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The Selection of Flood Mitigation Building Alternatives (Case Study: Jeroan River, Madiun Regency)

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Abstract— *This study concerns on The Jeroan River because it is one of the rivers in East Java that is experiencing problems with floods every year. The Jeroan River, located in Madiun Regency, plays an essential role in life, especially economic activities in the agricultural sector for the local community. The condition of the river is periodic. Abundant river discharge occurs in the rainy season, while the river discharge backs down in the dry season. Besides, the Jeroan River has the potential for sedimentation. This study used structural and non-structural flood control to prevent flooding. This study took primary data through interviews and the secondary data undertaken through Central Statistics Agency, Bakosurtanal, BMG, Research and Development Center for Water, Department of Water Resources Management, Balai River Basin and other sources. The finding indicated that the principle of water conservation guides flood prevention efforts. Then, it also found that the existing embankment on the Jeroan River is still unable to accommodate the discharge. The planned flood return period is 50 years after mitigation in the form of a retention pond, and for normalization, it is necessary to improve the control building. The embankment planned in this study is an embankment in the form of a parapet. The parapet is a superior alternative to flood control because it mainly functions as a flood controller, and flood discharge does not overflow. The new parapet design on the Jeroan River is planned using concrete construction with stakes as foundation reinforcement. Furthermore, the results of the analysis of the Hec Ras 6.0 program show that after the treatment, alternative flood control in the form of retention ponds, normalization, revetments and embankments parapet, there is no longer any potential for overflow or flooding along the Jeroan River channel and the Uneng River. Thus, flood prevention with the alternative offered ultimately succeeded in reducing flooding.*

Keywords— *Selection, Flood Mitigation, Building Alternatives, Jeroan River.*

I. INTRODUCTION

The issue of flooding is not new but has become one predictable disaster caused by a combination of human activities and factors related to natural resources. The Jeroan River is one of the rivers in East Java that is experiencing problems with floods every year. The Jeroan River, located in Madiun Regency, is a river that plays an essential role in life, especially economic activities in the agricultural sector for the local community. The condition of the river is periodic. Abundant river discharge occurs in the rainy season, while the river discharge backs down in the dry season. Besides, the Jeroan River can sedimentation, causing collisions in the river and erosion in the river several points along the river. Following Government regulations, the Republic of Indonesia number 121 of 2015 asserts that Water Resources Management is an effort to plan, implement, monitor, and evaluate water resources conservation, utilization of water resources, and water damage control.

However, dealing with the three management aspects, not all of them handled at once due to limited infrastructure budget allocations and increasing demands from the flood, has directly affected communities. Thus, it is necessary to carry out related studies in determining the countermeasures flood in terms of infrastructure that is appropriate and on target. This study will discuss flood mitigation that can be directly realized in the field, among others, through short-term or structural countermeasures of flood mitigation structures such as Normalization, Embankment, Ground Sill, Retention Pool and other buildings. In reality, efforts need to be undertaken to determine alternatives the most suitable control building from a technical point of view, such as through a study of the character of the flood and its existing conditions to determine the part of the river that is vulnerable to flooding, analyzing alternative flood control buildings based on the feasibility of hydraulics with using the HEC RAS 6.0 program, namely on capabilities and security in drain the design flood discharge.

II. LITERATURE REVIEW

Flood mitigation is crucial and involves engineering disciplines, including hydrology, hydraulics, watershed erosion, river engineering, river morphology and sedimentation, systems engineering flood mitigation, municipal drainage system, waterworks. According to Kodoatie (2013:166) argues that there are several steps to prevent flooding such as recognizing the magnitude of the flood discharge, isolating the flood inundation area, reducing the flood water elevation. Furthermore, flood control can be done in various ways, and it is grouped into two types

1. Upstream means building a flood control dam that can slow down the arrival time of floods and reduce the amount of flood discharge, field reservoirs that can change the flood hydrograph pattern and reforestation in Watershed (DAS).
2. Downstream means repairing river channels and embankments, drains on critical paths, making flood control paths or floodway, utilization of inundation area for retarding basin and so on.

Meanwhile, according to the technical handling of flood control, it can be divided into two such as technical flood control (structural method) and non-structural flood control (non-structural method).

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All of these activities are carried out in principle with the aim to reduce and slow down the flood discharge upstream to not affect the designated areas along the river, flow flood discharge to the estuary as quickly as possible with sufficient capacity downstream, add or enlarge the appearance of the river channel, reduce the value of river channel roughness, straighten or shorten the river channel on the river bend or meander, control of sediment transport.

Factors to consider in choosing the type of building flood control are as follows (Kodoatie, 2013: 167): the influence of the river regime, especially erosion and sedimentation (degradation and aggradation river) and its relationship to maintenance costs, the need for erosion protection in critical areas, the effect of buildings on the environment, regional development, the influence of the building on the flow conditions upstream and downstream of the river.

The flood control methods can be carried out in structural and non-structural flood control. Furthermore, the structural flood mitigation consists of:

(1) Flood Mitigation Building

a. Dam

It is placed across the river to regulate the flow of river water through the bending. The dam can be classified under flood divider dam, tide retaining dam, and dam tapping based on its function.

b. Check Dam

A check dam is a small permanent, temporary building built crosswise rivers/channels to reduce the slope of the riverbed along the river to reduce water velocity erosion and make sediment stay upstream of the building.

c. Ground Sil

Ground sill is construction for riverbed reinforcement to prevent erosion of the riverbed. In addition, Groundsill has benefits in reducing the speed of water flow and preventing scouring downstream of the dam (Kodoatie, 2013, p. 176).

d. Retarding Basin

In this way, the depression area (basin area) is needed to accommodate the volume of floods that come upstream and are rereleased when receded. With the field conditions very decisive and air can identify locations for flood pools based on field surveys, topographic maps, and photographs.

e. Building Polder

It is a system for handling urban drainage by isolating the area served (catchment area) against the entry of water from outside the system in the form of runoff (overflow) and flow below the ground surface (culverts and seepage), as well as controlling the flood water level in the system according to plan.

Polder system drainage is used when gravity drainage is used no longer possible, even though the investment and operating costs are higher expensive. The drainage component of the polder system consists of sluice gates, embankments, stations pumps, retention ponds, drainage networks, and collector channels.

(2) River System Improvement and Management

a. River Improvement

The river improvement system through dredging and widening of the channel aims to increase the river's capacity and facilitate flow. The analysis that must be taken into account is hydrology, hydraulics and sedimentation analysis. Calculation analysis needs to be done carefully considering the possibility of the river's return to its original form is very large. Directing the river and widening its cross-section is often the case land acquisition is required. Therefore, the study must consider the economic aspects (compensation) and social aspects, especially for community or other stakeholders who feel disadvantaged as a result of reduced land.

b. Flood Embankment Protection

Flood embankment is a barrier designed to hold back floodwater in the riverbed to protect the area around the river. Important factors that need to be considered in the construction of embankments according to (Kodoatie, 2013:188) such as the impact of the embankment on the river regime, passing flood hydrograph, guard height and river discharge capacity in buildings rivers, such as bridges. availability of local building materials, technical requirements and their impact on regional development, effects of runoff, mining, avalanches and leaks, the effect of the embankment on the environment, the higher water level in the river channel, embankment slopes with relatively stable river banks.

c. Bypass/Short Cut

A bypass is a channel used to divert part or the entire flow of floodwater to reduce flood discharge in the area protected.

d. Flood Way

The construction of a floodway is intended to reduce flood discharge in the old channel river and drain some of the flood discharge through the floodway. This can be done if local conditions support creating a floodway. Flood Way serves to drain some of the discharge flooding into the floodway concerning drainage capacity on the limited old flow.

Furthermore, non-structural flood control is also used because it does not use flood control technical building. Flood control by not using control buildings will have a reasonably good influence on the river regime. In other words, the success of non-structural methods for flood control contributes much greater than the structural method. Therefore, the costs incurred for the non-structural method are much cheaper than the costs incurred for the structural method because the non-structural method is more is a preventive measure before a flood occurs. The non-structural flood control can be undertaken through (Kodoatie, 2013: 215-219)

(1) Watershed Management

Watershed management is closely related to regulation, planning, implementation and training. Land management activities are intended to save water and conserve soil.

(2) Land Use Regulation

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The regulation of land use in watersheds is intended to regulate land use according to the existing regional spatial plan to avoid uncontrolled land use. As a result, the damage to watersheds which are by rainfed areas.

(3) Erosion and Sedimentation Control
Sediment in a river cross-section result from erosion in the watershed upstream of the cut, and the sediment is carried away by the flow from the erosion site occurs towards the cross-section. Therefore, the study of erosion control and sediments are also based on the two things above, namely based on studies limited supply of watersheds or transport capacity of rivers.

(4) Development and Management of Flood/Inundation Areas
The purpose of flood area control is to limit or determine the type of development, taking into account the risks and damages caused by flooding. Economic, social and environmental factors must also be considered.

Thus, it can be concluded that river management must be undertaken to prevent flooding, and the community must conduct river normalization to build the embankment, revetment, training wall and dam.

III. Method

A. Research Setting

Madiun Regency is one of 29 regencies in the Java Province East. Geographically, Madiun Regency is located around 70 12' to 70 48' 30" South Latitude and 1110 25' 45" to 1110 51' East Longitude. The whole total area, 1,010.86 km2, consists of 15 sub-district administration areas and 206 regions of village administration. The administrative boundaries of Madiun Regency are as follows:

Northern boundary : Bojonegoro Regency
Eastern boundary : Nganjuk Regency
Southern Boundary: Ponorogo Regency
West boundary : Magetan and Ngawi . Regencies

The location of the Jeroan River Study is located in Madiun Regency, precisely in the DAS, which has a watershed area of 428.89 km2, the length of the river 49.82 km and administratively Jeroan River is located between 7o 12' - 7o 48'30" South Latitude and 111o 25'45"- 111o 51" East Longitude. The Entrance River is one of the tributaries located in Madiun Regency, East Java Province, crossing from the Caruban area through the Balerejo District, Madiun Regency. While administratively part of the middle and downstream watersheds is located in the administrative area of Balerejo District, Saradan and Pilangkenceng District, Madiun Regency, East Java Province.

B. Data Collection

The researcher used primary and secondary data. The primary data taken through interviews with the societies and the related agencies can provide information clearer to the evaluation in this study. Furthermore, the secondary data were undertaken through Central Statistics Agency, Bakosurtanal, BMG, Research and Development Center for Water, Department of Water Resources Management, Balai River Basin and other sources from previous research by considering:

a. Hydrological data (Daily rain data for 2008-2017)
b. Topographic maps
c. Geological map
d. Land use map
e. inundation map

Jeroan River has seven Rain Stations which as shown as follows:

TABLE I. Rain Station

No	Rain Station	Latitude	Longitude	Elevation
1	Gemarang	-7.63000	111.7397	198
2	Balerejo	-7.55306	111.6044	68
3	Kuwu	-7.51861	111.6164	81
4	Kedungbanteng	-7.54778	111.5697	72
5	Kare	-7.48361	111.6917	104

C. Research Stage

(1) Hydrological Analysis
The parameters used included the area of the watershed and the river's length. The maximum debit occurs on average once in the review period. This data was processed and analyzed using Microsoft Excel software.

(2) Analysis of the flow profile with the help of the HEC-RAS program.
After the data was collected, the next step was to manage the required data using HEC-RAS 5.0.7 software. Data needed in analysis hydraulics was the condition data of the Jeroan River in the form of river geometry and flow data river in the form of planned flood discharge data. This planned flood discharge was obtained from the results of hydrological calculations are from rainfall for 12 years (2008-2019). Then, rainfall data used in this study were taken from five observation stations rain, namely Muneng Station (Sta. A), Kuwu Station (Sta. B), Balojero Station (Sta.C), Gamarang (Sta.D) and Kare Station (Sta.E). Analysis hydraulics included river system modelling, Manning and coefficient analysis, flow simulation for the existing condition, and flow simulation on several alternatives to select the best flood mitigation alternatives.

(3) Alternative Flood Management
This study concerned the river's condition, normalization, embankments, and retention ponds. To find out the condition of each scenario, seven alternatives are used to determine the efficient results for flood management. The following is a scenario matrix for each alternative presented in table as follows:

TABLE III. Matrix for Each Alternatives

No	Scenario	Alternative		
		Alt 1	Alt 2	Alt 3
1	Existing	✓		
2	Retention Pool		✓	✓
3	Normalization			✓
4	Embankment			✓

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IV. FINDING AND DISCUSSION

A. Analysis of Data Consistency Test

Multiple mass curve analysis is one way of testing the consistency of rain data. The researcher calculated the maximum annual rainfall for each rain station and it presented into the table as follows:

TABLE IIIII. Annual Maximum Rainfall Data for stations A,B,C,D and E

No	Year	Muneng (A)	Kuwu (B)	Balerejo (C)	Gamarang (D)	Kare (E)
1	2008	116.0	110.0	100.0	105.0	97.0
2	2009	92.0	94.0	75.0	85.0	88.0
3	2010	107.0	80.0	95.0	115.0	95.0
4	2011	97.0	114.0	118.0	125.0	105.0
5	2012	96.0	95.0	147.0	85.0	94.0
6	2013	95.0	75.0	62.0	60.0	88.0
7	2014	127.0	93.0	100.0	146.0	82.0
8	2015	105.0	140.0	75.0	80.0	78.0
9	2016	76.0	102.0	78.0	95.0	88.0
10	2017	112.0	118.0	96.0	115.0	104.0
11	2018	90.0	123.0	112.0	102.0	115.0
12	2019	101.2	100.0	126.0	180.0	124.0
Total		1214.2	1244.0	1184.0	1293.0	1158.0

TABLE IVV. Data Consistency Test at Station A towards,B, C, D and E

No	Year	Rain station A (mm)	Cumulative A (mm)	Mean B, C, D, E (mm)	Cumulative B, C, D, E (mm)
1	2008	116.0	116.0	103.0	103.0
2	2009	92.0	208.0	120.0	223.0
3	2010	107.0	315.0	110.0	333.0
4	2011	97.0	412.0	115.5	448.5
5	2012	96.0	508.0	105.3	553.8
6	2013	95.0	603.0	71.3	625.0
7	2014	127.0	730.0	105.3	730.3
8	2015	105.0	835.0	93.3	823.5
9	2016	76.0	911.0	90.8	914.3
10	2017	112.0	1023.0	113.0	1027.3
11	2018	90.0	1113.0	132.5	1159.8
12	2019	101.2	1214.2	1832.5	1292.3

Dealing with the results of the consistency test above, it shows that the correlation of the tested data coincides with a linear line that forms an angle of 450, with the value of the determinant (R2) of 0.995 or close to the value of 1, so there is no data deviation found. Thus, it can be concluded that from 2008 to 2019, the rainfall data at the A (Sta. Muneng) is consistent.

TABLE V. Data Consistency Test at Station B towards A, C, D and E

No	Year	Rain station B (mm)	Cumulative B (mm)	Mean A, C, D, E (mm)	Cumulative A, C, D, E (mm)
1	2008	110.0	110.0	104.5	104.5
2	2009	94.0	204.0	85.0	189.5
3	2010	80.0	284.0	103.0	292.5
4	2011	114.0	398.0	111.3	403.8
5	2012	95.0	493.0	105.5	509.3
6	2013	75.0	568.0	76.3	585.5
7	2014	93.0	661.0	113.8	699.3
8	2015	140.0	801.0	84.5	783.8
9	2016	102.0	903.0	84.3	868.0
10	2017	118.0	1021.0	104.8	972.9
11	2018	123.0	1144.0	132.8	1105.5
12	2019	100.0	1244.0	132.8	1238.3

Based on the results of the consistency test above, it shows that the correlation of the tested data coincides with a linear line that forms an angle of 450, with the value of the determinant (R2) of 0.996 or close to the value of 1, so there is no data deviation found. Thus, it can be concluded that from 2008 to 2019, the rainfall data at the B (Sta. Kuwu) is consistent.

TABLE VI. Data Consistency Test at Station C towards, A,B, D and E

No	Year	Rain station C (mm)	Cumulative C (mm)	Mean A, B, D, E (mm)	Cumulative A, B, D, E (mm)
1	2008	110.0	110.0	107.0	107.0
2	2009	75.0	175.0	89.8	196.8
3	2010	95.0	270.0	99.3	296.0
4	2011	118.0	388.0	110.3	406.3
5	2012	147.0	535.0	92.5	498.8
6	2013	62.0	597.0	79.5	578.3
7	2014	100.0	697.0	112.0	690.3
8	2015	75.0	772.0	100.8	791.0
9	2016	78.0	850.0	90.3	881.3
10	2017	96.0	946.0	107.5	988.8
11	2018	112.0	1059.0	126.3	1115.0
12	2019	126.0	1184.0	126.3	1241.3

Based on the results of the consistency test above, it shows that the correlation of the tested data coincides with a linear line that forms an angle of 45^0, with the value of the determinant (R^2) of 0.995 or close to the value of 1, so there is no data deviation found. Thus, it can be concluded that from 2008 to 2019, the rainfall data at the C (Sta. Balorejo) is consistent.

TABLE VII. Data Consistency Test at Station D against A,B, C and E

No	Year	Rain station D (mm)	Cumulative D (mm)	Mean A, B, C, E (mm)	Cumulative A, B, C, E (mm)
1	2008	105.0	105.0	105.8	105.8
2	2009	85.0	190.0	87.3	193.0
3	2010	115.0	305.0	94.3	287.3
4	2011	125.0	430.0	108.5	395.8
5	2012	85.0	515.0	108.5	503.8
6	2013	60.0	575.0	80.0	583.8
7	2014	146.0	721.0	100.5	684.3
8	2015	80.0	801.0	99.5	783.8
9	2016	95.0	896.0	86.0	869.8
10	2017	115.0	1011.0	110.0	979.8
11	2018	102.0	1113.0	112.8	1092.5
12	2019	180.0	1293.0	112.8	1205.3

Based on the results of the consistency test above, it shows that the correlation of the data tested coincides with a linear line that forms an angle of 45^0, with the value of the determinant (R^2) of 0.996 or close to the value of 1, so there is no data deviation found. Thus, it can be concluded that from 2008 to 2019, the rainfall data at the D (Sta. Gamarang) is consistent.

Based on the results of the consistency test below, it shows that the correlation of the tested data coincides with a linear line that forms an angle of 45^0, with the value of the determinant (R^2) of 0.998 or almost close to the value of 1, so there is no data deviation found. Thus, it can be concluded that from 2008 to 2019, the rainfall data at the E (Sta. Kare) is consistent.

TABLE VIII. Data Consistency Test at Station E against A,B, C and D

No	Year	Rain station E (mm)	Cumulative E (mm)	Mean A, B, C, D (mm)	Cumulative A, B, C, D (mm)
1	2008	97.0	97.0	107.8	107.8
2	2009	88.0	185.0	86.5	194.3
3	2010	95.0	280.0	89.0	283.3
4	2011	105.0	385.0	104.0	387.3
5	2012	94.0	479.0	105.8	493.0
6	2013	88.0	567.0	73.0	566.0
7	2014	82.0	649.0	115.0	681.0
8	2015	78.0	727.0	95.0	776.0
9	2016	88.0	815.0	87.8	863.8
10	2017	104.0	919.0	106.8	970.5
11	2018	115.0	1034.0	112.0	1082.5
12	2019	124.0	1158.0	112.0	1194.5

B. Spearman Method Absence of Trend Test Result

TABLE IX. Trend Test Result

No	Station	n	dt	KP	t-count	t-table	Description
1	Muneng	12	340	-0.1888	-0.6080	-2 228 < t-count < 2.228	Independent
2	Kuwu		176	0.3846	1.3176		Independent
3	Balerejo		234	0.1818	0.5847		Independent
4	Gamarang		270	0.0559	0.1772		Independent
5	Kare		258	0.0979	0.3111		Independent

The calculation results above refer to the table of the critical value of t-count (Soewarno, 1995: 77) with analysis of two-sided testing for the degree of confidence 5% then the value of $t_{0.975}$ = 2.228 and $t_{-0.975}$ = -2.228. The value of t-count in the table lies between -2.228 < t-count < 2.228, 5% indicates confidence level, it can be concluded that the rain data series is independent and does not show the trend.

C. F Test Calculation Results (Stationary Test)

TABLE X. Stationary Test Result

Station	n_1	n_2	S_1	S_2	F-count	F-table	Description
Muneng	6	6	9.1378	17.6327	0.2686	-2 F-count < 5.05	Homogeneous
Kuwu			15.5649	17.5689	0.7849		Homogeneous
Balerejo			30.4155	19.5798	2.4131		Homogeneous
Gamarang			23.7522	37.0117	0.4118		Homogeneous
Kare			12.4325	16.9430	0.5384		Homogeneous

From the results of the above calculations and by looking at the table of the critical value of Fc distribution of F (Soewarno, 1995:81) for the degree of confidence = 5% on the degrees of freedom dk1 = n1-1 and dk2= n2-1 of 5.05, then 95% of the discharge data is homogeneous from month to month.

D. Persistence Test Calculation Results

TABLE XI. Persistence Test Calculation Result

No	Station	n	m	KS	t-count	t-table	Description
1	Muneng	12	11	-0.6727	-2.7277	-2 t-count < 2.821	Homogeneous
2	Kuwu			-0.1182	-0.3570		Homogeneous
3	Balerejo			-0.0045	-0.0136		Homogeneous
4	Gamarang			-0.4864	-1.6699		Homogeneous
5	Kare			-0.4909	1.6904		Homogeneous

From the calculation results of the persistence test above is at a 5% confidence degree with degree freedom, m-2 = 11 – 2 = 9, then the obtained t-table is 2.821. It is due to the value of t-count is smaller than the t-table, it can be accepted. In other words that 95% of the data is independent or does not show persistence.

E. Alternative Flood Management

In this study, flood prevention efforts are guided by the principle of water conservation. He Races to model using debit the design of the 50-year return period ($Q50^{th}$) to be used as a reference for determining alternative flood control. The total volume of inundation due to overflow that occurred in the Jeroan River and Uneng River then the total result of Inundation Volume minus Volume River capacity and results indicate that the volume of inundation that must be reduced so as not to overflow occurs on land and residential areas of 3,686,954.38 m^3.

Furthermore, the result of calculating the width of the side spillway in the retention pond 1 in the path of Jeroan River Cross Section 47 using the De Marchi method has obtained the width of the building a spillway of 17 m with a discharge capacity that can run over is 122.70 m^3/second. Further, with a design discharge of 50 years, which initially occurred when the flood has occurred in the Jeroan River section with inundation height reaches an elevation of +56.76 m. After the alternative treatment for flood prevention in retention, ponds can reduce flood water levels up to +54.84 elevation. This incident illustrates that there is a decrease in the flood water level maximum of 1.92 meters or about 31.94%.

Then, it also has indicated that the existing embankment on the Jeroan River is still unable to accommodate the discharge. The planned flood return period is 50 years after mitigation in the form of a retention pond, and for normalization, it is necessary to improve the control building. The embankment planned in this study is an embankment in the form of a parapet. A parapet is a superior alternative to flood control because it mainly functions as a flood controller, and flood discharge does not overflow. The new parapet design on the Jeroan River is planned using concrete construction with stakes as foundation reinforcement.

Furthermore, the results of the analysis of the Hec Ras 6.0 program show that after the treatment, alternative flood control in the form of retention ponds, normalization, revetments and embankments parapet, there is no longer any potential for overflow or flooding along the Jeroan River channel and the Uneng River. Thus, flood prevention with the alternative offered ultimately succeeded in reducing flooding.

V. CONCLUSION

The selection of flood mitigation building alternatives on the Jeroan River has indicated that the design flood discharge of the Jeroan River at the study site with return periods of 2, 5, 10, 25 and 50 years is 240,081 m^3/sec, 280,427 m^3/sec, 291.230 m3/second, 301,328 m^3/sec and 332,984 m^3/second. Then, the results of running the existing condition of the Jeroan River capacity with a return period of 50 years with the help of the program Hec Race 6.0 find the total volume of river capacity plus the volume of the stagnant water of 7,252,615.31 m^3 whereas the carrying capacity of the Jeroan River is 3,565.660.93 m^3. This causes the occurrence of flood inundation in residential and agricultural areas of 3,686,954.38 m3. The last finding also indicates that the principle of water conservation guides efforts to control the Jeroan River flood. Alternative flood control buildings that are planned are in the form of reservoirs temporary, namely the retention pond. The retention pond is planned for 2 points, namely on Jeroan River and the Uneng River. With the retention pool capacity of A (at Jeroan River) being 3,313,045 m^3 and the holding capacity of the retention pond B (at Uneng River) of 988,384 m^3, it has succeeded in lowering the flood water level maximum of 1.92 meters or about 31.94%. However, it is necessary to continue with other flood control alternatives in the form of normalization and embankments parapet starting from cross-section 108 to cross-section 120 on the river channel of Jeroan because there is still overflow at that point. The second alternative results show no potential for overflow or flooding along the Jeroan River channel after the countermeasures.

References

[1] BR, Sri Harto, "Analisis Hidrologi". Jakarta : Gramedia Pustaka Utama, 1993.

[2] Kamiana, I.M, "Teknik Perhitugan Debit Rencana Bangunan Air". Yogyakarta: Garah Ilmu, 2011.

[3] Kodoatie, Robert J & Sugiyanto, "Banjir, Beberapa Penyebab dan Metode Pengendaliannya dalam Perspektif Lingkungan". Yogyakarta: Pustaka Pelajar, 2006.

[4] Kodoatie, Robert J., dan Roestam, Sjarief, "Pengelolaan Sumber Bencana Teradu, Banjir, Longsor, Kekeringan dan Tsunami. Jakarta", 2006.

[5] Kurniawan, R, " Studi Penanganan Banjir Kali Wrati Kabupaten Pasuruan". Thesis Magister Jurusan Teknik Pengairan. Malang: Universitas Brawijaya, 2014.

[6] Nivolianitou Zoe, "Flood disaster management with the use of AHP. Int. J. Multicriteria Decision Making", Vol. 5, Nos. 1/2, 2015.

[7] Quadri, S, "Studi Penanganan Banjir Sungai Bila Kabupaten Sidrap". Tesis. Tidak dipublikasikan. Malang: Universitas Brawijaya, 2016.

[8] Sudarsono, Suyono & Takeda, Kensaku, "Hidrologi untuk Pengairan. PT. Pradya Pramita Jakarta", 2005.

[9] Sudaryoko. Y, "Pedoman Penanggulangan Banjir". Jakarta: Departemen Pekerjaan Umum, 1987.

[10] Soewarno, "Hidrologi Pengukuran dan Pengolahan Data Aliran Sungai (Hidrometri)", Bandung: Penerbit Nova, 1995.

[11] Sekretariat Perencanaan dan Pengendalian Penanganan Bencana(P3B) BAPPENAS, " Penilaian Kerusakan dan Kerugian (Damages and Losses Assessment)", Jakarta, 2008.

[12] Tandean, Fanny, "Kajian Penanganan Banjir Sungai Anafre di Kota Jaya Pura". Tesis. Tidak dipublikasikan. Malang: Universitas Brawijaya, 2015.

[13] Triatmodjo, Bambang, "Hidrolika I". Beta Offset, Yogyakarta: Beta Offset, 1996.

[14] Triatmodjo, Bambang, "Hidrolika II". Beta Offset, Yogyakarta: Beta Offset, 1996.

[15] Herlina, Pipit Dwi, "Kajian Alternatif Pengendalian Banjir Sungai Jerohan Kabupaten Ngawi". Tesis. Yogyakarta: Universitas Gadjah Mada, 2011.

[16] Bagus, Vindha, "Pengendalian Banjir Di Sub Das Jeroan Kabupaten Madiun". Tesis. Malang: Universitas Brawijaya, 2016.

Antonius L. Antjak, Very Dermawan, and Evi Nur Cahya, "The Selection of Flood Mitigation Building Alternatives (Case Study: Jeroan River, Madiun Regency)," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 1, pp. 156-161, 2022.