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Analysis of The Bangkir Moving Dam As A Flood Control Measure In The Indramayu Regency Area

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ABSTRACT
Frequent flooding in the downstream area of the Cimanuk River, Indramayu, due to river overflow has highlighted the urgent need for effective flood control infrastructure. The Bangkir Movable Dam was constructed as a strategic measure to mitigate this recurring problem. This study aims to analyze the capacity of the Bangkir Movable Dam as a strategic solution for controlling flooding downstream of the Cimanuk River in Indramayu, which frequently occurs due to river overflow. This quantitative study uses rainfall data over a 10-year period (2015–2024) to calculate the design flood discharge, with the Weduwen method selected as the primary reference because it provides the most conservative estimates. The analysis results determine the 50-year return period flood discharge (Q50) at 599.58 m³/s. Meanwhile, the total dam capacity, calculated using the Sharp-Crested Weir method, reaches 1,329.68 m³/s. The comparison shows that the existing dam capacity is significantly greater than the planned flood discharge. Thus, the Bangkir Movable Weir is considered effective and capable of controlling floods for a return period of up to 100 years, thereby reducing the flood risk in the Indramayu region.

Keywords: Work Volume, Needs Analysis (Manpower, Materials and Tools), S Curve and Critical Path Method (CPM)

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INTRODUCTION

The Cimanuk River is one of the main rivers in West Java and serves an important role in providing water for the surrounding communities, particularly for agricultural irrigation, raw water supply, and household needs (Khalil et al., 2021; Fulazzaky, 2014). However, the Cimanuk River currently faces several challenges, including recurring floods caused by heavy rainfall, river siltation resulting from sedimentation processes, and damage to its watershed area (Ardiansyah et al., 2021). The Cimanuk watershed has been identified as one of the twelve watersheds in Indonesia with "very high" disaster risk, characterized by frequent flood occurrences that have shown an increasing trend over the past decade (Kompas, 2023). Flooding in the lower reaches, particularly in the Indramayu region and its surrounding areas, often causes substantial economic losses and disrupts community activities (Ridwansyah et al., 2020). The increased sediment load from upstream erosion has exacerbated the problem by silting up riverbeds, reservoirs, and irrigation systems, thereby reducing water-carrying capacity and increasing flood vulnerability (Lukas, 2016).

Movable dams have been widely recognized as effective structures for integrated water management in river systems. Previous studies have investigated their application in various contexts (Harlan et al., 2019; Magdalena et al., 2020; Tayfur et al., 2022). For instance, Figueroa and Son (2024) provided a comprehensive global analysis and synthesis of estuarine dams and weirs, demonstrating their effectiveness in coastal water management. Similarly, research by Figueroa et al. (2022) on estuarine dam location and discharge intervals highlighted the significant impact on hydrodynamics, sediment dynamics, and morphodynamics in river systems. A study by Decha et al. (2024) on floodgate operations emphasized the importance of real options analysis for controlling salinity intrusion in agricultural areas, providing valuable insights for operational decision-making. Furthermore, comprehensive research by Adi et al. (2020) on movable dam gate selection in the Parid River, Cilacap, Indonesia, underscored the necessity of decision support systems for site-specific applications, as generic designs often fail under local hydrological conditions.

While these studies establish the fundamental principles and regional applications of movable dams, a significant research gap remains concerning the specific efficacy of such structures within the unique hydrological context of the Cimanuk River's lower reaches. Existing literature lacks a detailed quantitative evaluation of the Bangkir Movable Dam's capacity against rigorously calculated design floods specific to this location.

As a strategic flood control measure on the Cimanuk River, the construction of the Bangkir Movable Dam was undertaken to address these issues. This study aims to fill the identified research gap by providing a detailed hydrological analysis to assess the dam's effectiveness. The novelty of this research lies in its specific methodological approach and analytical focus. It applies a comparative analysis of multiple flood discharge calculation methods—Rational, Weduwen, and Haspers—to determine the most conservative and appropriate design flood (Q50) for the unique characteristics of the Lower Cimanuk watershed, which is prone to high sedimentation and distinctive rainfall patterns. Furthermore, this study offers a precise evaluation of the Bangkir Movable Dam's existing capacity using the Sharp-Crested Weir method, providing a definitive quantitative assessment of its ability to manage floods up to a 100-year return period—an analysis not previously conducted for this infrastructure.

This movable dam functions to regulate river flow, divert part of the discharge to other channels, prevent seawater intrusion, and ensure stable water distribution during both the rainy and dry seasons. The existence of this structure also contributes to increasing the river's water-carrying capacity, thereby reducing flood risks and enhancing water resilience in the Indramayu region. The Bangkir Movable Dam is expected to minimize periodic flooding in Indramayu and neighboring areas. In addition, it has the potential to serve as a multifunctional facility that supports recreational activities and promotes more efficient water resource management.

METHOD

This research employs a quantitative approach to analyze the hydraulic capacity of the Bangkir Movable Dam as a flood control structure. The methodology is organized into several key stages, including data collection, data analysis, and hydraulic modeling, as illustrated in the following research flowchart and described in detail below.

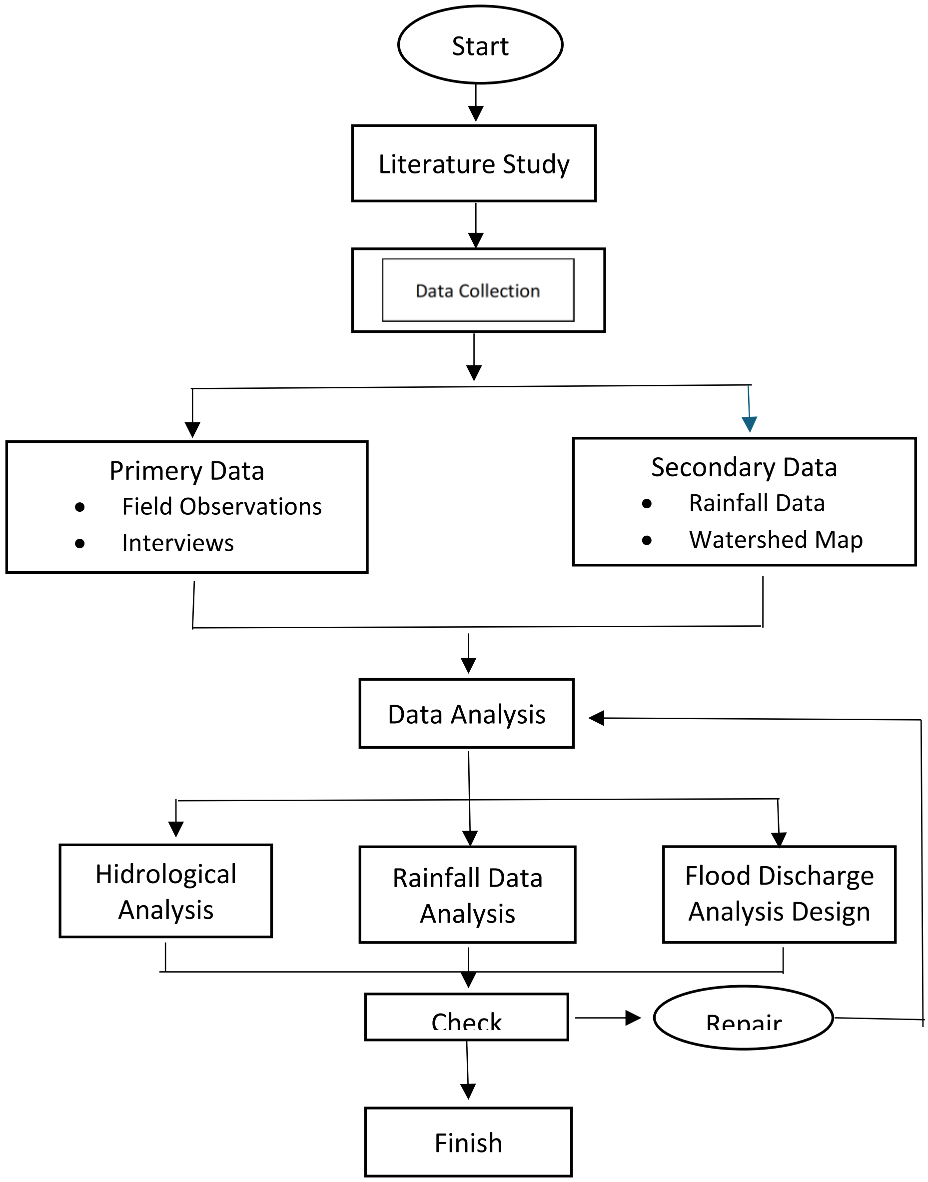

Figure 1. Research Methodology Flowchart
Source: Analysis Results (2025)

The method used is quantitative research. Quantitative research is a type of research that uses numerical data and statistical analysis to understand, explain, or predict certain phenomena.
This research was conducted at the Bangkir Dam in Indramayu Regency using secondary data in the form of rainfall data and TMA (water level) data

RESULTS AND DISCUSSION

Analysis of Average Rainfall in the Region

Area rainfall analysis is a calculation process to determine the average rainfall in a watershed or specific area using rainfall data obtained from several rain stations in the surrounding area (Triatmodjo, 2008). The names of the rain stations can be seen in Table 1.

Table 1. Rainfall Distribution

Station Name	Period	description
Pasekan	2015-2024	10 Year
Indramayu	2015-2024	10 Year
Sindang	2015-2025	10 Year

Source: BBWS Cimanuk Cisanggarung (2024)

Once the location of the rain gauge station is known, the next step is to find the size of the catchment area affected by the rain gauge station by drawing a polygon line from the three rain gauge station points, as shown in Figure 1 below:

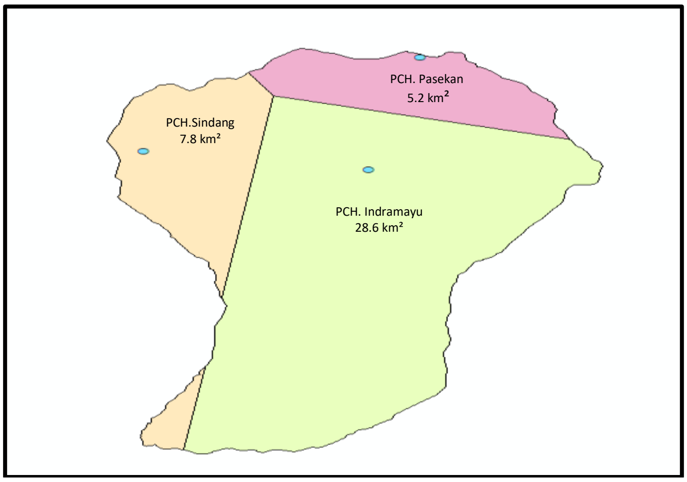

Figure 2. Lower Cimanuk River Basin
Sources: (BBWS Cimanuk Cisanggarung)

Thiessen Polygon Weight Coefficient

From Figure 1, the catchment area of the rain gauge station is known. To find the weight of the rain gauge station coefficient for the Cimanuk Hilir Lama watershed, the rain gauge station coefficient values can be seen in Table 2.

Table 2. Coefficient Poligon Thiessen

Rainfall Station Name	Polygon Thiessen Area (km2)	Coefficient Thiessen	Weigth (%)
Pasekan	8	0,19	19
Indramayu	29	0,69	69
Sindang	5	0,12	12
Total Number	42	1	100

Source: Analysis Results (2025)

Average Rainfall

Analysis of average rainfall in the region was conducted using the Thiessen polygon method to obtain representative rainfall values in the study area. This method considers the relative contribution of each rainfall station based on its area of influence, which is determined by forming polygons from the three nearest rainfall stations. (Achmad & Widyasari, 2021). The results of the calculations in Table 3 show that stations with a wider area of influence contribute more to the average rainfall in the region.

To calculate the average rainfall in a watershed, rainfall data from designated stations is required. Data on these rainfall stations can be found in the appendix. The following is an example of calculating the average rainfall in a watershed.

Table 3. Average Rainfall in the Region

Average Rainfall in the Region Using the Thiessen Polygon Method												
Year	**January**	**Febuary**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**Desember**
2015	148.34	158.34	57.50	88.34	55.84	23.34	8.34	7.50	5.84	5.00	18.24	112.50
2016	115.84	355.84	163.98	215.84	209.86	157.50	42.50	61.53	65.00	174.17	114.17	153.60
2017	344.20	235.00	160.84	124.17	42.31	38.34	18.08	41.74	68.34	35.84	208.03	69.17
2018	63.34	325.00	72.50	60.00	100.84	20.84	19.17	16.67	54.36	12.50	63.34	117.50
2019	235.84	115.84	109.17	69.17	72.22	70.53	68.15	66.46	44.74	63.08	60.00	234.17
2020	91.05	103.48	40.84	134.58	85.84	11.67	50.00	30.00	56.93	48.34	91.15	250.84
2021	305.41	374.17	195.24	100.84	14.17	120.00	32.50	4.86	58.22	36.67	170.15	118.72
2022	277.34	179.65	165.79	247.91	163.46	86.81	117.98	16.15	76.08	39.17	86.22	268.08
2023	202.79	295.15	130.55	125.12	81.67	34.70	33.27	23.50	12.86	1.67	38.24	83.24
2024	232.27	127.24	245.93	99.77	70.43	6.58	89.50	56.50	15.65	5.84	91.91	60.58

Source: Analysis Results (2025) based on BBWS Cimanuk Cisanggarung data (2024)

Table 4. Maximum Rainfall

Maximum rainfall		
No	**year**	**Total Rainfall (Xi)**
1	**2015**	158,34
2	**2016**	355,84
3	**2017**	344,20
4	**2018**	325,00
5	**2019**	235,84
6	**2020**	250,84
7	**2021**	374,17
8	**2022**	277,34
9	**2023**	295,15
10	**2024**	245,93

Source: Analysis Results (2025) based on BBWS Cimanuk Cisanggarung data (2024)

Table 5. Rainfall Data Consistency Test

n	**Q/n^0.5**			**R/n^0.5**		
	90%	95%	99%	90%	95%	99%
10	1,05	1,14	1,29	1,21	1,28	1,38
20	1,1	1,22	1,42	1,34	1,43	1,6
30	1,12	1,24	1,48	1,4	1,5	1,7
40	1,14	1,27	1,52	1,44	1,55	1,78
100	1,17	1,29	1,55	1,5	1,62	1,85
	1,22	1,36	1,63	1,62	1,75	2

With a 95% probability from the table	1,14	OK	Consistent
With a 95% probability from the table	1,28	OK	Consistent

Source: Triatmodjo (2008)

Analysis of Rainfall Distribution

Table 6. Recapitulation of Rainfall Distribution Analysis Results

PUH	Gumbel	Normal	Log Normal
Year	**m^3/Sec**	**m^3/Sec**	**m^3/Sec**
2	277.30	286.26	278.51
5	356.24	341.82	345.49
10	408.50	370.93	386.77
15	437.99	382.83	405.05
20	458.64	394.74	424.19
25	474.54	406.64	444.23
30	487.48	409.69	449.51
40	507.81	415.77	460.24
50	523.53	421.86	471.23
100	572.15	440.38	506.33

Source: Analysis Results (2025)

The analysis of annual maximum rainfall distribution using the Gumbel, Normal, and Log Normal methods shows that the Gumbel distribution provides the most consistent and highest estimation results. The Normal distribution is considered less appropriate because the data sample is relatively small. Meanwhile, the Log Normal distribution produces moderate and fairly consistent results but remains less precise than the Gumbel method.

The results of the annual maximum rainfall distribution analysis using the Gumbel, Normal, and Log Normal methods, as presented in Table 5, indicate that the Gumbel distribution is the most suitable for representing extreme rainfall characteristics (Suprihanto, 2010). This distribution yields the highest rainfall estimates compared to the other methods. The Normal distribution is deemed less appropriate because the data values are relatively small and fail to reflect the extreme nature of rainfall events. Meanwhile, the Log Normal distribution produces moderate estimates with a reasonably good level of fit, though it remains less accurate than the Gumbel distribution. Therefore, the Gumbel method is recommended for hydrological planning in this study area.

Analysis of Planned Debit Using the Rational Method

The following is the calculation of planned debit using the Rational Method.

Table 7. Planned Flow Rate Parameter

Parameter					
No	**Data**		**Notation**	**Value**	**Unit**
1	**Average rainfall over 50 years (Gumbel)**		**R50**	523.53	**mm**
2	**Drainage area**		**A**	42	**km^2**
3	**River Length**		**L**	15	**km**
4	**Difference between headwaters and location**		**ΔH**	2	**m**
	Upstream	**5**			
	Location	**3**			
5	**Average Slope**		**s**	0.00013	

Table 8. Results of Rational Method Calculations

No	Calculation	Result	Unit
1	**Flow Velocity**	0.34	**m/Sec**
2	**Time**	44.03	**Hour**
3	**Intensity**	14.55	**mm/Hour**
4	**Flow Coeffcient**	0.50	
5	**Discharge**	84.90	**m³/Sec**

Source: Analysis Results (2025)

Analysis of Planned Debit Using the Weduwen Method
The following is the planned discharge calculation using the Weduwen Method. The calculation parameters can be seen in Table 6.

Table 9. Results of Rational Method Calculations

No	Calculation	Result	Unit
1	**Tested at t = 1 hour**		
	a. Reduction coefficient	0.79	
	b. Rainfall intensity	27.61	**m^3/Sec/km^2**
	c. Concentration time	14.53	**Hour**
	d. Flow coefficient	0.88	
	e. Time	9.37	**Hour**
2	**Calculate standard Qmax**		
	a. Standard Qmax	274.84	**m^3/Sec**
3	**Standard Qmax Maximum discharge with 50-year PUH**		
	a. Q50	599.52	**m^3/Sec**

Source: Analysis Results (2025)

7. Analysis of Planned Debit Using the Haspers Method
The following is the planned discharge calculation using the Weduwen Method.
The calculation parameters can also be seen in Table 6.

Table 10. Ha Haspers Method Calculation

No	Calculation	Result	Unit
1	**Tested at t = 1 hour**		
	a. Flow Coefficient	0.57	
	b. Concentration Time	14.53	**Hour**
	c. Reduction Coefficient	2.00	
	Maka :	0.50	
	Hitung r		
	a. For t < 2 hours	-	
	b. For 2 Jam < t < 19 hours	489.81	**Mm**
	b. For 2 Jam < t < 30 days	-	
	c. For t = 1 hour	-	
	therefore:	489.81	**Mm**
2	**Hitung I**		
	a. *I*50	9.365	**m^3/sec/km^2**

	Qmax standard		**m³/Sec**
3	**Maximum debit with 50-year PUH**		
	a. Q50	112.99	**m³/Sec**

Source: Analysis Results (2025)

8. Results of Planned Flood Discharge Analysis

The calculation of the planned flood discharge for a 50-year return period (Q50) was carried out using three methods, namely Rational, Weduwen, and Haspers. These methods were applied to obtain a more comprehensive understanding of peak discharge estimates based on the characteristics of the watershed and planned rainfall. The results indicate that the Weduwen method produces the highest flood discharge compared to the Rational and Haspers methods, at 599.52 m³/s. The Rational method yields a lower discharge value of 84.90 m³/s due to its simple approach, which relies heavily on rainfall intensity and runoff coefficients. The Haspers method provides intermediate results, empirically considering rainfall and watershed area, yielding 112.99 m³/s. Meanwhile, the Weduwen method accounts for hydrological variables more comprehensively and produces higher discharge estimates, thus considered to provide a more conservative outcome. Therefore, the planned flood discharge for a 50-year return period in this study is established based on the results derived from the Weduwen method.

9. Comparison of Dam Capacity Using the Sharp-Crested Weir Method

The following is the planned discharge calculation using the Sharp-Crested Weir Method.

Table 11. Technical Data Parameters of Bangkir Movable Weir

Dam Capacity Calculation Parameters				
No.	Data	Notation	Result	Unit
1	Flood Discharge Plan (Haspers)	Q50	599,52	m^3/Sec
2	Discharge Coefficient	Cd	1,7	
3	Flow Type		Free Flow	
4	Width per Gate	L	10	m
5	Number of Gates	n	3	
6	Drainage Area	A	42	m^2
7	Threshold Height	H	3,26	m
8	Gravity	g	9,81	m/s^2

Source: BBWS Cimanuk Cisanggarung (2024)

Table 12. Calculation Results Using the Sharp-Crested Weir Method

Calculation		
QDoor	443,23	**m³/Sec**
Qtotal	1329,68	**m³/Sec**

Source: Analysis Results (2025)

Table 13. Analysis of the Storage Capacity of the Bangkir Movable Dam

Period	**Method**			**that is used**	**capacity**	**Status**	**Length of Sea Water Intrusion**	**Volume of seawater intrusion**		**door opening**		**Status**
recurrence	Rasional	Weduwen	Haspers		Dam	collect	Li (Km)	A (m^2)	V (m^3)	Max (m)	Plan (m)	accommodate
2	44,97	168,20	59,85	168,20	1329,68	controlled	20,702	202,5	4192,06	7	1,24	controlled
5	57,77	277,60	76,89	277,60	1329,68	controlled	34,167	202,5	6918,75	7	2,04	controlled
10	66,25	365,04	88,17	365,04	1329,68	controlled	44,928	202,5	9097,96	7	2,68	controlled
15	71,03	419,65	94,54	419,65	1329,68	controlled	51,649	202,5	10458,89	7	3,09	controlled
20	74,38	460,14	98,99	460,14	1329,68	controlled	56,633	202,5	11468,22	7	3,38	controlled
25	76,96	492,61	102,42	492,61	1329,68	controlled	60,629	202,5	12277,36	7	3,62	controlled
30	79,06	519,84	105,22	519,84	1329,68	controlled	63,980	202,5	12955,96	7	3,82	controlled
40	82,36	564,11	109,61	564,11	1329,68	controlled	69,429	202,5	14059,39	7	4,15	controlled
50	84,91	599,58	113,00	599,58	1329,68	controlled	73,794	202,5	14943,28	7	4,41	controlled
100	92,79	716,14	123,50	716,14	1329,68	controlled	88,140	202,5	17848,35	7	5,27	controlled

Source: Analysis Results (2025)

CONCLUSION

Based on the results of hydraulic analysis using the Sharp-Crested Weir method, the relatively high rainfall intensity and discharge controlled by the Bangkir Movable Weir is 300.19 m^3/s. Meanwhile, the planned flood discharge obtained from the Weduwen method analysis for Q50 is 599.52 m^3/s. Therefore, it can be concluded that the Bangkir Movable Dam is not capable of controlling floods during the 50-year return period, putting the Indramayu District at risk of flooding. Given the potential for uncontrolled flooding during this period, river normalization efforts must be implemented to mitigate flood impacts. Additionally, conservation measures should be carried out to monitor and manage sedimentation, preventing excessive accumulation over the long term.

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