Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 4, Number 09, 2025, DOI 10.58471/esaprom.v4i09
ESSN 2828-9463 (Online)
https://ejournal.seaninstitute.or.id/index.php/esaprom

Determination of River Regime Coefficient and Water Storage Coefficient in Assessing Watershed Health in the Pacal Watershed, Bojonegoro

Yuliani Wahyu Sardana
Department of Civil Engineering, Bojonegoro University, Bojonegoro

Article Info

Keywords:
Watershed Health,
River Regime Coefficient (KRS),
Water Storage Cofficient(KSA),
Pacal Watershed.

ABSTRACT

Watershed health is a crucial indicator of the watershed's ecological function and its capacity to provide sustainable environmental services. Environmental degradation due to anthropogenic activities such as land conversion in the Pacal watershed, Bojonegoro, has triggered an increase in the frequency of floods and droughts, indicating a critical decline in the watershed's hydrological function. This study aims to quantitatively evaluate the health level of the Pacal watershed through the analysis of two hydrological parameters River Regime Coefficient (KRS) and Water Storage Coefficient (KSA). The analysis results indicate that the hydrological condition of the Pacal Watershed falls into the poor category. The average KRS value during the 2013-2022 period was 282, classified as Very High. This very high KRS value indicates extreme discharge fluctuations and significant river flow instability, which have a high potential to trigger floods and droughts. Meanwhile, the average KSA value obtained was 0.057, classified as Poor. A very low KSA value indicates very limited infiltration and groundwater storage capacity, resulting in most rainwater becoming rapid surface runoff and minimal base flow during the dry season. Poor KRS and KSA values indicate that the water regulation function of the Pacal Watershed has been critically degraded.

Corresponding Author:
Yuliani Wahyu Sardana
Bojonegoro University
Jl. Lettu Suyitno No. 2, Kalirejo Bojonegoro
yulianiwahyusardana25@gmail.com

INTRODUCTION

A watershed is an integrated ecosystem that plays a vital role in the hydrological cycle, encompassing interactions between physical, biological, and socioeconomic components (Suprayogi et al., 2024). Watershed health is a multidimensional indicator that reflects the ecological function and capacity of the watershed to provide sustainable environmental services (Wariunsora et al., 2024). Watershed health assessment is crucial for identifying environmental degradation, formulating effective conservation strategies, and ensuring the sustainability of water resources for future generations (Sudiyanto et al., 2025). This assessment often uses a quantitative approach, one of which is through hydrological analysis, which includes river regime coefficients (KRS) and water storage coefficient (KSA) (Ilmi, 2019).

KRS is a hydrological parameter that reflects fluctuations in river water discharge throughout the year, which is an indicator of river flow stability (Saifudin et al., 2017). A high KRS indicates a significant variation in discharge between the rainy and dry seasons, indicating an unhealthy watershed with a high potential for flooding and drought. Conversely, a low KRS indicates a more stable flow, reflecting the watershed's ability to regulate water (Bin Ishaq & Purwadi, 2016). Meanwhile, KSA measures the water storage capacity within a watershed, which is closely related to vegetation conditions, infiltration, and groundwater reserves (Mazmum & Mardyanto, 2015). A good KSA indicates that a watershed has a high carrying capacity to store water, reduce surface runoff, and maintain water availability during the dry season (Khalis et al., 2025).

The Pacal River is a watershed in Bojonegoro Regency, East Java, which plays a vital role in supporting the agricultural sector and meeting the domestic water needs of the surrounding community (Harjono & Widyastuti, 2019). However, anthropogenic activities such as land conversion and deforestation in the upstream area of the Pacal watershed have the potential to cause environmental degradation that affects the watershed's hydrological function (Ridwan & Sarjito, 2024). The increasing frequency of floods and droughts in the downstream area of the Pacal watershed is an indication of a decline in watershed health that requires an in-depth study. Based on these problems, this study focuses on analyzing KRS and KSA as two key hydrological indicators to evaluate the health of the Pacal watershed.

Previous studies have extensively discussed watershed health assessment using various methods, including spatial analysis, land cover indices, and socioeconomic evaluations (Faridawaty et al., 2024; Dahlan, 2024; Basuki, 2014). However, research specifically integrating comprehensive KRS and KSA analyses as quantitative measurement tools for watershed health assessment in the Pacal Bojonegoro area is still limited. Therefore, this study aims to determine the hydrological characteristics of the Pacal watershed through KRS and KSA calculations, assessing the health level of the Pacal watershed based on these hydrological parameters.

While broader ecological assessments often rely on remote sensing data for land cover classification (Latuamury, 2020), the KRS and KSA indices offer a more direct and dynamic perspective on watershed hydrological functioning (Widiatmoko et al., 2020). Both analyses distil the complex impacts of land-use change into a single quantity that quantifies the watershed's response to rainfall input. Therefore, for watersheds experiencing significant stress, such as the Pacal River, these approaches provide an indispensable metric for understanding how severely the regularity of the water cycle has been disrupted, ultimately determining vulnerability to hydrological hazards.

The degradation occurring in the Pacal watershed, driven primarily by the conversion of forest to cultivated land and settlements, fundamentally alters two key aspects. First, the removal of the vegetation canopy reduces interception and increases the impact energy of rainwater, accelerating erosion. Second, soil compaction resulting from anthropogenic activities significantly reduces the infiltration rate, a key component of the AQA. When infiltration is hindered, a significant portion of rainwater becomes surface runoff directly,

Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 4, Number 09, 2025, DOI 10.58471/esaprom.v4i09
ESSN 2828-9463 (Online)
https://ejournal.seaninstitute.or.id/index.php/esaprom

resulting in increased peak discharge (flooding) and decreased base discharge (drought), both of which manifest as deteriorating AQA values.

The consequences of this deteriorating hydrological function have a direct impact on regional water security in Bojonegoro. For communities heavily dependent on agricultural irrigation from the Pacal River, extreme fluctuations in river discharge pose a significant threat to crop productivity and the economic stability of farmers. Furthermore, declining groundwater reserves, reflected in low KSA values, trigger scarcity and conflicts over water use, particularly during prolonged dry seasons. Therefore, the assessment of KRS and KSA is not merely an academic exercise, but a strategic mandate to ensure risk mitigation and ensure water availability for life and livelihoods.

METHODS

The research location is situated in the Pacal Watershed, Bojonegoro Regency, covering a watershed area of 303.24 km² (Figure 1.). This location was chosen because the Pacal River is the longest in Bojonegoro Regency, measuring 66 km in length. It crosses several sub-districts in Bojonegoro Regency, with its upstream section located in Gondang District and its downstream section in Kapas District.

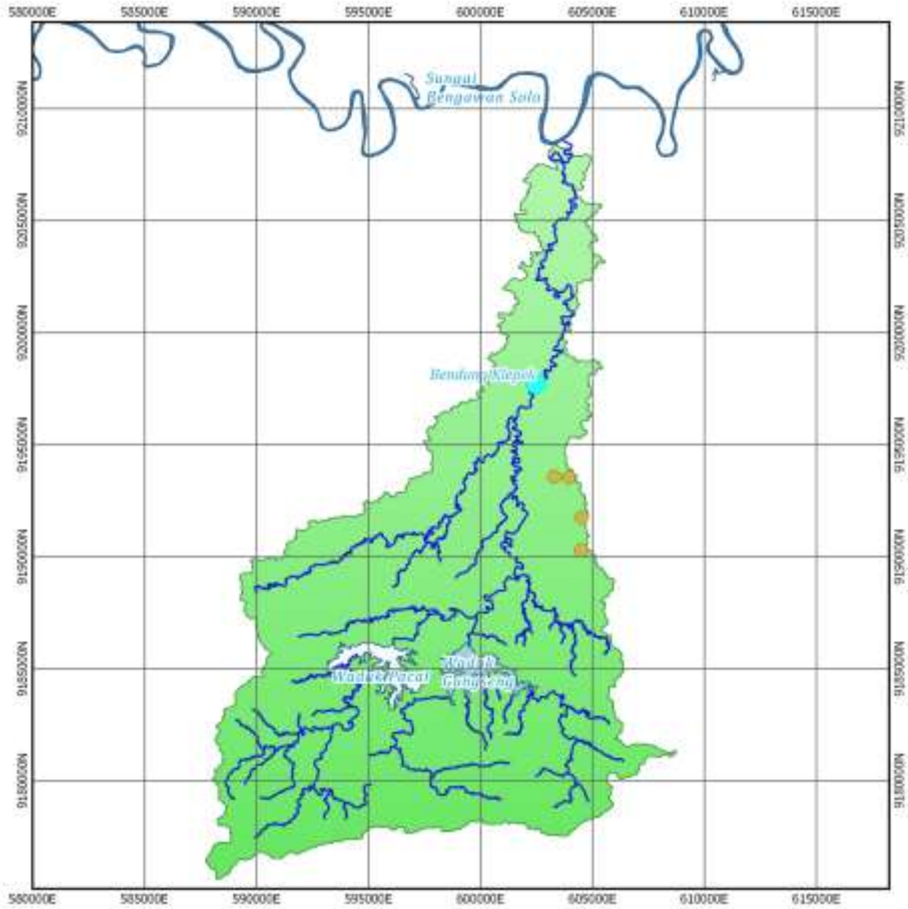

Figure 1. Pacal Watershed Research Location

Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 4, Number 09, 2025, DOI 10.58471/esaprom.v4i09
ESSN 2828-9463 (Online)
https://ejournal.seaninstitute.or.id/index.php/esaprom

This study uses a quantitative method with a descriptive approach to analyze and assess the health of the Pacal Bojonegoro River Basin . The data used are secondary data, including daily water discharge data, rainfall, and watershed geospatial data, sourced from relevant agencies such as the Bengawan Solo River Basin Centre and the Meteorology, Climatology, and Geophysics Agency, for the period 2013-2022. These data are then processed and analyzed using software, namely Microsoft Excel and QGIS. The use of QGIS aims to map and visualize spatial data related to the physical characteristics of the watershed, including area and land use.

Data analysis was conducted in two main stages, namely determining the River Regime Coefficient (KRS) and the Water Storage Coefficient (KSA). The first stage, determining the KRS, involved comparing the annual maximum water discharge (Q_{max}) with the annual minimum water discharge (Q_{min}) using the formula $KRS=Q_{max}/Q_{min}$. The KRS value indicates the level of fluctuation in river water discharge. The second stage, determining the KSA, is carried out by comparing the minimum annual water discharge (Q_{min}) with the average annual water discharge (Q_{rate}) using the formula $KSA=Q_{min}/Q_{rate}$. The KSA value reflects the watershed's ability to store water during the dry season.

Once the KRS and KSA values are obtained, these two coefficients are used as indicators to assess watershed health. Watershed health assessment is based on criteria established by the Ministry of Environment and Forestry, which classifies watersheds into several categories, such as healthy, reasonably healthy, or diseased. These criteria cover the ideal range of KRS and KSA values. The results of this analysis provide an objective picture of the hydrological conditions in the Pacal Bojonegoro watershed, which can then serve as the basis for policy recommendations to improve and sustain better watershed management.

RESULTS AND DISCUSSION

The health of a watershed cannot be assessed solely on its physical or biological condition; rather, it is a synthesis of its hydrological and ecological functions. In the context of quantitative analysis, the River Regime Coefficient (KRS) and the Water Storage Coefficient (KSA) serve as two key diagnostic pillars that synergistically describe the hydrological health status of a watershed.

River Regime Coefficient (KRS)

The River Regime Coefficient (KRS) is a hydrological parameter used to measure fluctuations in river water discharge. This parameter is calculated by comparing the maximum discharge (Q_{max}) and minimum discharge (Q_{min}) recorded over a specified period. KRS reflects the watershed's ability to regulate water flow. The results of the recapitulation of maximum daily debit and minimum daily debit in Pacal DAS are presented in Table 1.

The recapitulation of the River Regime Coefficient (KRS) calculations for the Pacal Watershed from 2013 to 2022 shows an average value of 282. This value indicates very high discharge fluctuations, indicating significant instability in river flow between the rainy and dry seasons. Based on the applicable evaluation standards for KRS, this value is categorized as poor (greater than 80). This condition indicates the watershed's low capacity to maintain water flow continuity, as well as its limited ability to infiltrate and store rainwater.

Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 4, Number 09, 2025, DOI 10.58471/esaprom.v4i09
ESSN 2828-9463 (Online)
https://ejournal.seaninstitute.or.id/index.php/esaprom

Table 1. Value of Q_{min} dan Q_{maks} Every Year (m^3/s)

Year	Maximum		Minimum	
	Discharge (m^3/s)	Date	Discharge (m^3/s)	Date
2013	54,23	14 April 2013	0,63	22 September 2013
2014	52,54	19 March 2014	0,24	14 October 2014
2015	50,31	13 April 2015	0,07	01 September 2015
2016	42,99	01 January 2016	0,09	21 December 2016
2017	44,48	28 February 2017	0,24	02 November 2017
2018	46,97	01 February 2018	0,19	03 November 2018
2019	47,1	06 March 2019	0,26	13 September 2018
2020	58,81	25 January 2020	0,32	13 October 2020
2021	66,55	03 March 2021	0,34	31 October 2021
2022	54,88	20 March 2022	0,17	20 September 2022

*) Source : Processing Results, 2025.

A high KRS value indicates that the Pacal Watershed has a low capacity to store and regulate water, resulting in rapid runoff. This can be caused by land degradation in the upstream watershed, such as reduced vegetation cover and changes in land use to agricultural or residential areas that are less effective at absorbing water. This condition risks causing flooding during the rainy season and drought during the dry season, which directly impacts the availability of clean water and irrigation for the surrounding community.. Analysis of the annual data reveals a worrying trend, as shown in Table 2. The lowest KRS value was recorded in 2013, at 86.08, which falls into the high category. This can be considered the starting point of degradation, where the watershed still has little capacity to regulate discharge.

Tabel 2. Recapitulation of KRS Value Calculation Results

Year	Q_{maks} (m^3/s)	Q_{min} (m^3/s)	KRS	Category
2013	54,23	0,63	86,08	High
2014	52,54	0,24	218,92	Very High
2015	50,31	0,07	718,71	Very High
2016	42,99	0,09	477,67	Very High
2017	44,48	0,24	185,33	Very High
2018	46,97	0,19	247,21	Very High
2019	47,1	0,26	181,15	Very High
2020	58,81	0,32	183,78	Very High
2021	66,55	0,34	195,74	Very High
2022	54,88	0,17	322,82	Very High

*) Source : Processing Result, 2025.

In 2015, the KRS value jumped dramatically to 718.71, the highest value during the observation period. This extreme fluctuation could be the result of a combination of very high

Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 4, Number 09, 2025, DOI 10.58471/esaprom.v4i09
ESSN 2828-9463 (Online)
https://ejournal.seaninstitute.or.id/index.php/esaprom

rainfall on the one hand (increasing Qmax) and severe drought conditions on the other (decreasing Qmin). This value indicates that the watershed is in deplorable condition, with almost no adequate water storage capacity.

Despite slight fluctuations, most years from 2014 to 2022 showed KRS values in the very high category. This indicates that the watershed's condition is not improving but instead continues to be under significant hydrological stress. The average value of 282 confirms that these extreme fluctuations are not sporadic events, but rather the dominant hydrological characteristic of the Pacal watershed over the past decade.

Water Storage Coefficient (KSA)

The Water Storage Coefficient (KSA) is a ratio that indicates what percentage of rainfall falling in a watershed is converted into surface flow (runoff). The WCS value reflects the watershed's ability to absorb and store water in the soil. The calculation results show that the average KSA value obtained was 0.057, which falls within the poor category, namely <0.1. For most years, the KSA value was in the poor category. The lowest values were recorded in 2016 (0.018) and 2015 (0.022), which coincided with extreme spikes in the KRS value. This indicates that when the watershed's water storage capacity reaches its lowest point, discharge fluctuations become very severe.

Very low KSA values are directly related to low Qmin, indicating minimal base flow. Base flow is the discharge that originates from groundwater reserves. When Qmin is very small, it means that the groundwater reserves in the watershed are virtually non-existent or unable to recharge the river. These results indicate limited groundwater infiltration and storage capacity, caused by suboptimal land cover and vegetation degradation. As a result, most rainwater flows as surface runoff, increasing the risk of flooding.

Tabel 3. Summary of KSA Value Calculation Results

Year	Q_{min} (m/s)	Q_{rerata} (m/s)	KSA	Category
2013	0,63	5,5	0,115	Pretty Bad
2014	0,24	4,04	0,059	Bad
2015	0,07	3,12	0,022	Bad
2016	0,09	4,99	0,018	Bad
2017	0,24	2,76	0,087	Bad
2018	0,19	4,79	0,040	Bad
2019	0,26	3,68	0,071	Bad
2020	0,32	5,98	0,054	Bad
2021	0,34	4,7	0,072	Bad
2022	0,17	5,11	0,033	Bad

*) Source: Processing Results, 2025.

The low KSA value aligns with the high KRS finding. This condition indicates that the Pacal watershed is unable to function as a natural "sponge" that absorbs rainwater. Instead, it tends to act as a water channel that rapidly moves water, thus worsening hydrological conditions. KRS is a reflection of surface hydrological conditions, indicating how water moves through the watershed, while KSA is an indicator of subsurface hydrological conditions, indicating how water is stored. The combination of poor KRS and poor KSA values in the Pacal watershed collectively indicates that all hydrological functions of the watershed—from infiltration to discharge—are in critical condition. The watershed is unable to balance water discharge, which is its primary hydrological function.

CONCLUSION

The conclusion drawn from the analysis conducted on the Pacal Bojonegoro Watershed is that the River Regime Coefficient (KRS) is alarming and the Water Storage Coefficient (KSA) is limited, thus posing a serious health risk for the Pacal Watershed. The combination of high KRS and low KSA values in the Pacal Watershed clearly indicates that the watershed has experienced severe degradation.

REFERENCE

Basuki, T. M. (2014). Indikator dan parameter kriteria lahan untuk monitoring dan evaluasi kinerja sub-das. *Jurnal Penelitian Sosial dan Ekonomi Kehutanan*, *11*(3), 281-297.

Bin Iskhaq, F., & Purwadi, O. T. (2016). Kajian pengelolaan sumber daya air permukaan berbasis Geographics Information System (GIS) di Kota Bandar Lampung. *Jurnal Rekayasa Sipil dan Desain*, *4*(3), 128328.

Dahlan, N. A. (2024). *Analisis Perubahan Penutupan Lahan Sebagai Salah Satu Indikator Kualitas Daerah Aliran Sungai Biang Loe= Analysis Of Land Cover Changes As One Of The Quality Indicators Of The Biang Loe River Flow Area* (Doctoral dissertation, Universitas Hasanuddin).

Faridawaty, W., Lihawa, F., Hasim, D. W. K., & Mahmud, M. (2024). Analisis Model Spasial Kondisi Lahan Daerah Aliran Sungai (DAS): Mendukung Pengambilan Keputusan Berkelanjutan di DAS Paguyaman, Indonesia. *Journal of International Multidisciplinary Research Vol*, *2*(5).

Harjono, H., & Widhiastuti, Y. (2019). Analisa hidrologi dan hidrolika pada daerah aliran sungai (DAS) kali Pacal Bojonegoro. *Rekayasa Sipil*, *13*(1), 16-23.

Ilmi, M. K. (2019). Kajian pengaruh perubahan tata guna lahan terhadap kondisi hidrologi daerah aliran sungai (DAS) Dodokan, Provinsi Nusa Tenggara Barat. *Prosiding Konferensi Nasional Pascasarjana Teknik Sipil (KNPTS) X, ISSN*, 2477-00.

Khalis, I. M., Swahip, S., Hidayat, A. R., & Fibriyanti, B. V. (2025). Kajian Daya Dukung Tata Air sebagai Upaya Perencanaan Pengelolaan Daerah Aliran Sungai (DAS) yang Berkelanjutan (Studi Kasus pada DAS Dodokan, NTB, Indonesia). *AGREGAT*, *10*(1), 1302-1312.

Latuamury, B. (2020). *Pemodelan Perubahan Penggunaan Lahan dan Karakteristik Resesi Aliran Dasar Sungai*. Deepublish.

Mahzum, M. M., & Mardyanto, M. A. (2015). Analisis Ketersediaan Sumber Daya Air dan Upaya Konservasi Sub DAS Brantas Hulu Wilayah Kota Batu. *Institut Teknologi Sepuluh Nopember*.

Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 4, Number 09, 2025, DOI 10.58471/esaprom.v4i09
ESSN 2828-9463 (Online)
https://ejournal.seaninstitute.or.id/index.php/esaprom

Ridwan, M., & Sarjito, J. (2024). Studi kajian dampak perubahan tutupan lahan terhadap kejadian banjir di daerah aliran sungai. *ENVIRO: Journal of Tropical Environmental Research*, *26*(1), 38-45.

Saifudin, I., Suripin, S., & Suharyanto, S. (2017). Kajian Respon Perubahan Penggunaan Lahan Terhadap Karakteristik Hidrologi DAS Garang (Doctoral dissertation, Postgraduate Program).

Sudiyanto, I. W., Judijanto, L., Azis, S. M., Pakanan, J. J., & Ayyub, F. R. (2025). *Ekologi dan Konservasi Lingkungan*. PT. Sonpedia Publishing Indonesia.

Suprayogi, S., Purnama, L. S., & Darmanto, D. (2024). *Pengelolaan Daerah Aliran Sungai*. UGM PRESS.

Widiatmoko, N., Tarigan, S. D., & Wahjunie, E. D. (2020). Analisis Respons Hidrologi untuk Mendukung Perencanaan Pengelolaan Sub-DAS Opak Hulu, Daerah Istimewa Yogyakarta. *Jurnal Ilmu Pertanian Indonesia*, *25*(4), 503-514.

Wariunsora, S., Kusuma, Z., & Suprayogo, D. (2024). Analisis Hubungan Tutupan Lahan dan Indikator Kesehatan Hidrologi DAS Rejoso, Jawa Timur. *Jurnal Tanah dan Sumberdaya Lahan*, *11*(1), 289-300.