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STUDY OF MORPHODYNAMIC CHANGE IN RIVER DUE TO SABO DAM DEVELOPMENT

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ABSTRACT

The problem of flooding and sediment needs to be a special concern in preserving the ecosystem and the existence of construction along the river body. Until now there has been no practical solution in handling sedimentation rates with natural flushing systems. Sediment material carried by debris flow in the form of *suspended* load, wash load and bed load shows a decline in the function of the water catchment area. The process can trigger land erosion in the upstream river which accelerates the process of river sedimentation to the downstream river area. Matakabo River is located on Seram Island, East Seram Regency, one of the rivers in Indonesia with typical debris which is categorized as an ephemeral river which has the potential for land erosion in the upstream area and sedimentation in river bodies. This is shown when the debris flow rains in the Matakabo River have a large enough destructive power and potential for flash floods. River morphodynamics function for correct management and prediction of important erosion and sedimentation processes involved in river activities, such as river bank erosion, overflow, sediment balance in dam regulation, sediment wave propagation, interaction with anthropic structures (bridges, weirs), reservoir siltation, renaturalization, sediment mining, aggradation, deformation planning, slope and hydraulic geometry balance arrangements, renaturalization issues. Improvement of river morphodynamics illustrates the morphological process in dynamic river widening as a result of variable sediment input and to identify measures to locally control ecologically valuable habitat development. Aspects such as the balance of sediment range scale, vegetation, and grain size distribution will also be considered because they are important factors that influence the ecological and morphological benefits of river widening. The results showed that the placement of Sabo in the Matakabo River did not really affect the downstream area but affected the upstream part.

Keywords: river morphodynamics, sabo DAM, Matakabo River

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1. INTRODUCTION

Water is the source of life for all living things in the world, one of the sources of water comes from rivers. The river has a positive role for human life such as irrigation water sources, raw water, tourism, flood control and other positive functions. Besides that, rivers can also cause problems if they are not managed properly and efficiently, such as flooding and sedimentation.

In general, the problem of rivers in Indonesia is flooding and sedimentation, especially rivers with typical debris with uncontrolled flow patterns and have a destructive power that has the potential to damage the ecosystem and stability of the buildings around it. The problem of flooding and sediment needs to be a special concern in preserving the ecosystem and the existence of construction along the river body. Until now there has been no practical solution in handling sedimentation rates with natural flushing systems. Sediment material carried by debris flow in the form of suspended load, wash load and bed load shows a decline in the function of the water catchment area. The process can trigger land erosion in the upstream river which accelerates the process of river sedimentation to the downstream river area.

Matakabo River is one of the major rivers in the Ambon-Seram River Basin (WS) which has a length of 42 km with a watershed area of 286 km^2 and 8 river orders. The main problem in the Matakabo River is flooding and sediment caused by high sediment transport from upstream rivers as a result of the decline in the function of the catchment area. The decline in the function of the catchment area can trigger landslides and landslides in the upstream which can accelerate the process of sedimentation along the river downstream. This problem must be addressed immediately because the Matakabo River is used as a source of irrigation water with an area of 3,050 hectares. One effort to prevent flood hazard is to analyze the flow patterns and sediment transport that occur. For this reason, it is necessary to have a model both a physical model and a numerical model that can simulate the dynamics of the flow patterns and distribution of floods and the future flood modeling through various data and event information. One of the two-dimensional numerical models that can be applied to hydrodynamic cases is iRIC (International River Interface Cooperative) with the Solver Nays2Dflood model, which is a two-dimensional (2D) model that is able to solve several problems, especially flood modeling and analysis of flow pattern calculations, sediment transport, basic evolution and river erosion developed by Dr. Yasuyuki Shimizu from Hokkaido University. The Nays2Dflood Solver model uses topographic input data for the study area, watershed maps and rainfall calculation plans to analyze flooding and examine the effect of rainfall on flood events in the area.

In order to find solutions or alternatives for handling the floods in the Matakabo River. One effort that can be taken is the systematic study of flood mitigation systems with Sabo Dam construction in order to obtain optimal handling solutions.

2. MATERIAL AND METHODS

2.1. Research location

The research location is located in Seram Island, East Seram Regency, Maluku Province astronomically located between 2°36'6 " - 7°27'22" South Latitude and 129° 47'46 " - 132°40'45" East Longitude.

In accordance with Regulation of the Minister of Public Works and Public Housing Number 04/prt/m/2015 concerning Criteria and Designation of River Areas in Indonesia. The research location is located in the Ambon-Seram River Region with WS Code 06.05.A3 and in detail is included in the Matakabo River Basin. The Matakabo River has the length of the main river and tributaries and the width of the sub-watershed can be seen in Table 1. For areas of the Matakabo River in this case the watershed area is shown in Figure 1.

Table 1. Area of the Matakabo watershed

No.	River name	River length (km)	Area of watershed (km^2)
1	Main Matakabo River	42.00	286.00
2	Way Janna 1	2.40	5.80
3	Way Janna 2	2.40	5.09
4	Way Janna 3	4.70	15.13
5	Way Ines	1.70	16.66
6	Way Hatno	8.70	23.19
7	Way Sop	9.90	34.96
8	Way Mol	6.40	33.69
9	Way Sol	7.80	28.04

Figure 1. Matakabo watershed map

2.2. Nature of Research

The research conducted is a mathematical model and modeling using iRIC software. The research objective is to simulate a design flood discharge using iRIC, to obtain the pattern of flow distribution in the Sabo Dam series on the Matakabo River, to obtain the performance of the Sabo Dam system in relation to the discharge variable (Qn).

2.3. Researched Parameters

Getting the performance of the Sabo Dam system in relation to the discharge variable (Qn)

2.4. Simulation Using iRIC Software (Nays2DFlood)

Nays2DFlood is a 2-dimensional flow simulation modeling program that considers coordinate boundaries or rectangular coordinate systems for common curvilinear coordinate systems. There are several stages / windows namely pre-processing window, Solver window and post-processing window visualizing the results. This program requires data derived from DEM (Digital Elevation Model) data input. To control the inflow by adjusting it with a background image. This model makes it possible to set various parameters for boundary conditions, riverbed friction is set using the Manning roughness coefficient. This model is used to simulate small and medium scale river floods and applies to simulations of river flood processes in developing countries.

Pre-Processing

At this stage it starts by opening iRIC software on a PC or laptop, then selecting the "Create New Project" option on the Start Page. Next choose the type of solver to be used, the Nays2DFlood solver, the initial appearance of the iRIC Software can be seen in Figure 2.

Figure 2. Display Start Page Software iRIC

After entering the work page of the iRIC software, then import the topographic data into the software, by selecting the Import menu on the Menu Bar, then selecting Geographic Data → Elevation (m). Figures 2 and 4 shows the topographic data that will be and has been inputted.

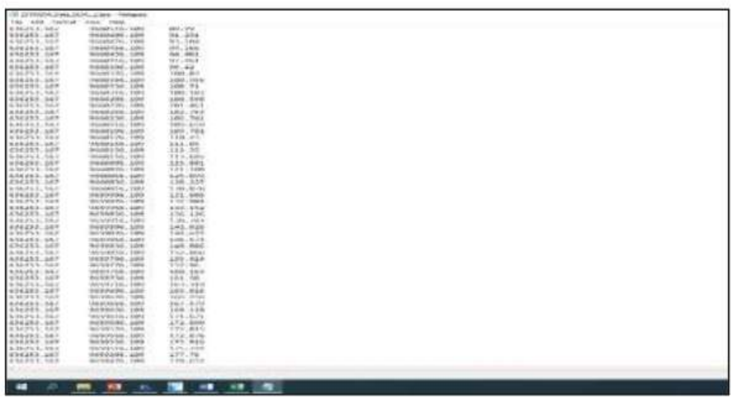

Figure 3. Topographic data to be inputted

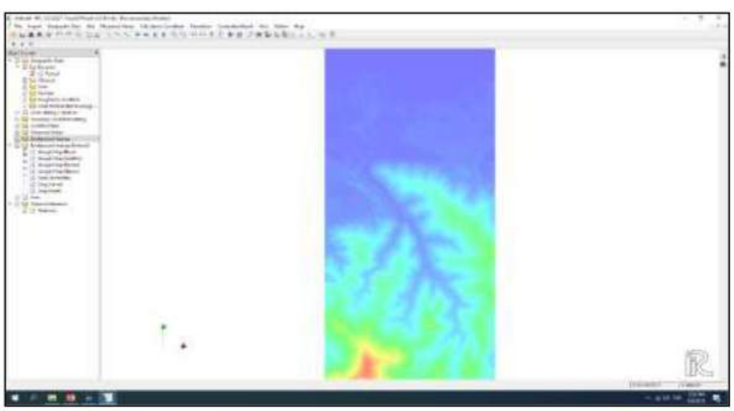

Figure 4. Topographic data that has been inputted

Next adjust the coordinate system according to the study location. Select the File menu on the Menu Bar, then click Properties. In the Project Property window, click Edit Coordinate System then select the coordinate system that suits the study area. After the coordinates are appropriate, then we can make a computational grid along the river flow that will be examined. Select the Grid menu on the Menu Bar, then click Select Algorithm to Create Grid. Then in the Select Grid Creating Algorithm window, choose Create Grid from Polygonal Line and Width. Next we will enter the Calculation Condition menu on the Menu Bar then click Settings, to determine the boundary conditions for running the simulation. In Calculation Conditions, design discharge input is also carried out which will be flowed to the river flow under study. After completion, the project is saved first to a file (.ipro) before entering the simulation stage.

The Solver Console Stage

At this stage a running simulation that has been conditioned in the previous stage is carried out. Running requires time that depends on the ability of the computer, the number of grids used, and the amount of time step used. To start running the simulation click Simulation on the Menu Bar then click Run. Furthermore iRIC will display a window showing the running process of the simulation. If a simulation failure occurs a pop up window will appear informing that the calculation of the simulation has failed and needs to be checked again in the grid, calculation conditions, and other parameters. If the simulation process runs smoothly, a window will appear informing you that the solver has completed the calculation process. The running process of the Nays2DFlood solver is shown in Figure 5.

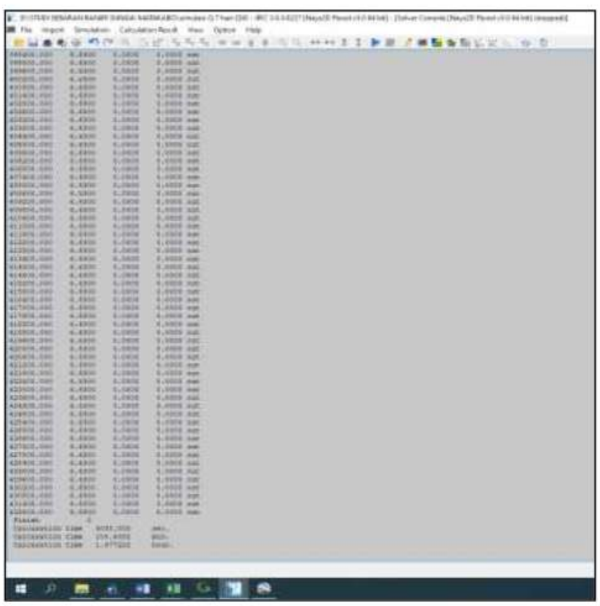

Figure 5. IRIC Software Simulation Running Process

Post Processing Stage

After all running processes are finished and no errors occur during the running process, then the results of running simulations can be visualized in the post processing window. Click Calculation Result on the Menu Bar, then click Open New 2D Post-Processing Window. Furthermore, the parameters of the simulation results can be displayed as needed through the

Object Browser window. Visualization of the application after running can be seen in Figure 6.

Figure 6. Visualization of iRIC software simulation results

3. RESULTS AND DISCUSSION

3.1. Discharge Plan

The recapitulation of design discharge for each method is shown in Table 2 and the Nakayasu Synthetic Hydrograph (HSS) is shown in Figure 7.

Table 2. Recapitulation of flood discharge designs for each method

Re-period (Year)	Design Flood Discharge (m^3/dtk)			
	Haspers method	Weduwen method	Rational method	HSS Nakayasu
2	132.46	80.21	410,.2	74.99
5	209.05	151.26	647.71	118.35
10	271.62	219.63	841.57	153.77
20	347.25	312.27	1075.92	196.59
25	364.74	334.79	1130.10	206.49
50	445.17	444.41	1379.32	252.02
100	535.33	576.20	1658.67	303.07

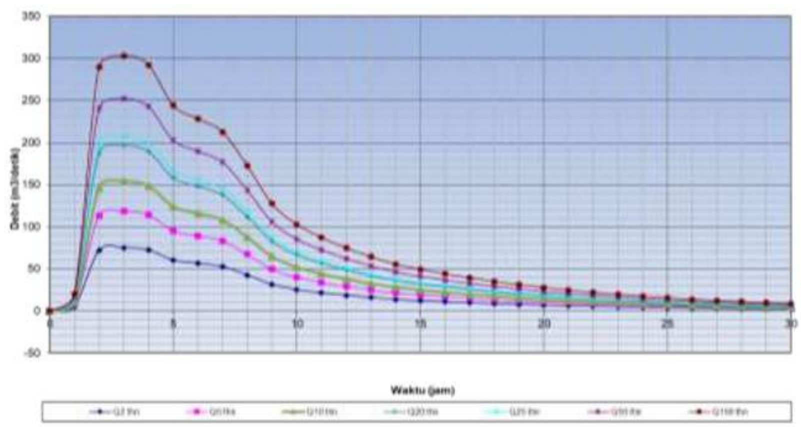

Figure 7. Discharge plan for Nakayasu HSS method

3.2. Model Validation and Calibration

The calibration of the velocity measurement model was conducted in August 2018. The location of the speed and current data collection in the Matakabo River Basin is shown in Figure 8. The results of the comparison of the current velocity between the field measurements and the simulation results were carried out with a discharge condition of 6.63 m / s, in Figure 9. Based on Figure 9, the difference between the velocity of the field measurement current and the simulation speed of the flow ranges from 3.79 - 20.12%, with the results concluded that the data is valid.

Figure 8. Location of current speed data collection

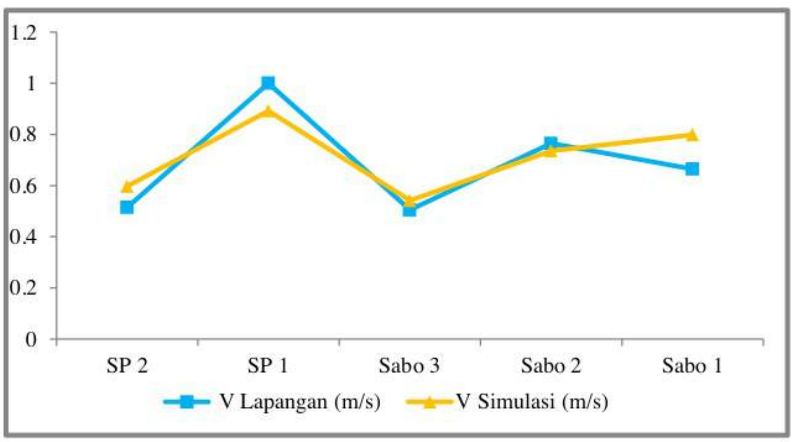

Figure 9. Comparison of field speed current measurement with simulated current speed

3.3. Simulation Results on Nays2DFlood

The analysis of the results of this study was carried out on the downstream of Way Matakabo river using iRIC Solver Nays2dFlood software, where the output of the application will be seen in comparison of each parameter in the form of flood inundation area, flow velocity and depth. The discharge of Q20 in 196.59 m^3/sec.

The simulation results for the Q20 return period without building conditions, obtained the capacity of the Matakabo River cannot accommodate the river flow shown in the downstream area with a maximum depth of 4,148 m, and the flow velocity of 0.71 m/s. Meanwhile the simulation results for Q20 with buildings also showed flood inundation of 47.66 Ha in the downstream area with a maximum depth of 3.654 m and a flow velocity of 0.67 m/s. the complete picture can be seen in Figure 10. Figure 11 shows the relationship of riverbed elevation, water level and depth in all buildings with Q20 years.

From the review of the results obtained in flood discharge simulations in Sabo 1, Sabo 2 Sabo 3 and Sp1 Sp2, the morphodynamic changes of each simulation result with return periods of Q20.

In Sabo 1 for changes in flow depth, water surface, and river bed elevation in conditions before and after the construction of Sabo, it does not show a significant effect, can be seen in the graph above

Likewise in Sabo 2 for changes in the depth of the flow before and after the construction of Sabo, the graph does not show a significant effect, the amount of depth is influenced by the size of the existing storage at that point, which is also affected by the extended slope at the Sabo point.

On Sabo 3, it can be seen that there is a change in the depth of the flow before and after the construction of the Sabo, the graph explains that the depth of the flow in the situation without any building is greater than the situation with the Sabo building. river of approximately 1 m under normal discharge conditions. At the height of the flow face does not experience a significant change that is 139 m.

For SP 1 the effect is based on these graphs, also not too significant. The magnitude of the depth, elevation and water level are relatively constant both before and after the existence of Sabo. Likewise, the effect of SP 2 based on the graph, is also not too significant.

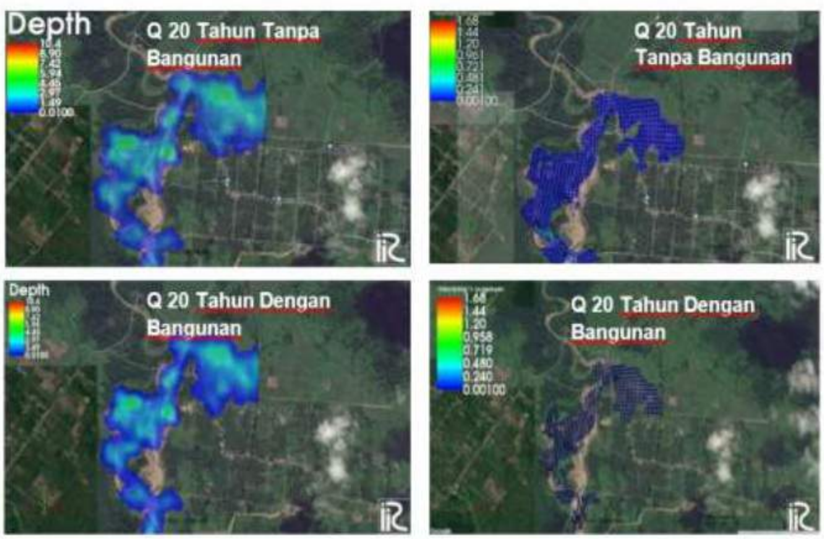

Figure 10. Simulation of depth and speed with Q20 years

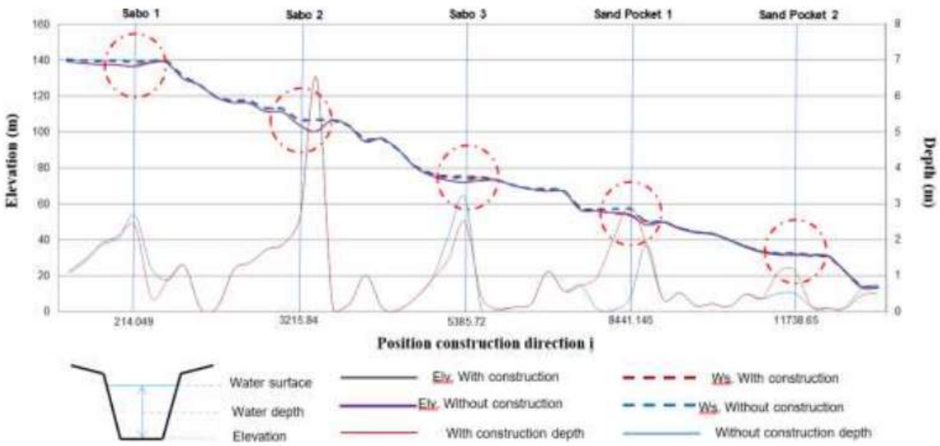

Figure 11. The relationship of riverbed elevation, water level and depth in all buildings with Q20 years

4. CONCLUSIONS

- Based on the results of the simulation with variations in the discharge on the condition of the building and without the building it was concluded that the existence of the Sabo system reduces the magnitude of the parameters of depth and flow velocity.
- Placement of Sabo in the upper course of the Matakabo River greatly affects the downstream area.

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