JWS JOURNAL OF WORLD SCIENCE
JOURNAL OF WORLD SCIENCE
https://jws.rivierapublishing.id/index.php/jws
Volume 4 No. 8 August 2025
P-ISSN: 2828-8726
E-ISSN: 2828-9307

Cross-Sectional Analysis of the Cisanggarung River Against Flooding in Babakan Village Using the HEC-RAS Program

Fadhli Dzil Ikram[1], Muhammad Ghafar Franandi[2], Akyono[3], Awliya Tribhuwana[4]
Universita Swadaya Gunung Jati, Indonesia
Email: fadhlidzilikram1227@gmail.com, mghafar776@gmail.com, akyono63@gmail.com, tribhuwana69@gmail.com

ABSTRACT
Floods are hydrometeorological disasters that significantly affect communities, infrastructure, and the environment. This study aims to assess the capacity of the *Cisanggarung* River to accommodate flood discharge flow using HEC-RAS software. The analysis was based on rainfall data from three observation stations: Losari Station, Cangkuang Station, and Gebang Station. The research utilized frequency analysis, probability distribution tests, and hydrological and hydraulic simulations to evaluate the river's ability to handle floodwaters. The findings indicated that the current cross-section of the *Cisanggarung* River is insufficient to accommodate the planned flood discharge of 904.8 m³/sec, suggesting the need for river normalization efforts. This study provides critical insights for flood mitigation strategies, including infrastructure improvements and watershed management optimization. By implementing effective mitigation measures, the risk and impact of flooding in the region can be significantly reduced, contributing to improved flood resilience and urban planning.

Keyword: Flood mitigation, HEC-RAS simulation, River cross-section capacity

Corresponding Author: Fadhli Dzil Ikram
E-mail: fadhlidzilikram1227@gmail.com

INTRODUCTION

Floods are among the most common natural disasters and have a significant impact on human life, infrastructure, and the environment. They occur when the volume of flowing water exceeds the capacity of rivers or drainage systems, causing water to overflow into surrounding areas. In Indonesia, floods occur almost every year. Over the past decade, flood incidents have consistently ranked at the top of the list of the most frequently occurring disasters (Alliyu, 2023b, 2023a; Qodriyatun, 2020; Rai Ayari & Asyiawati, 2023; Tuharyati et al., 2023). A *Daerah Aliran Sungai* (*DAS*), or River Basin, is an area that collects and channels rainfall to a single point with the same flow, typically to areas with lower topography. In other words, the boundaries of a river basin are determined by the highest points in its landscape (Haezer et al., 2023).

According to Article 33, paragraph (3) of the 1945 Constitution of the Republic of Indonesia, natural resources such as land, water, and the wealth contained therein fall under the authority of the state and must be utilized to the fullest extent for the welfare of the people. As watersheds are part of the environment containing water resources and natural wealth, their existence must be preserved, regulated, and managed by the state for the benefit of the community. Watershed management encompasses various actions aimed at maintaining a balance between the utilization of natural resources and human activities within them so that ecosystems remain sustainable and their benefits can be enjoyed continuously (Aryani et al., 2020). The causes of floods are diverse, ranging from extremely high rainfall and overflowing water bodies to changes in land use (Miller & Hutchins, 2017).

The main factor contributing to flooding is heavy rainfall lasting for extended periods. Another factor is weak supervision of land use in flood-prone areas, reflecting the low effectiveness of spatial planning instruments in mitigating floods (Hamdani et al., 2016). Changes in one or more components of the environment will invariably affect other components with varying intensities (Rosyidie, 2013).

As Adolph states in their comprehensive study of river systems, “Rivers not only function as natural pathways that carry water to lower-lying areas, but also as sediment transport systems that maintain the natural morphological balance. This process occurs continuously and has long-term impacts on the formation of the surrounding landscape and ecosystems” (Adolph, 2016). Similarly, according to Mujahid Zakir in their research on river ecology, “Rivers play an irreplaceable role as life-sustaining systems, providing a sustainable water source for many species and actively supporting the growth and development of ecosystems, both on land and in aquatic environments. The presence of rivers creates unique and diverse microhabitats, which in turn support high biodiversity” (Mujahid Zakir et al., 2023). Rivers also contribute significantly to the energy sector, particularly through hydroelectric power plants (*HPPs*). The utilization of a river’s potential energy to generate electricity has become one of the most effective and sustainable renewable energy solutions (Peraturan Presiden Republik Indonesia, 2022).

With the rapid pace of urbanization and climate change, the risk of flooding continues to rise. Climate change can cause shifts in rainfall patterns and increase the frequency of extreme weather events. Meanwhile, urbanization often reduces the soil’s ability to absorb water, thereby increasing surface runoff (IPCC, 2014). Therefore, it is crucial to have effective tools for analyzing and predicting flood flow directions so that appropriate mitigation measures can be implemented (Kholiq et al., 2023).

HEC-RAS (*Hydrologic Engineering Center’s River Analysis System*) is one of the most widely used tools for hydrological and hydraulic analysis, particularly in flood modelling and river flow simulation. Developed by the United States Army Corps of Engineers, HEC-RAS has been applied in various projects to study and predict water flow behavior, both under normal conditions and during extreme events. This software offers features that enable users to simulate river flow in different flood scenarios, taking into account factors such as topography, rainfall intensity, and land use changes (Wigati & Soedarsono, 2016). HEC-RAS can also be used to map floods directly on area maps, allowing visualization of the extent of flood-affected areas (Sardana et al., 2023).

This study focuses on the *DAS Cisanggarung*, located in West Java Province, Indonesia. The *DAS Cisanggarung* covers an area of approximately 1,250 km² and encompasses various types of land use, including forests, agricultural land, and residential areas. The *Cisanggarung* River is one of the main rivers in the region and frequently experiences flooding, particularly during the rainy season. Flooding in this river basin affects several villages and towns, damaging infrastructure, farmland, and disrupting daily community activities.

This study addresses gaps in flood management research by applying the HEC-RAS method to analyze flood flow in the *DAS Cisanggarung*. Previous studies, such as Qodriyatun (2020), highlight the increasing frequency of floods in Indonesia but do not delve into specific river basin analyses or the use of advanced hydrological modelling tools like HEC-RAS to predict flood patterns. Similarly, Hamdani et al. (2016) discussed weaknesses in land use supervision in flood-prone areas but did not incorporate specialized flood prediction tools to optimize planning.

The purpose of this study is to use the HEC-RAS method to analyze flood flow directions in the *Cisanggarung* watershed, with the aim of providing more precise information on flood patterns to support effective mitigation planning (Nuzul et al., 2021). Through this analysis, high-risk flood areas can be identified, and appropriate mitigation measures can be formulated to reduce the impact of future floods. Based on the available data, this research focuses on the analysis of planned flood discharge using rainfall data from several rainfall observation stations, including the Ciwaru Rainfall Station, the Jatiseeng Rainfall Station, and the Garawangi Rainfall Station. The objective is to determine whether the *Cisanggarung* River's cross-section can accommodate the analyzed flood discharge by applying literature review methods and the HEC-RAS software.

METHOD

Figure 1. Research Location

Data collection methods refer to various systematic techniques used by researchers and analysts to obtain the information needed in a study or analysis. This process plays an essential role in every study, as the accuracy and relevance of the data obtained greatly influence the validity and reliability of the research results. The following describes the data collected in this study.

Consistency Test

The Double Mass Curve Analysis method was applied by analyzing rainfall data obtained from three observation stations: Losari Station, Cangkuang Station, and Gebang Station.

Frequency Distribution of Rainfall

Distribution testing plays a crucial role in statistical data analysis because many commonly used inferential statistical methods—such as regression analysis, *t*-tests, and analysis of variance (*ANOVA*)—are based on fundamental assumptions about the underlying data distribution. In particular, the assumption of a normal distribution often serves as the primary basis for these statistical methods.

Probability Distribution Test

The probability distribution test is a statistical method used to evaluate the goodness of fit between the observed data and the expected theoretical distribution.

Rainfall Plan

This refers to the method of estimating the amount of rainfall likely to occur over a specified future period. The results serve as a basis for planning drainage systems, flood protection measures, and other infrastructure.

Calculation of Nakayasu *HSS* Flood Discharge

This method focuses on simplifying the shape of the hydrograph for ease of interpretation. Based on the results of the Nakayasu *HSS* calculation, the maximum discharge is 904.8 m^3/second at a 10-year return period.

Analysis Using *HEC-RAS* Software

For flood analysis using the *HEC-RAS* software, the input data consisted of flood discharge values calculated using *HSS* Snyder analysis for a 10-year return period, applied within the Steady Flow method.

RESULTS AND DISCUSSION

Consistency Test

The Double Mass Curve Analysis method is used by analyzing rainfall data obtained from three observation stations, namely Losari Station, Cangkuang Station, and Gebang Station.

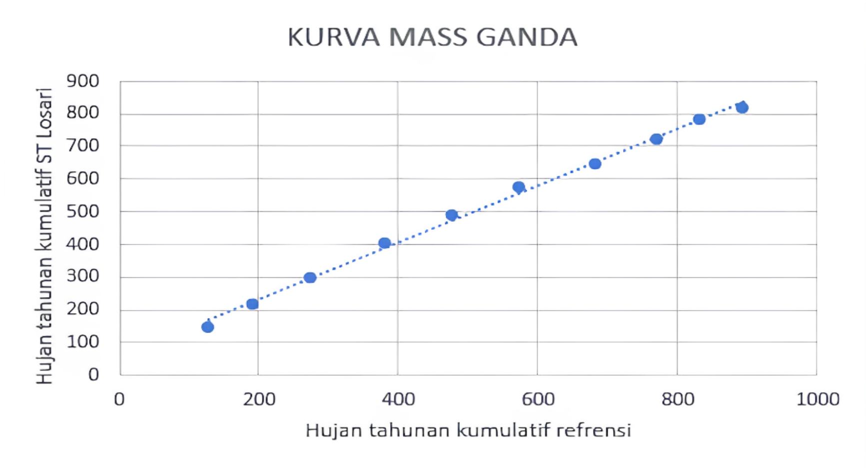

Figure 1. The Double Mass Curve

Frequency Distribution of Rainfall

Below are the results of the distribution calculation in tabular form:

Table 1. Frequency Distribution of Rainfall

No	Requirements		Results	Description
Gumbel	Cs	1.14	0.77	Disagree
	Ck	5.4	5.88	
Normal	Cs	0	0.77	Disagree
	Ck	3	5.88	
Log Pearson	Cs	not other than 0	1.3214	Agree
Log Normal	Cs	2	0.0062	Disagree
	Ck	4	3	

Description :
Cs = Coefficient Skewness
Ck = Coefficient Kurtosis

Based on the frequency distribution criteria listed in Table 1, it can be concluded that only the Log Pearson method fulfils the distribution standard. Nonetheless, additional testing is required to ensure that the method to be used is truly appropriate.

Probability Distribution Test

Values on the Chi Square parameter (X^2) (calculated) must be smaller than the critical Chi squared value.

Table 2. Probability Distribution Test

Metode	X^2(Hitting)	X^2(Critis)	Description
Gumbel	8.4	5.991	Disagree
Normal	5.2	5.991	Agree
Log Pearson	13.2	5.991	Disagree
Log Normal	5.2	5.991	Agree

Based on the results of the Chi-Quadrat test calculation, the Gumbel and Log Pearson methods do not fulfil the criteria as the values obtained are greater than the Critical Chi. Meanwhile, the Normal and Log Normal methods fulfil the requirements, as the resulting Chi Count value is smaller than the Critical Chi.

Rainfall Plan

From the results of the above calculations, the Log Normal Method for Rainfall Analysis was chosen, so the following values were obtained:

Table 3. Probability Distribution Test

TR	KTR	RTR
100	2.326	1505
50	2.05	1054
25	1.724	691.9
10	1.282	391.1
5	0.842	221.6
2	0.000	74.7

Hourly Rainfall Analysis - Mononobe era

It can be seen that the ratio of Rainy Hour – Mononobe era below:

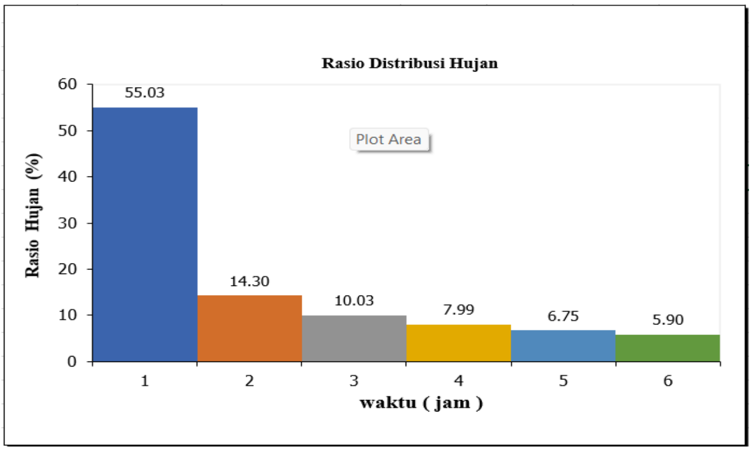

Figure 2. Hourly Rainfall Analysis - Mononobe era

From the diagram above, it can be seen that in the first hour the hourly rainfall rate reached 55.03% or 91.36 mm/day of the 50-year return period plan of 166.01 mm/day.

Calculation of Nakayasu HSS Flood Discharge

This method is focused on simplifying the shape of the hydrograph for user-friendly representation. Based on the results of the Nakayasu HSS calculation, the maximum discharge from the Nakayasu HSS Method is 904.8 m^3/second at a 10-year return period.

Table 4. Nakayasu HSS Flood Discharge

Characteristic	Notation	Equation	Start Notation	Value	End Notation	Value
Rising Curve	Qa	$Qp \cdot (t/Tp)^{2.4}$	0	0	Tp	6.4848
Falling Curve Stage 1	Qd1	$Qp \cdot 0.3\^[(t - Tp) / T_{0.3}]$	Tp	6.4848	$Tp + T_{0.3}$	25.2588
Falling Curve Stage 2	Qd2	$Qp \cdot 0.3\^[(t - Tp + 0.5T_{0.3}) / 1.5T_{0.3}]$	$Tp + T_{0.3}$	25.2588	$+ T_{0.3} + 1.5T_{0.3}$	53.4198
Falling Curve Stage 3	Qd3	$Qp \cdot 0.3\^[(t - Tp + 1.5T_{0.3}) / 2T_{0.3}]$	$+ T_{0.3} + 1.5T_{0.3}$	53.4198	~	~

Table 5. Ordinate Nakayasu HSS Flood Discharge

T (hours)	U(t,1) (m³/s/mm)	Hourly Rainfall (mm) R_1 = 51.959	R_2 = 13.505	R_3 = 9.474	R_4 = 7.542	R_5 = 6.369	R_6 = 5.567	Base Flow (m³/s)	Q (m³/s)
0.00	0.00								0.000
1.00	0.13	6.862							6.862
2.00	0.70	36.217	1.784						38.000
3.00	1.84	95.836	9.414	1.251					106.501
4.00	3.68	191.154	24.910	6.603	0.996				223.663
5.00	6.28	326.563	49.685	17.474	5.257	0.841			399.820
6.00	9.74	505.828	84.881	34.853	13.911	4.439	0.735		644.646
7.00	11.35	589.715	131.475	59.542	27.746	11.747	3.880		824.106
8.00	10.64	553.084	153.279	92.227	47.401	23.431	10.268		879.690
9.00	9.98	518.728	143.758	107.522	73.422	40.028	20.481		903.940
10.00	9.36	486.507	134.828	100.843	85.598	62.002	34.990		904.767
11.00	8.78	456.286	126.453	94.579	80.281	72.284	54.197		884.081
12.00	8.24	427.943	118.598	88.704	75.294	67.794	63.185		841.519
13.00	7.72	401.361	111.231	83.194	70.617	63.583	59.260		789.247
14.00	7.24	376.430	104.322	78.026	66.231	59.633	55.579		740.221
15.00	6.79	353.047	97.842	73.180	62.117	55.929	52.127		694.241
16.00	6.37	331.117	91.764	68.634	58.258	52.455	48.889		651.117
17.00	5.98	310.549	86.064	64.371	54.639	49.197	45.852		610.672
18.00	5.61	291.259	80.718	60.372	51.245	46.141	43.004		572.739
19.00	5.26	273.167	75.704	56.622	48.062	43.275	40.332		537.162

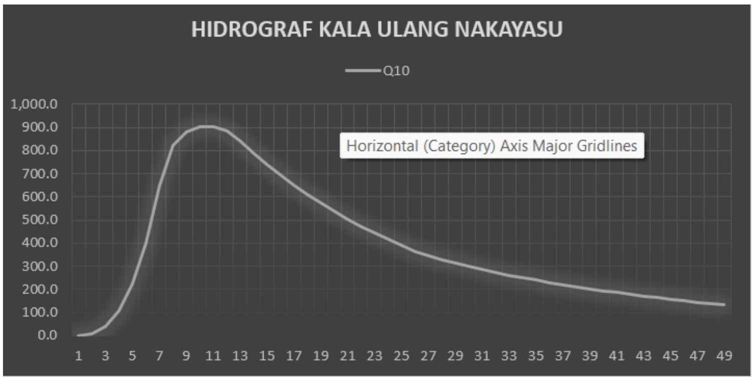

Figure 3. Ordinate Nakayasu HSS Flood Discharge

Based on the results of the above analysis, the maximum flood discharge value of 904.8 m^3/second is obtained at a return period of 10 years which will be inputted into the HEC RAS Programme.

Analysis Software HEC RAS

In flood analysis using HEC-RAS Software, the data used is flood discharge data calculated using HSS Synder Analysis for 10 years, used in the Steady Flow and Unsteady flow methods The following are the results of the steady flow analysis. And Unsteady Flow.

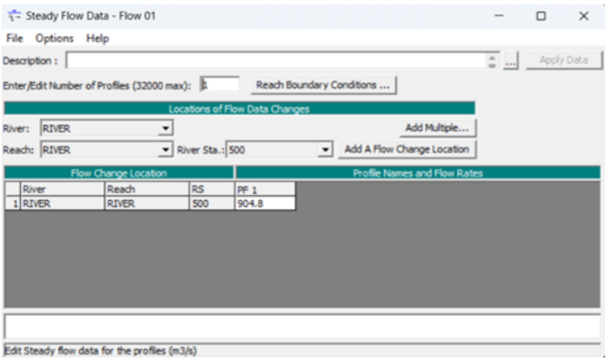

Figure 4. Analysis Steady Flow

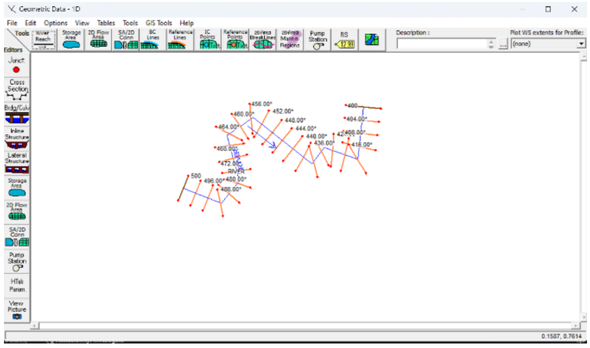

Figure 5. River Reach

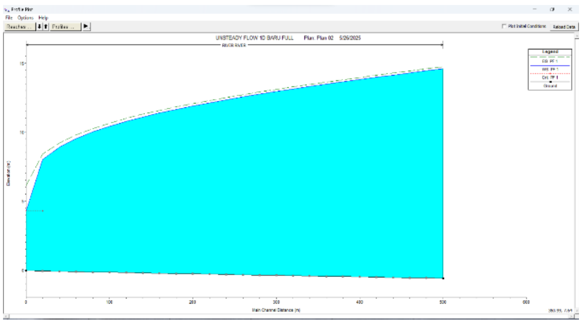

Figure 6. Analysis Unsteady Flow

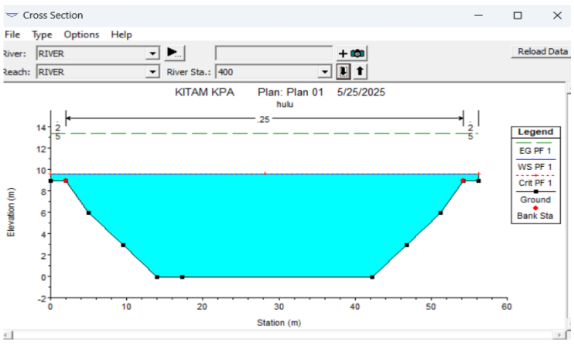

Figure 7. Analysis Steady Flow

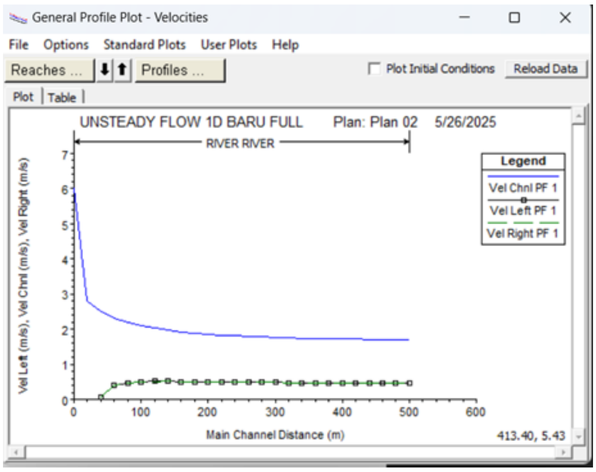

Figure 8. Analysis Unsteady Flow

From the picture above, it is found that the results of the analysis show that the cross section of the cisanggarung river is not able to accommodate Qdebit flow for 10 years. Therefore, normalization of the river cross section is required.

River Dimension Normalization Calculation

After conducting a steady flow analysis, it was found that the peak flood discharge based on the Nakayasu HSS method reached 904.8 m³/sec. With a significant difference in capacity, it is clear that the river cross section cannot accommodate the flood discharge. Therefore, normalization efforts were made and the river height was increased to 1.5 meters. Through this adjustment, the discharge capacity increased so that it could accommodate the Q10 flood discharge.

CONCLUSION

With a peak flood discharge based on the Nakayasu *HSS* of 904.8 m³/second, it was evident that the river's existing capacity was insufficient. Therefore, normalization efforts were undertaken by increasing the embankment height by 1.5 meters. Through this adjustment, the river's capacity increased, enabling it to accommodate the *Q10* flood discharge.

REFERENCES

Alliyu, A. A. (2023a). Bencana banjir: Pengertian penyebab, dampak dan usaha penanggulangannya berdasarkan UU Penataan Ruang dan RUU Cipta Kerja. ResearchGate.

Alliyu, A. A. (2023b). Penanggulangannya berdasarkan UU Penataan Ruang dan RUU. *Bencana banjir: Pengertian penyebab, dampak dan usaha penanggulangannya berdasarkan UU Penataan Ruang dan RUU Cipta Kerja*, Mei.

Aryani, N., Ariyanti, D. O., & Ramadhan, M. (2020). Pengaturan ideal tentang pengelolaan daerah aliran sungai di Indonesia (Studi di Sungai Serang Kabupaten Kulon Progo). *Jurnal Hukum Ius Quia Iustum, 27*(3), 592–614. https://doi.org/10.20885/iustum.vol27.iss3.art8

Haezer, H. R., Herawati, H., & Nurhayati, N. (2023). Analisis faktor-faktor penyebab banjir pada bagian hilir DAS Sekadau. *JeLAST: Jurnal Teknik Kelautan, PWK, Sipil, dan Tambang, 11*(2).

Hamdani, H., Permana, S., & Susetyaningsih, A. (2016). Analisa daerah rawan banjir menggunakan aplikasi sistem informasi geografis (Studi kasus Pulau Bangka). *Jurnal Konstruksi, 12*(1), 1–13. https://doi.org/10.33364/konstruksi/v.12-1.283

Intergovernmental Panel on Climate Change. (2014). *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Kholiq, G. S., Hidayat, H., & Nurwatik, N. (2023). Pemodelan dan visualisasi genangan banjir menggunakan data DTM LiDAR (Studi kasus: Kota Batu, Jawa Timur). *Jurnal Teknik ITS, 12*(1). https://doi.org/10.12962/j23373539.v12i1.105847

Miller, J. D., & Hutchins, M. (2017). The impacts of urbanisation and climate change on urban flooding and urban water quality: A review of the evidence concerning the United Kingdom. *Journal of Hydrology: Regional Studies, 12*, 345–362. https://doi.org/10.1016/j.ejrh.2017.06.006

Mujahid Zakir, A., Rumparam, A., Anif Farida, & Murni, M. (2023). Sosialisasi kebersihan air sungai pada masyarakat sekitar Kanal Victory Kota Sorong. *Jurnal Pengabdian Kolaborasi dan Inovasi IPTEKS, 1*(6), 891–896. https://doi.org/10.59407/jpki2.v1i6.190

Nuzul, M., Achmad, M., & Soma, A. S. (2021). Analisis genangan banjir akibat debit puncak di DAS Baubau menggunakan HEC-RAS dan GIS. *Jurnal Pembangunan Wilayah dan Kota, 17*(2), 192–206. https://doi.org/10.14710/pwk.v17i2.34152

Peraturan Presiden Republik Indonesia Nomor 112 Tahun 2022 tentang Percepatan Pengembangan Energi Terbarukan untuk Penyediaan Tenaga Listrik. (2022).

Qodriyatun, S. N. (2020). Bencana banjir: Pengawasan dan pengendalian pemanfaatan ruang berdasarkan UU Penataan Ruang dan RUU Cipta Kerja. *Aspirasi: Jurnal Masalah-Masalah Sosial, 11*(1). https://doi.org/10.46807/aspirasi.v11i1.1590

Rai Ayari, G., & Asyiawati, Y. (2023). Upaya pengendalian pemanfaatan ruang berbasis risiko bencana banjir di Kecamatan Samarinda Utara. *Bandung Conference Series: Urban & Regional Planning, 3*(1). https://doi.org/10.29313/bcsurp.v3i1.6745

Rosyidie, A. (2013). Banjir: Fakta dan dampaknya, serta pengaruh dari perubahan guna lahan. *Journal of Regional and City Planning, 24*(3). https://doi.org/10.5614/jpwk.2013.24.3.1

Sardana, Y. W., Suripin, S., Nugroho, H., & Rendra, M. I. (2023). Pemetaan area genangan banjir menggunakan model HEC-RAS 2D dan GIS pada DAS Pacal Kabupaten

Bojonegoro. *JSI: Jurnal Sistem Informasi (E-Journal), 15*(1), 3102–3110. https://doi.org/10.18495/jsi.v15i1.21609

Tuharyati, Y., Dhefiatul Jannah, A., & Triagustin, S. A. (2023). Bencana banjir: Pengendalian dan pemanfaatan ruang pasca berlakunya UU Cipta Kerja. *Pubmedia Social Sciences and Humanities, 1*(1). https://doi.org/10.47134/pssh.v1i1.11

Wigati, R., & Soedarsono, S. (2016). Analisis banjir menggunakan software HEC-RAS 4.1.0 (Studi kasus Sub DAS Ciberang HM 0+00 - HM 34+00). *Fondasi: Jurnal Teknik Sipil, 5*(2), 51–61. https://doi.org/10.36055/jft.v5i2.1261