for the UK. Proceedings of the ICE-Municipal Engineer”, 166 (ME2), 65–76. ISSN 0965-0903.

[6] Baja, S. (2012), Tata Guna Lahan dan Pengembangan Wilayah. Pendekatan Spasial dan Aplikasinya. Andi Yogyakarta.

[7] Bajocco, S., De Angelis, A., Perini, L., Ferrara, A., and Salvati, L. (2012). The Impact of Land Use/Land Cover Changes on Land Degradation Dynamics: a Mediterranean Case Study, Environmental Management. 49 (5), 980–9. doi:10.1007/s00267-012-9831-8.

[8] Bales, J.D., and Wagner, C.R. (2009). Sources of Uncertainty in Flood Inudation Maps, Journal of Flood Risk Management. 2 (2): 139-147.

[9] Budinetro, H.S, Fatchan, A.K, & Sahid, N. (2012). Pengendalian Aliran Permukaan Akibat Perubahan Tata Guna Lahan Dengan Konsep Low Impact Development. Seminar Nasional Teknik Sipil UMS 2012, 100-111.

[10] Chow, V.T., Maidment, D.R, and Mays, L.W. (1998) Applied Hydrology, McGraw-hill, New York.

[11] Data Citra Landsat 8 imagery (http://earththexplorer.usgs.gov/).

[12] Hamilton, G. W. and D. V. Waddington. (1999). Infiltration rates on residential lawns in central Pennsylvania. Journal of Soil and Water Conservation Vol. 54(3): 564-568.

[13] Kachholz, F & Tranckner, J. (2020). Long-Term Modelling of an Agricultural and Urban River Catchment with SWMM Upgraded by the Evapotranspiration Model Urban EVA. www.mdpi.com/journal/water.

[14] Keputusan Dekan Fakultas Teknik Sipil dan Lingkungan Institut Teknologi Bandung Nomor:113/SK/11.C09/KP/2020 Tanggal 8 Januari 2020 tentang Satgas Kajian Penanggunalangan Banjir DKI Jakarta dan Sekitarnya Center for Infrastrukture and Built Environment (CIBE) Fakultas Teknik Sipil dan Lingkungan Institut Teknologi Bandung, 2020.

[15] Kodoatie, R. J. (2013). Rekayasa dan Manajemen Banjir Kota. Penerbit C.V. Andi Offset

[16] Kepala Lembaga Penelititan dan Pengabdian Kepada Masyrakat Institut Pertanian Bogor, (2020) : Penyusunan Kajian dan Pemetaan Drainase Vertikal di Provinsi DKI Jakarta.

[17] Kalin, L. & Hantush, M. M. (2003). " Evaluation of Sediment Transport Models and Comparative Application of Two Watershed Models," United States Environmental Protection Agency.

[18] Lumbangaol, B K, Irawan A P & Pranoto, W A (2022) "Performance Review of Sustainable Urban Drainage System with LID Concept." IJEBD (International Journal of Entrepreneurship and Business Development) Volume 05 Number 04 July 2022.

[19] Lumbangaol, B K, Irawan A P & Pranoto, W A (2022) "Study of Integrated Systems Pumps in Coast of DKI Jakarta." IJEBD (International Journal of Entrepreneurship and Business Development) Volume 05 Number 03 May 2022.

[20] Lumbangaol, B K, Irawan A P & Pranoto, W A (2023) "Inundation Prediction Model based on land Use in Krukut Watershed." IJEBD (International Journal of Entrepreneurship and Business Development) Volume 06 Number 05 September 2023.

[21] Malamassam, M.R. & Pakasi, S. E. (2006). “Simulasi Pemanfaatan Lahan Berdasarkan Pendugaan Erosi Tanah: Studi Kasus Sub DAS Mowewe di DAS Konaweha Sulawesi Tenggara”. Jurnal Perennial, Vol.2(2), 47-52.

[22] Mahmmod, R et al. (2010) Impact of land use/land cover change on climate and future research priority, American Meteorogical society.

[23] McCuen, R. H. (1989). Hydrologic Analysis and Design. Prentice Hall, New York.

[24] Nurhamidah, Junaedi & Kurniawan, M. (2018). "Tinjauan Perubahan Tata Guna Lahan Terhadap Limpasan Permukaan, Kasus: DAS Batang Arau Padang". Jurnal Rekayasa Sipil (JRS-UNAND). Vol.14 No.2 ISSN (online):2477-3484.

[25] Peraturan Gubernur Provinsi DKI Jakarta Nomor 138 Tahun 2012 Tentang Penguasaan Perencanaan/Peruntukan Bidang Tanah Bagi Pelaksanaan Pembangunan untuk Kepentingan Umum Rencana Trace Kali Krukut, 2012.

[26] Peraturan Menteri Pekerjaan Umum Nomor 12/PRT/M/2009 Tanggal 24 Juni 2009 Tentang Pedoman Penyediaan dan Pemanfaatan Lahan Non Hijau di Wilayah Kota/Kawasan Perkotaan, Perencanaan Prasarana, Sarana dan utilitas RTNH berpedoman pada Konsep LID (Low Impact Development).

[27] Purwono, N (2013). “Pemodelan Spasial Untuk Identifikasi Banjir Genangan di Wilayah Kota Surakarta Dengan Pendekatan Metode Rasional, (RATIONAL METHOD)”. Publikasi Karya Ilmiah.

[28] Putra, C.P, Mudra, w. & Yulianti, E. (2022). Perencanaan Kolam Retensi Dalam Penanganan Banjir di Kabupaten Pasuruan Jawa Timur. Student Journal GELAGAR Vol.4 No.2.

[29] Ramadhan, I.K.B, & Susetyo C. (2020). Prediksi debit limpasan air permukaan dapa daerah rawan banjir di kabupaten jombang berdasarkan pemodelan penggunaan lahan. Jurnal Teknik ITS Vol.9. No.2. ISSN:2337-3539 (2301-9271).

[30] Seyhan., Ersin. (1977). Fundamentals of Hidrology. Instituut voor Aardwetenschappen vrije Universiteit, Amsterdam.

[31] Soemarno, (2006). Perencanaan Pengelolaan Lahan di Daerah Aliran Sungai (DAS) Kali Konto, Agritek Yayasan Pembangunan Nasional. Malang.

[32] Syukur, S. (2009). Laju infiltrasi dan Perannya Terhadap Pengelolaan Daerah Aliran Sungai Allu-Bangkala. Jurnal Agroland. 16 (3): 231 -236.

[33] Tetra Tech, Inc. (2007), Sept. Elements of Progressive Stormwater Ordinances Encouraging LID. Oakland, CA: Ocean Protection Council. (Available upon request).

[34] Undang-undang Republik Indonesia Nomor 7. (2004). Sumberdaya Air. Lembaran Negara Republik Indonesia Tahun 2004 Nomor 32, Tambahan Lembaran Negara Republik Indonesia Nomor 4377. Jakarta.

[35] Undang-undang Republik Indonesia Nomor 26. (2007). Penataan Ruang. Jakarta.

[36] Wibowo, M. (2011). Pemodelan statistik Hubungan debit dan kandungan sedimen sungai Contoh kasus di DAS Citarum – Nanjung, Jurnal Teknologi Lingkungan. 2 (3): 255-260.

[37] Wirosoedarmo, R., Tunggul, A.S.H., dan Meidya, E.P. (2010). Studi Bentuk, Jaringan Drainase, Dan Hidrograf Daerah Aliran Sungai Menggunakan Simodas (Studi Kasus Di Pulau Sabu Nusa Tenggara Timur). 11 (2): 123-130.

[38] Z., Peng, and V, Stovin, (2017). “Independent Validation of the SWMM green roof module”. Journal of Hydrologic Engineering, 22(9).

[39] Zhao, Y., Zhang, K., Fu, Y., and Zhang, H. (2012). Examining Land-Use/Land-Cover Change in the Lake Dianchi Watershed of the Yunnan-Guizhou Plateau of Southwest China with remote sensing and GIS techniques: 1974–2008. International Journal of environmental research and public health. 9 (11): 3843–65. doi:10.3390/ijerph91138

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