Effect Of Barito River on Drainage Performance in Dadahup Lowland Irrigation Area

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Abstract. Food Estate is a presidential directive signalled by FAO to anticipate the potential threat of scarcity and world food crisis as a result of the global Covid-19 pandemic and strengthen national food reserves. The land area of 165,000 Hectares divided into 4 Blocks (Block A, Block B, Block C and Block D) will be used for the development of agricultural areas and food security as well as increasing agricultural productivity with technological and management advantages. The current condition of the infrastructure in the Food Estate area is not all in good condition and can serve all existing irrigation areas. Some of the problems that occur include the not yet optimal drainage performance at Dadahup Lowland Irrigation Area, Block A area. This area is influenced by the tides of the Barito River, when the tide occurs in the rainy season this area floods as high as 0.5 - 1.0 m for ± 2-3 months. The purpose of this study is to minimise flooding in the Dadahup Lowland Irrigation Area in high tides condition on the Barito River and during the rainy season by optimising the existing drainage performance. Irrigation activities at Dadahup Lowland Irrigation Area are closely related to the condition and morphology of the Barito River. Dadahup Lowland Irrigation Area agricultural potential area is 21,226 Hectares and dominated by peatland. This study uses several data, including rainfall, river discharge, climatology, topography and digital elevation model (DEM), Barito River cross section, tides, land cover, cropping, and other supporting data. Drainage performance in Dadahup Lowland Irrigation Area is assessed through analysis and modelling. Hydrological analysis is conducted to obtain flood discharge which will be an input in the hydraulic model by using Hec-RAS software. The output of this model is evaluated and further can be used to get recommendations whether the drainage can operate by gravity or requires a pump due to the influence of the Barito River water level.

1. Introduction

According to Law no. 17 of 2019 about Water Resources, water resource management is planning, implementing, defeating, and destroying Water Resources Conservation, Utilization of Water Resources, and Control of Water Damage. This definition becomes the basis for the government to implement a program of activities to utilize water resources. One of the government's programs for 2020-2024, the Presidential Directive is to build an integrated food area, one of which is in the Dadahup Lowland Irrigation Area, Central Kalimantan [1]. The current condition of the Dadahup Lowland Irrigation Area infrastructure is not all in good condition and there are still several blocks that have been submerged for more than 2 weeks, so restoration is needed to restore the existing infrastructure to an optimal condition and improvement in order to increase the functional area of the irrigation area which is recorded as a potential residual area. Rehabilitation is necessary due to the following problems: (i) the overflow of the Barito River that enters the Dadahup Lowland Irrigation Area during the rainy season, (ii) due to flooding caused by discharge from upstream causing flooding in agricultural land areas, (iii) the effect of tidal water (Java Sea) and river discharge from upstream on the swamp network management plan, (iv) The water level is not able to serve the farthest and highest rice fields in the dry season, (v) Irrigation infrastructure in Dadahup Lowland Irrigation Area is not optimal yet.

2. Study area

Dadahup lowland irrigation area with a potential area of 43,503 Ha (Figure 1) is administratively located in the Kapuas Regency, Province of Central Kalimantan and 21,226 Ha of it is the area of Dadahup lowland irrigation. One of the sources of irrigation water for Dadahup lowland irrigation area comes from the Barito River whose upstream is in the Schwaner Mountains - Central Kalimantan and downstream is in the Java Sea - South Kalimantan with a river length of ± 838.23 km. This river has a watershed area of ± 62,347.43 km^2 with various depths, namely between ± 4 – 20 m with a width of between 200 m and reaches 4,000 m in the downstream part of the river.

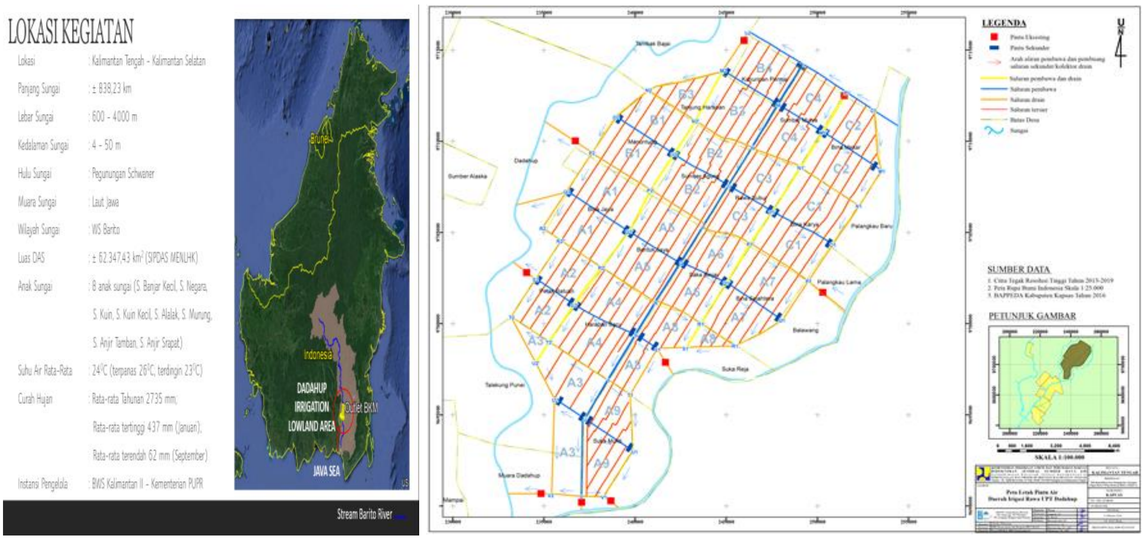


Figure 1. Dadahup lowland irrigation watershed and area map [2]

3. Material and methods

Based on the flow chart of study (Figure 2) hydrology and hydraulic analysis have been done after data inventory. Watershed delineation was analysed with the help of ArcGIS Software, using 116 Grid DEM (Digital Elevation Model) data from upstream – downstream of the Barito River to obtain a watershed map. Study location and watershed profile (watershed area, river length and river slope). Processing daily rainfall data for 10 years (2011 – 2020) from 6 rain stations are Beringin, Timpah, Mandomai, Maliku, Sanggu and Dadahup Rain Station. The rain data will be processed to obtain the maximum annual daily rainfall and the planned flood discharge for a 2 and 25 years return period using the Gumbel method. A hydro topographic map is needed to obtain the elevation of the land and to determine the characteristics of the swamp in each tertiary block. Performing the calculation of the drainage modulus required to increase the discharge load on the land to be disposed of with the required discharge for irrigation. Hydraulics analysis using HecRAS 1D Software to obtain runoff points in Dadahup lowland irrigation area. The data entered is the terrain from the DEM, the design flood discharge data, the drainage modulus as a boundary downstream of the secondary channel, the slope of the river and the tidal elevation at the review point. Tidal data used is taken from tides.big.go.id. From the HecRAS 1D modelling, we get inundation locations that cause agricultural productivity to decrease.

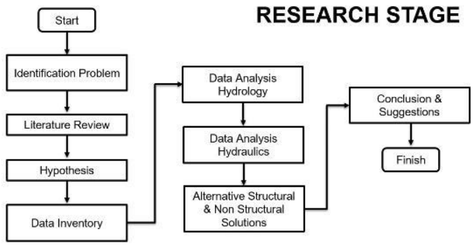


Figure 2. Flow Chart of Study

4. Result and discussion

4.1. Hydrology analysis

From the results of the watershed delineation, the area of the study area watershed is 47,407.36 km^2, the length of the river from upstream to the study site point is 734.26 km and the average slope is 0.0011. Dadahup lowland irrigation area covering an area of 21,226 Ha has 10 points are M, N, O, P, Q, R, S, T, U and V. Dadahup lowland irrigation area is divided into 17 blocks are blocks A1 – A9, B1 – B4 and C1 – C4. In this raw water irrigation area, primary channels, secondary canals, collector exhaust channels and several water control gates have been built. One of the main water sources comes from the Barito River and dumps excess water in the irrigated land into the Barito River, this shows that the agricultural activities of the Dadahup lowland irrigation area are strongly influenced by the Barito River. However, the current condition of irrigation areas is often submerged for more than 3 weeks during the rainy season because the condition of the existing irrigation infrastructure is not optimal (Figure 3).

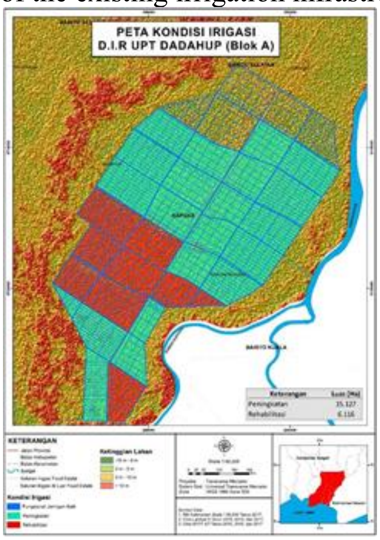


Figure 3. Dadahup lowland irrigation area existing infrastructure condition [3]

The hydrological analysis begins by recapitulating daily rainfall data for 10 years from each rain station and the results are shown in Figure 4. The empty rain data in 2011 – 2016 at the Dadahup Rain Station was calculated using the Normal Ratio method. The data gap is due to the Dadahup Rain Station being built and functioning in November 2017. Only 5 data that can be used for frequency analysis passed the outlier test, so the data at Beringin Station was not used for frequency analysis. The results of the frequency analysis using the Gumbel method which have the smallest error value (0.0859) can be seen in Figure 4, this value will be used for calculating the planned flood discharge.

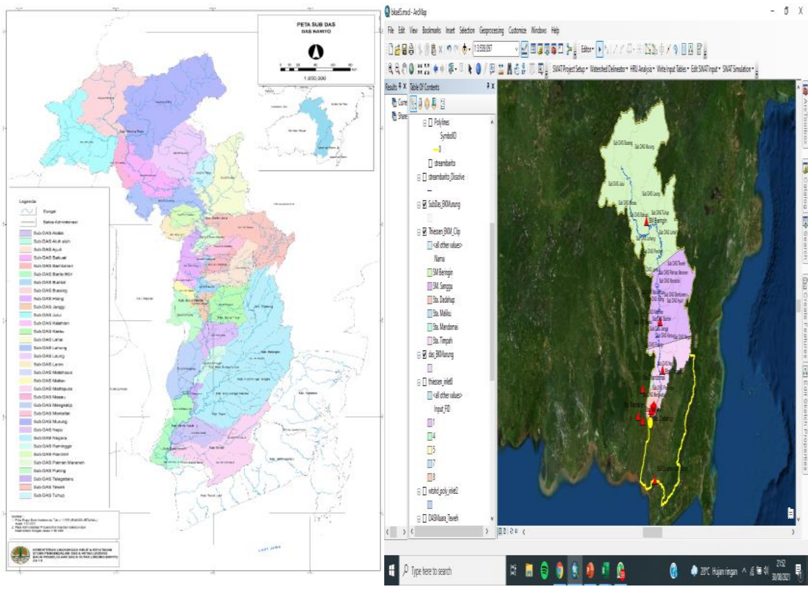
The calculation of the planned discharge requires an Area Reduction Factor (ARF) [4] is with the provisions of the multiplier coefficient in Figure 6, but because the area of the study area is > 30,000

km^2 (47,407.36 km^2), the area rains in the watershed location The study was broken down into sub-groups with an area of < 30,000. Based on the sub-basin map obtained from the Barito BPDASHL (Watershed Management Centre and Protected Forest), the Barito watershed consists of 33 sub-basins, after the ArcGIS masking only 28 sub-das were included in the watershed of the study location and each sub-basin area and its ARF were obtained (Figure 5).

No	Return Period (T)	Design Rainfall (mm)			
		Normal	Gumbel	Log Normal	Log Pearson III
1	2	131.58	126.61	128.68	126.18
2	5	157.03	153.34	154.76	153.47
3	10	170.34	171.03	170.44	172.04
4	25	184.54	193.39	188.92	196.15
5	50	193.71	209.98	201.90	214.63
6	100	201.95	226.45	214.34	233.59
7	200	209.50	242.85	226.39	253.18
8	1000	225.05	280.85	253.42	301.79
Smirnov-Kolmogorof Test		0.1380	0.0859	0.1053	0.0918
		0.4100	0.4100	0.4100	0.4100
		accepted	accepted	accepted	accepted
Chi-Square Test		1.0000	2.0000	1.0000	3.0000
		5.9910	5.9910	5.9910	5.9910
		accepted	accepted	accepted	accepted

Figure 4. Maximum daily rainfall data

Of the 28 ARF values, an average ARF value of 0.776 (Figure 5) was obtained for the watershed of the study location. Furthermore, the ARF value is multiplied by the planned rain value for the Gumbel return period (Table 1) and will be used for the analysis of the planned flood discharge.



No.	Nama Sub DAS	Luas (km^2)	ARF
1	Sub DAS Paminggir	686.13	0.80
3	Sub DAS Hiang	1,029.54	0.78
4	Sub DAS Murung	7,436.18	0.67
5	Sub DAS Laung	2,934.81	0.72
6	Sub DAS Jului	4,300.67	0.70
7	Sub DAS Buntok	354.65	0.84
8	Sub DAS Puning	1,180.92	0.77
9	Sub DAS Napu	1,220.70	0.77
10	Sub DAS Mengkatip	1,813.20	0.75
11	Sub DAS Montallat	724.17	0.80
12	Sub DAS Janggi	458.04	0.82
13	Sub DAS Pandreh	735.15	0.80
14	Sub DAS Bambanen	614.15	0.81
15	Sub DAS Lemo	612.82	0.81
16	Sub DAS Babuat	1,904.75	0.75
17	Sub DAS Tuhup	806.26	0.79
18	Sub DAS Kalahien	255.10	0.86
19	Sub DAS Maliau	321.41	0.84
20	Sub DAS Teweh	3,260.51	0.72
21	Sub DAS Ayuh	1,580.14	0.76
22	Sub DAS Karau	1,696.75	0.75
23	Sub DAS Busang	3,871.82	0.71
24	Sub DAS Lahai	3,259.76	0.72
25	Sub DAS Lahung	1,859.46	0.75
26	Sub DAS Panran Maranen	649.35	0.81
27	Sub DAS Malahipua	113.94	0.90
28	Sub DAS Masau	718.77	0.80

Figure 5. Barito Sub-Basin Map and Average Area [7]

Analysis of the planned flood discharge was carried out using the calculation of the Synthetic Hydrograph Unit (SHU). Rainfall data on the planned return period which has been distributed through hourly rain using the PSA 007 method for 12 hours. This is based on the characteristics of the watershed where the average rain that occurs is for 12 hours, the infiltration value uses the SCS Curve Number formula. After that input the hourly rainfall distribution using PSA 007 distribution for 12 hours. The peak flood discharge value is obtained at each return period. Then the value of the flood discharge is made an SHU graph of the comparison between the calculation methods of Nakayasu, SCS, ITB-1 and ITB-2 [8] (Figure 6).

Tr	Nakayasu (Alpha=2.0)	SCS	ITB-1b	ITB-2b
2	6,635.19	12,436.39	12,488.94	10,112.21
5	8,682.80	16,305.88	16,379.98	13,225.09
10	10,091.85	18,969.88	19,059.10	15,367.21
25	11,872.18	22,335.84	22,444.18	18,083.33
50	13,192.93	24,832.90	24,955.42	20,098.79
100	14,560.64	27,431.04	27,569.61	22,186.29

Figure 6. Value of the flood discharge

4.2. Hydraulic modelling

In the simulation, it is only modelled for flooding with a return period of Q2 and Q25 years and selected with HSS Nakayasu with a maximum flood discharge of 6,635.19 m^3/s (Q2 years) and 11,872.11 m^3/s (Q25 years) which will be used as the boundary for the upper Barito river during modelling. Hydraulic analysis was carried out with the help of HEC-RAS software for 1D unsteady flow type at the Dadahup lowland irrigation area study site. Modelling for 3 conditions, are Condition 1 floods in the rainy season Q2 year, Condition 2 floods in the rainy season Q25 year, and Condition 3 floods in the Q2 rainy season when it doesn't rain. These three conditions are carried out with the following conditions: (i) DEMNAS data to obtain river cross section, (ii) Data (shp) of existing primary and secondary Dadahup irrigation canals as a reference for reach modelling, (iii) the upstream boundary using the Barito River uses planned flood discharges for 2-year and 25-year return periods for 145 hours, (iv) the downstream boundary of the primary channel uses tidal data on the Barito River during the rainy season, (v) the downstream boundary of the secondary channel uses the drainage modulus, (vi) there is no salinity during the rainy season (salinity = 0 ppt), (vii) there is no water structure in the channel (flowing by gravity), (viii) Not modelling the drain collector channel around the Dadahup lowland irrigation area network.

Dadahup lowland irrigation area is a natural reservoir for discharge in the upstream Barito watershed during the rainy season and is still affected by the tides during the dry season. Meanwhile, during the rainy season, Dadahup lowland irrigation area is a swampy swamp which is only affected by the discharge of the Barito river and rain. Tidal data used for calculations and modelling are data at points L1 and V. The duration for discharging water due to the land load of the Dadahup lowland irrigation area is influenced by the duration of the lowest and highest tides in the upstream and downstream of the primary channel. From the picture below, it can be seen that on November 26th, 2020 – December 28, 2020 there was a small tide (neap) on December 8th-14th, 2020 where the tide lasted for ±7 hours in a day and receded for ±16 hours in a day. The neap position indicates that the water level is low, so the water will not inundate the rice plants. Meanwhile, on December 15th-21th, 2020 there will be a large tide (spring) where the tide lasts for ±8 hours in a day and recedes for ±17 hours in a day. In this condition the water level is at the highest position so it is feared that the water will inundate the rice plants. It can be concluded that the average time to defecate in a day in the canal is when the water level in the channel is at low tide for 17 hours (Figure 7).

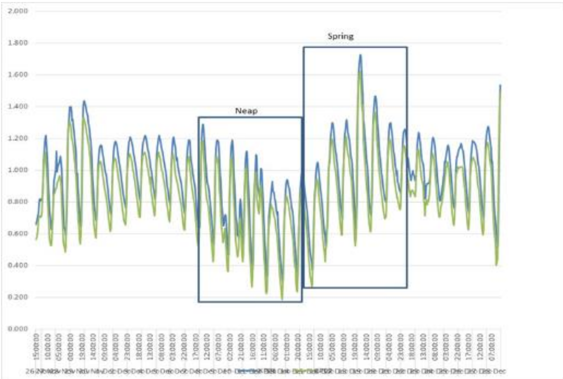


Figure 7. Tidal data November – December 2020 at point L1 (blue) and V (green) Dadahup [6]

With a water discharge time of 17 hours, the calculation is also adjusted by (n x 17/24), so that the drainage modulus calculation [8] is obtained as follows

D(n) = R(n)T + n(IR – ET – P) – ΔS
= 170.50 + ((3 x 17/24) x (0 – 2.73 – 0)) – 50
= 114.70 mm
Dm = D(n) / (n x 8.64)
= 114.70 / ((3 x 17/24) x 8.64)
= 6.24720 lt/s/ha
= 6.25 lt/s/ha

Where
D(n) = Surface discharge runoff for n days (mm)
R(n)T = Rainfall in (n) consecutive days with a return period of T years (mm)
n = Number of consecutive days
IR = Irrigation water requirement (mm/day)
ET = Evapotranspiration (mm/day)
P = Percolation (mm/day)
ΔS = Additional containment (mm)
Dm = Drainage module (lt/s/ha)
17/24 = water discharge time in 1 day

Then obtained the design discharge in each secondary channel with the equation Qd = 1.62 x Dm x $A^{0.02}$. The calculation results are in the Figure 8 below.

No.	Channel Name	Irrigation Supply		D(n)	Dm	Area (A)	Area ($A^{0.02}$)	Planned Discharge (Qd)	
		lt/s	m^3/s	mm	lt/s/ha	Ha	Ha	lt/s	m^3/s
I	**Main Primary Channel**	**34,536.75**	**34.54**	**114.70**	**6.25**	**17,424.00**	**13,503.60**	**136,723.95**	**136.72**
1	M Secondary Channel (Left)	4,018.50	4.02	114.70	6.25	2,060.50	1,813.24	18,359.06	18.36
2	N Secondary Channel (Left)	2,385.75	2.39	114.70	6.25	1,590.50	1,431.45	14,493.43	14.49
3	O Secondary Channel (Left)	2,303.25	2.30	114.70	6.25	1,535.50	1,381.95	13,992.24	13.99
4	P Secondary Channel (Left)	2,178.75	2.18	114.70	6.25	1,452.50	1,321.78	13,382.97	13.38
5	Q Secondary Channel (Left)	2,160.00	2.16	114.70	6.25	1,440.00	1,310.40	13,267.80	13.27
6	R Secondary Channel (Left)	1,446.00	1.45	114.70	6.25	964.00	910.98	9,223.67	9.22
7	S Secondary Channel (Left)	702.00	0.70	114.70	6.25	468.00	468.00	4,738.50	4.74
8	T Secondary Channel (Left)	583.50	0.58	114.70	6.25	389.00	389.00	3,938.63	3.94
9	U Secondary Channel (Left)	1,200.00	1.20	114.70	6.25	800.00	760.00	7,695.00	7.70
10	M Secondary Channel (Right)	1,255.50	1.26	114.70	6.25	837.00	795.15	8,050.89	8.05
11	N Secondary Channel (Right)	3,304.50	3.30	114.70	6.25	1,003.00	942.82	9,546.05	9.55
12	O Secondary Channel (Right)	2,152.50	2.15	114.70	6.25	729.00	699.84	7,085.88	7.09
13	P Secondary Channel (Right)	2,437.50	2.44	114.70	6.25	797.00	757.15	7,666.14	7.67
14	Q Secondary Channel (Right)	2,643.00	2.64	114.70	6.25	825.00	783.75	7,935.47	7.94
15	R Secondary Channel (Right)	1,368.00	1.37	114.70	6.25	801.00	760.95	7,704.62	7.70
16	S Secondary Channel (Right)	1,698.00	1.70	114.70	6.25	732.00	702.72	7,115.04	7.12
17	T Secondary Channel (Right)	1,500.00	1.50	114.70	6.25	600.00	582.00	5,892.75	5.89
18	U Secondary Channel (Right)	1,200.00	1.20	114.70	6.25	400.00	400.00	4,050.00	4.05
	TOTAL	**34,536.75**	**34.54**				**TOTAL**	**164,138.15**	**164.14**
	WASTE DIFFERENCE	**129,601.40**	**129.60**						

Figure 8. Calculation of planned discharge Dadahup Lowland Irrigation Area

The total discharge required by irrigation is 34.54 m^3/s, while the discharge that must be removed from the land area is 164.14 m^3/s, so the difference is 129.60 m^3/s. It is this difference that needs to be removed from the irrigated area and accommodated by drainage channels. The design discharge value for each secondary channel will be used as the downstream boundary for each secondary channel in the HecRAS 1D modelling. The modelling is done by making a set up model (Figure 9) by drawing the reach on the Barito River and on the primary and secondary channels of Dadahup lowland irrigation area. Adjusting the channel depth according to conditions in the field. Then enter the value for the upstream boundary conditions (Flow Hydrograph) Q2 for 145 hours (Figure 9) obtained from the results of hydrological analysis (Nakayasu) and downstream boundary conditions using tidal water level elevation at Point V of the Barito Kapuas Murung River during the rainy season.

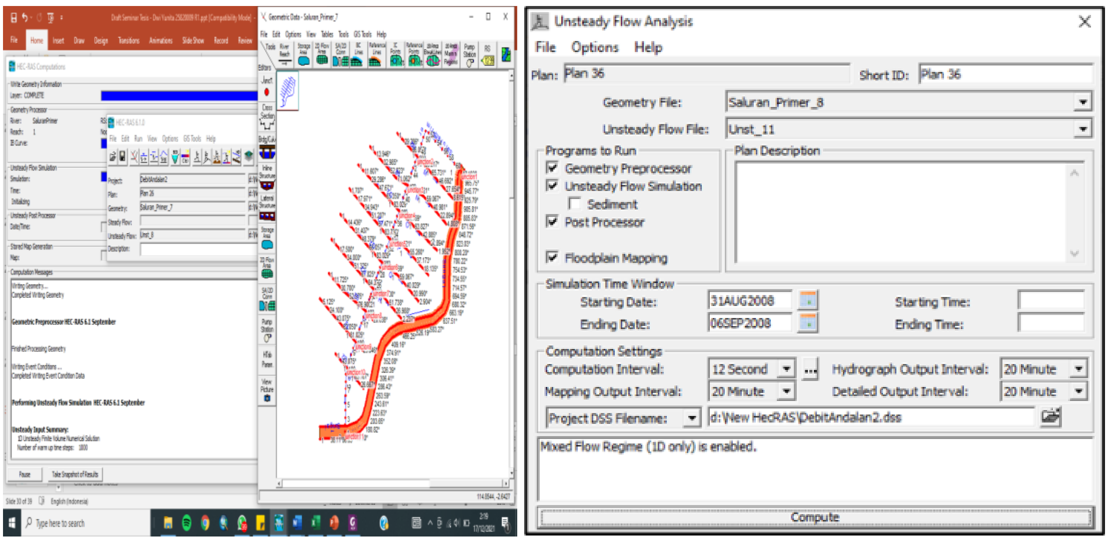


Figure 9. Modelling set up and unsteady flow analysis

After running, the results obtained on Max WS at point M (upstream) point O (middle) and point V (downstream) and compared with the land elevation as shown in Figure 10. Water level elevation of the channel is higher than the elevation on the land at points M, Q and U. From the rating curve it can also be seen that the discharge that the canal needs to accommodate due to the discharge load on the land is quite large. The water level elevation with condition 1 and 2 in each primary and secondary canal can be seen in Figure 11. The red font is an area where the land elevation is lower (> 20 cm) than the water level in the channel. Based on the Figure 11, it can be seen which blocks will always be inundated and cannot be removed by gravity, so that the pumping points (red dots in the Figure 12) are obtained for planning.

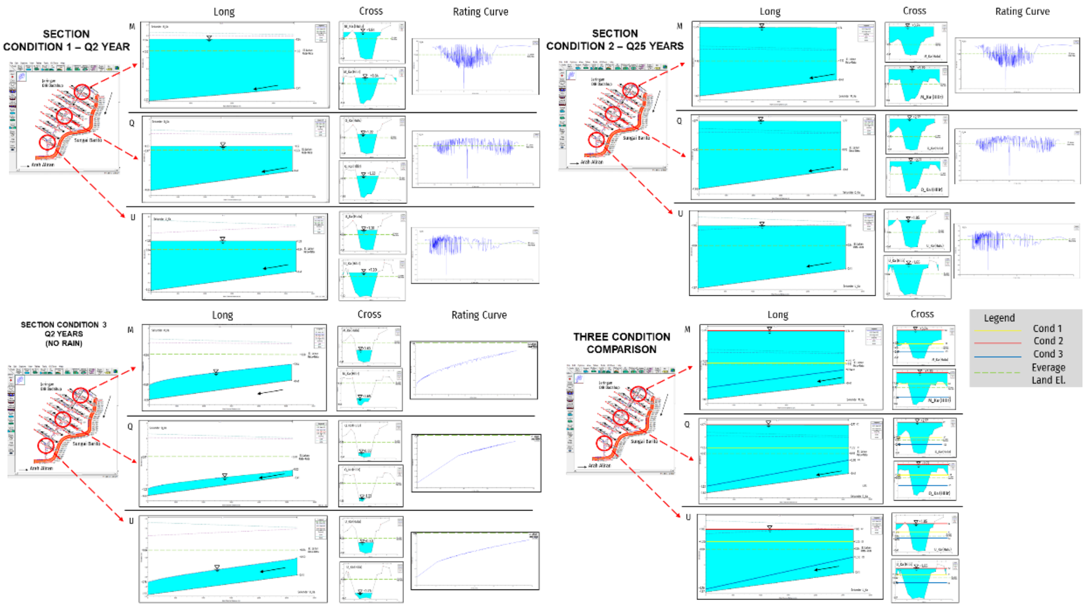


Figure 10. The result of Condition 1 (left), Condition 2 (right), Condition 3 (bottom) and three condition comparison (bottom) WS Max at Point M_Right, Q_Right and U_Right

Num.	Block	Land Elevation			Channel Water Level																	
					Condition 1 - Q2						Condition 2 - Q25						Condition 3 - Q2 (When there is no rain)					
					Primary			Secondary			Primary			Secondary			Primary			Secondary		
		Highest (mdpl)	Lowest (mdpl)	Average (mdpl)	Channel	Max WS Up Stream	Max WS Down Stream	Channel	Max WS Up Stream	Max WS Down Stream	Channel	Max WS Up Stream	Max WS Down Stream	Channel	Max WS Up Stream	Max WS Down Stream	Channel	Max WS Up Stream	Max WS Down Stream	Channel	Max WS Up Stream	Max WS Down Stream
1	A1	1.44	0.45	0.91	Reach 5	1.27	1.23	P Left	-	1.27	Reach5	2.94	2.82	P Left	-	2.93	Reach5	0.68	0.66	P Left	-	- 1.31
					Reach 6	1.23	1.21	Q Left	-	1.23	Reach6	2.79	2.63	Q Left	-	2.77	Reach6	0.65	0.64	Q Left	-	- 1.29
								R Left	-	1.22				R Left	-	2.61				R Left	-	- 1.24
2	A2	1.41	0.42	0.87	Reach 7	1.21	1.20	R Left	-	1.22	Reach7	2.63	2.43	R Left	-	2.61	Reach7	0.64	0.63	R Left	-	- 1.24
					Reach 8	1.20	1.19	S Left	-	1.20	Reach8	2.39	2.14	S Left	-	2.40	Reach8	0.63	0.62	S Left	-	- 1.14
								T Left	-	1.20				T Left	-	2.12				T Left	-	- 1.06
3	A3	0.76	0.45	0.60	Reach 9	1.20	1.20	T Left	1.19	1.20	Reach9	2.12	1.88	T Left	2.92	2.12	Reach9	0.63	0.69	T Left	0.26	- 1.06
					Reach10	1.21	1.31	U Left	1.20	1.20	Reach10	1.85	1.41	U Left	1.85	1.85	Reach 10	0.70	0.78	U Left	- 0.49	- 0.80
4	A4	0.93	0.53	0.73	Reach 7	1.21	1.20	R Left	1.21	-	Reach7	2.63	2.43	R Left	2.60	-	Reach7	0.64	0.63	R Left	-	-
					Reach 8	1.20	1.19	S Left	1.20	-	Reach8	2.39	2.14	S Left	2.39	-	Reach8	0.63	0.62	S Left	0.10	-
								T Left	1.19	-				T Left	2.92	-				T Left	0.26	-
5	A5	1.74	0.57	1.19	Reach 5	1.27	1.23	P Left	1.27	-	Reach5	2.94	2.82	P Left	2.92	-	Reach5	0.68	0.66	P Left	- 0.06	-
					Reach 6	1.23	1.21	Q Left	1.22	-	Reach6	2.79	2.63	Q Left	2.77	-	Reach6	0.65	0.64	Q Left	- 0.04	-
								R Left	1.21	-				R Left	2.60	-				R Left	-	-
6	A6	1.60	0.93	1.21	Reach 5	1.27	1.23	P Right	1.27	-	Reach5	2.94	2.82	P Right	2.92	-	Reach5	0.68	0.66	P Right	- 0.06	-
					Reach 6	1.23	1.21	Q Right	1.22	-	Reach6	2.79	2.63	Q Right	2.77	-	Reach6	0.65	0.64	Q Right	- 0.03	-
								R Right	1.21	-				R Right	2.60	-				R Right	-	-
7	A7	1.40	0.83	1.02	Reach 5	1.27	1.23	P Right	-	1.27	Reach5	2.94	2.82	P Right	-	2.93	Reach5	0.68	0.66	P Right	-	- 1.24
					Reach 6	1.23	1.21	Q Right	-	1.23	Reach6	2.79	2.63	Q Right	-	2.77	Reach6	0.65	0.64	Q Right	-	- 1.23
								R Right	-	1.21				R Right	-	2.61				R Right	-	- 1.14
8	A8	1.67	0.78	1.21	Reach 7	1.21	1.20	R Right	1.21	1.21	Reach7	2.63	2.43	R Right	2.60	2.61	Reach7	0.64	0.63	R Right	-	- 1.14
					Reach 8	1.20	1.19	S Right	1.20	1.20	Reach8	2.39	2.14	S Right	2.39	2.40	Reach8	0.63	0.62	S Right	0.12	- 1.05
								T Right	1.19	1.20				T Right	2.12	2.13				T Right	0.25	- 0.92
9	A9	1.74	0.46	1.05	Reach 9	1.20	1.20	T Right	1.19	1.19	Reach9	2.12	1.88	T Right	2.12	2.13	Reach9	0.63	0.69	T Right	0.25	- 0.92
					Reach10	1.21	1.31	U Right	1.20	1.20	Reach10	1.85	1.41	U Right	1.85	1.85	Reach 10	0.70	0.78	U Right	0.50	- 0.76
10	B1	1.70	0.64	1.33	Reach 3	1.66	1.46	N Left	-	1.65	Reach3	3.40	3.14	N Left	-	3.42	Reach3	1.12	0.86	N Left	-	- 1.03
					Reach 4	1.42	1.28	O Left	-	1.41	Reach4	3.14	2.95	O Left	-	3.19	Reach4	0.80	0.68	O Left	-	- 1.34
								P Left	-	1.27				P Left	-	2.93				P Left	-	- 1.31
11	B2	1.72	1.00	1.34	Reach 3	1.66	1.46	N Left	1.65	-	Reach3	3.40	3.14	N Left	3.40	-	Reach3	1.12	0.86	N Left	0.22	-
					Reach 4	1.42	1.28	O Left	1.41	-	Reach4	3.14	2.95	O Left	2.77	-	Reach4	0.80	0.68	O Left	- 0.11	-
								P Left	1.27	-				P Left	2.92	-				P Left	- 0.06	-
12	B3	1.63	1.14	1.38	Reach 2	1.85	1.67	M Left	-	1.84	Reach2	3.74	3.43	M Left	-	3.81	Reach2	1.28	1.13	M Left	-	- 0.23
								N Left	1.65	1.65				N Left	3.40	3.42				N Left	0.22	- 1.03
13	B4	1.75	0.85	1.42	Reach 1	2.62	1.88	M Left	1.84	1.84	Reach1	4.59	3.78	M Left	3.75	3.81	Reach1	2.04	1.33	M Left	0.63	- 0.23
14	C1	1.68	0.60	1.26	Reach 3	1.66	1.46	N Right	-	1.65	Reach3	3.40	3.14	N Kanan	-	2.40	Reach3	1.12	0.86	N Right	-	- 1.02
					Reach 4	1.42	1.28	O Right	-	1.41	Reach4	3.14	2.95	O Kanan	-	3.16	Reach4	0.80	0.68	O Right	-	- 1.28
								P Right	-	1.27				P Kanan	-	2.93				P Right	-	- 1.24
15	C2	1.67	1.06	1.34	Reach 1	2.62	1.88	M Right	-	1.84	Reach1	4.59	3.78	M Kanan	-	3.79	Reach1	2.04	1.33	M Right	-	- 0.73
					Reach 2	1.85	1.67	N Right	-	1.65	Reach2	3.74	3.43	N Kanan	-	3.43	Reach2	1.28	1.13	N Right	-	- 1.00
16	C3	1.63	0.99	1.28	Reach 3	1.66	1.46	N Right	1.65	-	Reach3	3.40	3.14	N Kanan	3.40	-	Reach3	1.12	0.86	N Right	0.22	-
					Reach 4	1.42	1.28	O Right	1.41	-	Reach4	3.14	2.95	O Kanan	3.15	-	Reach4	0.80	0.68	O Right	- 0.11	-
								P Right	1.27	-				P Kanan	2.92					P Right	- 0.06	-
17	C4	1.62	1.03	1.28	Reach 1	2.62	1.88	M Right	1.84	-	Reach1	4.59	3.78	M Kanan	3.74	-	Reach1	2.04	1.33	M Right	0.64	-
					Reach 2	1.85	1.67	N Right	1.65	-	Reach2	3.74	3.43	N Kanan	3.40	-	Reach2	1.28	1.13	N Right	0.22	-

Figure 11. Water elevation at Canal in condition 1, 2 and 3

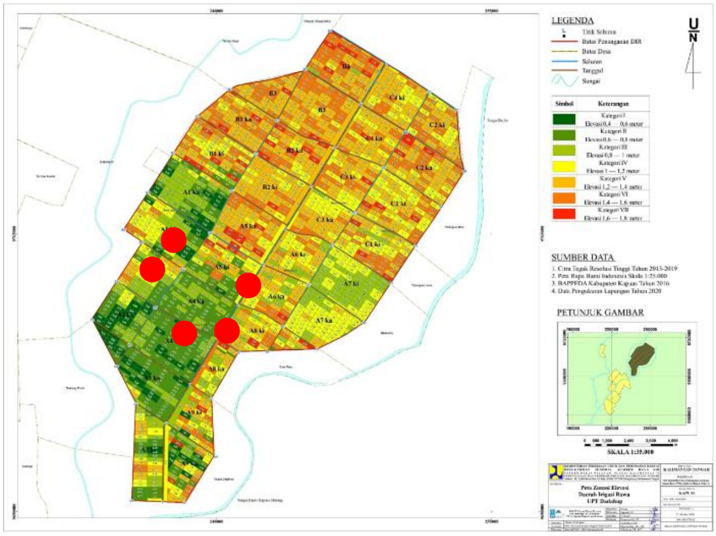


Figure 12. Pumping Point (Red Dot) [10]

5. Conclusion

Based on the results of HecRAS[11] modelling, the condition of the existing swamp irrigation network infrastructure there are still some areas that are inundated > 30 cm during Condition 1, Condition 2 and Condition 3. The duration of high and low tides is the basis for the management of opening and closing

doors. The drain time in a day is about 18 hours, where at low tide conditions the water level in the channel is relatively low, taking into account the opening of the floodgates to prevent over-drain.
Blocks A3 and A4 are blocks that will be inundated and cannot be disposed of by gravity because the land elevation is < the water level of the canal. The pumping point needs to be planned further and it is recommended to use a mobile pump. The mobile pump is intended so that it can also be used to supply water during the dry season at a land elevation higher than the channel elevation. Further development of this research can be done by making good road access for mobile pump (Figure 12). In addition to planning a mobile pump, it can also be planned to calculate the dimensions of the existing channel with the current rainy conditions in order to be able to accommodate the discharge during the Q2 and Q25 rainy season.

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