Study of Reservoir Effect on Water Dynamics in the Main Channel of Belanti I Lowland Irrigation Area

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ABSTRACT

The Belanti I lowland irrigation area is a lowland development area built in the 1980s through the Tidal Rice Field Development Project (P4S). Currently, the land functioned for agriculture is only 1.211 hectares out of 3.392 hectares. These conditions are caused by unfulfilled water and soil quality requirement in that area, so many of the areas are abandoned by farmers. Siltation occurs at several channel points, especially in the reservoir (*kolampasang*) that is filled with sediment and overgrown shrubs. *Kolampasang* siltation will certainly cause water flow dynamics in the main channel, so the issues are interesting to be studied. The methods used in this study were based on field observation to verify the existing data. In addition, HEC-RAS hydraulic analysis simulation will be adopted to obtain channel water dynamics using geometric and boundaries data of Belanti I Lowland Irrigation Area. Based on the results of the HEC-RAS simulation, it is found that the presence of a *kolampasang* will affect the water level, velocity, and discharge in the main channel of Belanti I Lowland Irrigation Area, so that the hydraulic performance of the channel is optimal.

Keywords: *Reservoir, Lowland irrigation areas, Water dynamics*

1. INTRODUCTION

Indonesia is one of the countries with the largest population in the world. The total population of Indonesia in 2020 is 270.20 million people and is projected to increase in 2035 to 305 million people [1,2]. The food security sector is the biggest challenge for the government in the condition of an uncertain world after the COVID-19 pandemic and conflicts abroad. On the other hand, the available land to support food availability is increasingly limited due to changes in land use in the residential, plantation, office, and other sectors. Therefore, one of the current efforts by the government to ensure the availability of national food is the policy of developing and increasing agricultural production in the lowlands. Indonesia has a lowland area of 33.4-39.4 million hectares. The developed land area is ±4.5 million Ha, including the ex-peatland development area (ex-PLG), Central Kalimantan Province [3]. Development and increase in agricultural production can be done by opening new land (extensification) or increasing agricultural production, such as increasing the cropping index (intensification). According to Marwanto (2021) [4], the remaining land that has the potential to be developed (extensification) in the ex-PLG Block D area is around 36.245 hectares of the total area of almost 165.000 hectares.

The Belanti I Lowland Irrigation Area is one of the lowland irrigation areas located in the block D area of the ex-PLG. Built in the 1980s, located in Central Kalimantan Province, Pulang Pisau Regency, Pandih Batu District, Sanggang and Pantik Villages. The potential area is 3.392 Ha, while the functional area for paddy fields is 1.211 Ha. There is still 1.200 Ha of abandoned land in the form of shrubs left by the cultivators. The rests are plantation and residential areas [5]. The amount of land left by the cultivators is suspected to be due to the unfinished reclamation process, so the soil and water quality are not good [6].

The Belanti I Lowland Irrigation Area macro water management system is a two-way flow system with a *sisir* type. The main channel is a supplier and disposes of excess water utilizing tidal energy. A reservoir (*kolampasang*) is installed at the end of the primary channel (Figure 1). Based on the survey results, the current condition of *kolampasang* is not functioning because it is full of sediment and overgrown with shrubs. The existence of *kolampasang* is useful to

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accommodate the leaching of sulfuric acid soil that does not get out of the channel [7]. In addition, *kolampasang* can significantly increase the volume of water that enters during high tide conditions [8]. The role of the *kolampasang* makes the authors interested in studying the effect of *kolampasang* on water dynamics in the main channel of The Belanti I Lowland Irrigation Area.

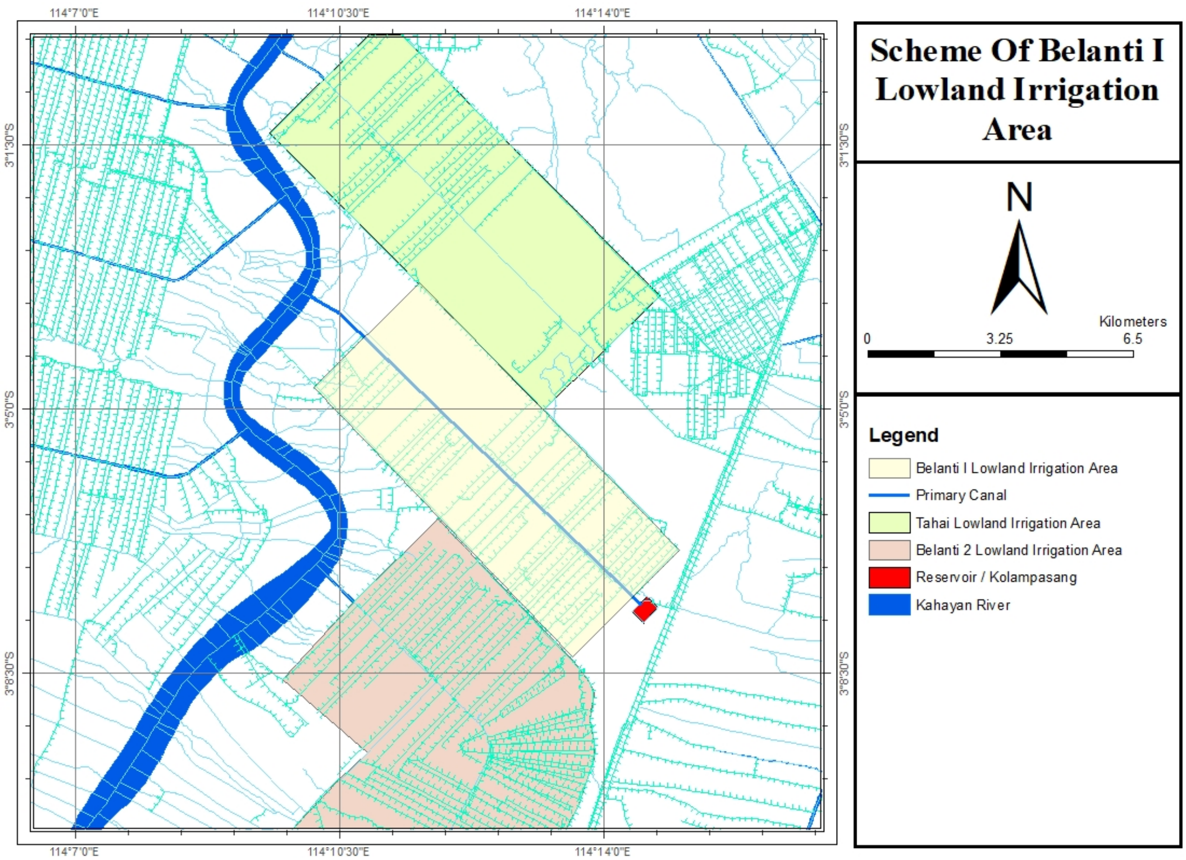

Figure 1 Scheme Of Belanti I Lowland Area Irrigation.

2. MATERIAL AND METHODS

The method used in this research is as follows:

2.1. Field observations

Field observations were conducted to get an overview of the existing conditions and validate the secondary data collected.

2.1.1. Water Quality

Observed water quality using a digital multiparameter tool. The water sample taken is surface water using a sterile container. Observations were made at several points and times. The data obtained are the value of pH, Tds, and Ec.

The observed results of pH and Tds values will be compared with Government Regulations concerning water quality management and pollution control. As for the Ec value, the author uses other criteria because it has not been accommodated in the regulation. Here are the water quality parameters used:

Table 1. Water Quality Criteria by Class [9]

Parameter	Unit	Class			
		I	II	III	IV
Disolve Residue	Mg/L	1000	1000	1000	2000
pH *		6 - 9	6 - 9	6 - 9	5 - 9

* If naturally outside the range, then it is determined based on natural conditions

Table 2. Irrigation water class criteria

Water Class	Ec (µs/cm)
Very Good	0 – 250
Good	250 -270
Enough	750 – 2000
Less	2000 – 3000

Bad	>3000

2.1.2. Soil Typology

The soil sampling location consisted of 2 points of former rice fields left by the cultivators. The two points are on the right and left secondary land. The tools used to observe soil typology are hand drills and hydrogen peroxide solution. Observations were made visually by looking at the reactions when the soil was dripped with a hydrogen peroxide solution.

2.2. Hec-Ras Modelling Simulation

The simulation is simple modelling using Hec-Ras 5.0.7 application to compare the dynamics of water in the main channel. Several simulated scenarios were a) Channel conditions without *kolampasang*; b) Channel conditions with an area of 20 Ha of *kolampasang*; c) Channel conditions with an area of 40 ha of *kolampasang*. Modelling of the main channel Belanti I Lowland Irrigation Area uses secondary data from *Balai Wilayah Sungai Kalimantan II*. The length of the main channel is 10.4 km, with a total cross-section of 53 pieces. The cross-sectional area of the channel gets smaller until upstream. The initial design of the Belanti I Lowland Irrigation Area had a *kolampasang* with a width of 400 meters, a length of 500 meters, and a depth of 2 meters.

The downstream boundary conditions used are simultaneous water level observations for 48 hours for the spring period from November 16, 2020, to November 18, 2020. The data was obtained from *Balai Wilayah Sungai Kalimantan II*. The upstream boundary conditions and initial flow conditions are assumed to be 0 m^3/s.

3. RESULT AND DISCUSSION

3.1. Water Quality

The results of observations of water quality in the main channel of Belanti I Lowland Irrigation Area can be seen in Table 3:

Table 3. Recapitulation of water quality observations in the main channel

Location	High Tide			Low Tide		
	pH	Tds (ppm)	Ec (µs/cm)	pH	Tds (ppm)	Ec (µs/cm)
Downstream	4.13 – 4.47	22 - 33	44 – 486	2.45 – 2.63	332 – 413	703 – 828
Middle	2.95 – 3.36	172 - 267	344 - 536	2.52 – 2.71	293 – 335	586 – 707
Upstream	3.75	168	337	2.61 – 2.87	234 - 278	516 – 578

Based on observations, the value of the degree of acidity (pH) fluctuates at each sampling point. At high tide conditions, the pH value is in the range of 2.95 – 4.47. The pH is even worse at low tide, in the 2.45 – 2.87. The pH value remains far from the required parameter, the range 5-9 [9].

Total Dissolve Solid (Tds) is the number of dissolved solids or the concentration of the number of cations (positive charge) and anions (negative charge) in the water. The Tds value fluctuates at each sampling point. During high tide conditions, the Tds value is 22 - 267 ppm, while low tide conditions are 234 - 413 ppm. This water quality parameter is within the required limit of <2,000 mg/l [9].

Electrical Conductivity (Ec) is the ability of water to conduct electricity. Ec values during high and low tide conditions ranged from 44 – 536 µs/cm dan 516 – 828 µs/cm. According to the classification by Schofield (1948), these conditions are classified in the good to sufficient category for irrigation water class. Judging from the distribution pattern in the main channel, the closer to the end, the value of Ec gets lower. This condition is possible because the farther from the sea, the less the influence of salt in the water.

Pyrite oxidation causes acidity of the water (pH) in the channel, as seen from the characteristic yellowish color of the water. The bottom of the secondary channel is higher than the bottom of the primary channel. Existing water structures are not functioning. This condition causes all of the water to be wasted in the primary channel, as seen in Figure 2. Therefore, it is necessary to manufacture and optimize the function of water structures at the ends of secondary channels to maintain the groundwater level and minimize pyrite oxidation occurrence [6].

3.2. Soil typology

Based on the visual observations, the soil sampling location found shallow pyrite content < 50 cm and no peat soil. The location, which is a former abandoned rice field, causes the soil to be in an aerobic condition, and the pyrite compounds have been oxidized. The distribution of soil types can be seen in Figure 3.

Widjaya-Adhi (1995) classified the soil condition as an alluvial sulfide-2 typology or acid sulfate with the symbol SMA-2. Acid sulfate soil is a challenge for lowland reclamation for agricultural cultivation because it contains toxic substances harmful to plants. Special treatments are needed, such as amelioration, fertilization, and adaptive varieties so that agricultural yields can be optimal. In addition, proper water management techniques such as regular soil leaching processes and the application of a one-way flow management water system are effective efforts [10] [11].

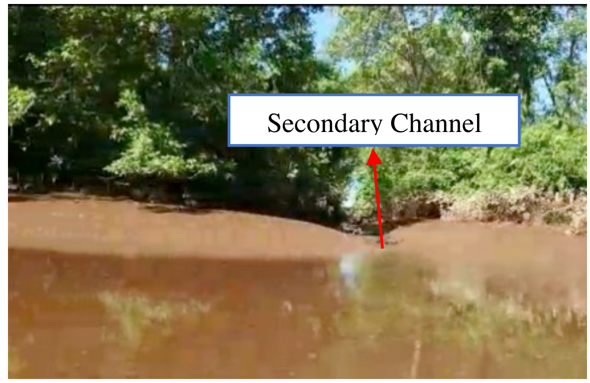

Figure 2 Observation of the water level at low tide.

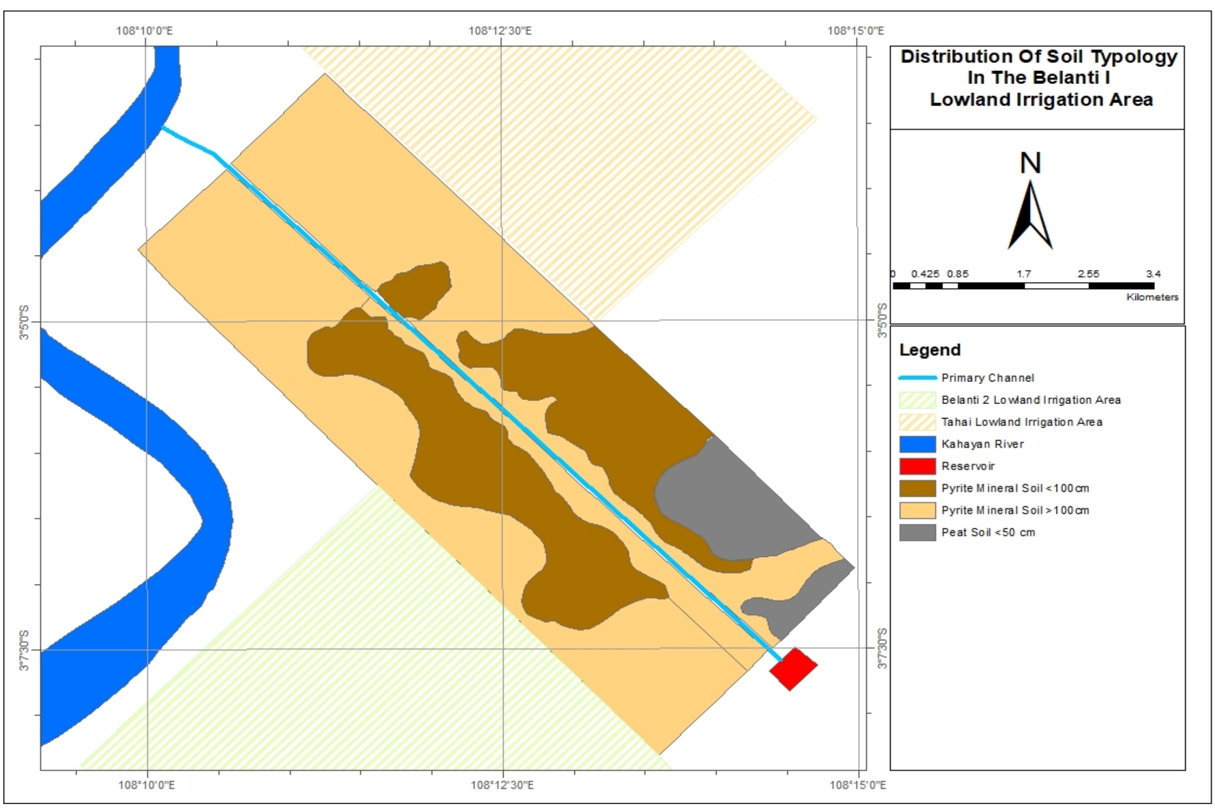

Figure 3 Soil type distribution map [5].

3.3. Simulation Result

The water dynamics reviewed in each scenario include water level, velocity, and discharge in the channel. The point of view is divided into 3, namely the downstream (RS.600), middle (RS.5000), and upstream (RS.9600).

3.3.1. High Water Level

The existence of *kolampasang* can significantly cause changes in water level upstream of the channel approaching the *kolampasang*. The water level fluctuation for each scenario can be seen in Figure 4 until Figure 6.

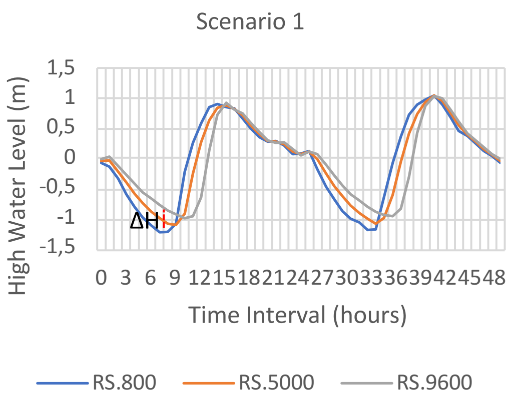

Figure 4 Water Level Graph in Scenario 1.

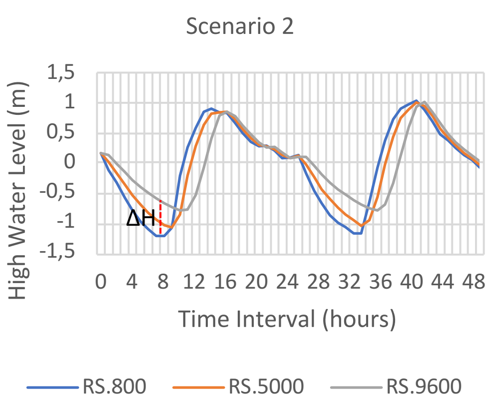

Figure 5 Water Level Graph in Scenario 2.

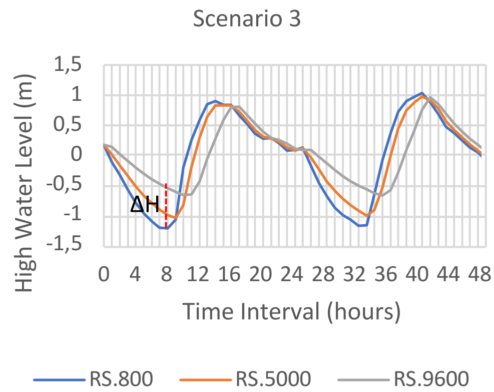

Figure 6 Water Level Graph in Scenario 3.

The line at the downstream (RS.800) and middle (RS.5000) do not experience a significant difference in each scenario (Figure 4 – Figure 6).). A significant difference occurs at the line of the upstream reference point (RS.9600). It is seen that the presence of a *kolampasang* causes the line of a graph to be more sloping. The change in water level upstream of the channel causes the height difference between the downstream and the upstream of the channel (ΔH) to get bigger. This change is directly proportional to the area of the *kolampasang*. The larger the *kolampasang* area (scenario 3), the higher the difference in water level between the downstream and the upstream of the channel (ΔH).

3.3.2. Velocity

Referring to the concept of the energy equation in an open channel (Figure 7), the difference in water level at the downstream and the upstream of the channel can give an energy grade line. The relationship is linear, so the average velocity will also be greater [7].

$$\frac{v_1^2}{2g} + y_1 + z_1 = \frac{v_2^2}{2g} + y_2 + z_2 + h_{L,1-2} \tag{1}$$

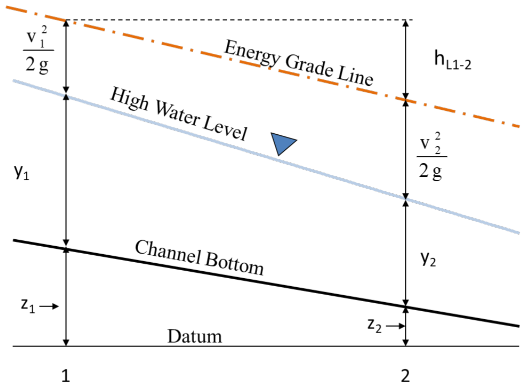

Figure 7 Energy equation concept.

This relation can be proven by comparing the simulation results. Based on the 8th-hour interval, it was found that the presence of *kolampasang* with scenario 2 and scenario 3 could increase the flow velocity upstream of the channel (RS.9600) up to 2 and 3 times. Meanwhile, at the middle of the channel review point (RS.5000), there was only an increase in each scenario of 15% and 25%. At the channel downstream (RS.800), the increase is 5.5% for scenario 2 and 11.1% for scenario 3.

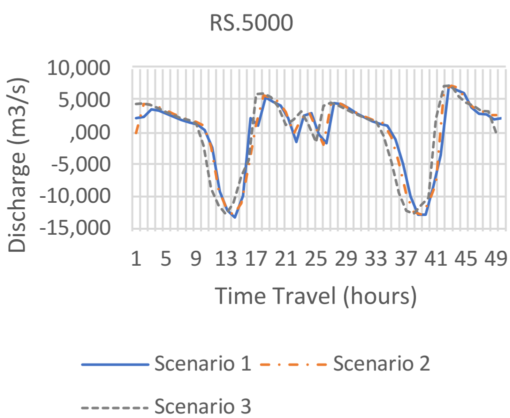

Figure 8 Discharge Comparison Chart RS.5000.

3.3.3. Discharge

Kolampasang effect on discharge can be seen in the middle and upstream channels (Figure 8) and (Figure 9). Meanwhile, there is almost no significant change in discharge at the channel downstream review point (RS.800), which is 9.6 km from the kolampasang.

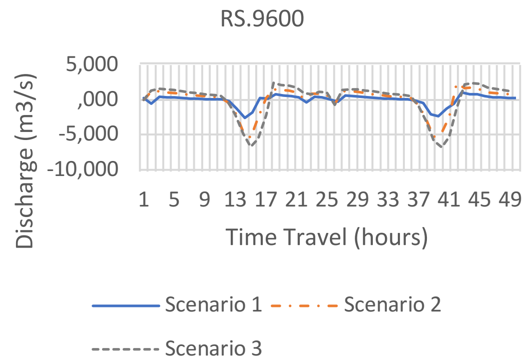

Figure 9 Discharge Comparison Chart RS.9600.

From the graph, the total volume of water inflow and outflow of the channel can also be calculated. The total volume of water is obtained by calculating the area of the discharge graph above. The discharge value that shows a negative number (-) is an inflow, while the discharge value that shows a positive number (+) is an outflow. This is because the direction of the channel geometry is from upstream to downstream. The ratio of the volume of water inflow and outflow of the channel can be seen in Table 4 until Table 6.

Table 4. The ratio of water total volume RS.800

	Scenario 2	Scenario 3
Inflow	2.09%	3.85%
Outflow	0.34%	1.72%

At the channel downstream (RS.800), the presence of *kolampasang* did not significantly affect the total volume of water during the 48-hour time interval. This is because the distance is too far from the *kolampasang*, which is 9.6 km. The ratio of the increase in the volume of water inflow is greater than the volume of water outflow.

Table 5. The ratio of water total volume RS.5000

	Scenario 2	Scenario 3
Inflow	11.32%	18.87%
Outflow	10.41%	16.44%

A significant effect occurs in the middle of the main channel (RS.5000), which is 5.4 km from the *kolampasang*. As seen on Table *5*, If the *kolampasang* is enlarged (scenario 3), the ratio of the increase in inflow and outflow volumes will be even greater. The increase in the volume of water inflow is also greater than the volume of water outflow.

Table 6. The ratio of water total volume RS.9600

	Scenario 2	Scenario 3
Inflow	143.64%	257.37%
Outflow	163.39%	262.26%

The effect of the presence of *kolampasang* is very significant at the end of the channel (Table 6). This effect shows that the closer the review point is to the *kolampasang*, the greater the effect on fluctuations in water volume. However, in contrast to the previous review points (RS.800 and RS.5000), the increase in the outflow volume was greater than the volume of water inflow. The size of the *kolampasang* area is also directly proportional to the magnitude of the increase in the water volume.

4. CONCLUSION

The reclamation process at Belanti I Lowland Irrigation Area has not been completed yet. This process can be seen from the indicators of water and soil quality. The pH value and the finding of shallow pyrite need mitigation and improvement efforts. On the other hand, the non-functioning of the *kolampasang* has a significant effect on the water level, velocity, and discharge upstream of the channel. These changes cause the hydraulic performance in the main channel to be less than optimal. So that it has the potential to inhibit the leaching process because it reduces the volume of water for dilution of acids.

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