Study of Barito River Supply System on Dadahup Lowland Irrigation in Central Kalimantan Food Estate Area

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Abstract. The Dadahup Swamp Irrigation Area (DIR Dadahup) is a part of The Ex-Mega Rice Project Area (MRP) Block A which is one of the locations for the Food Estate Area in Kapuas Regency, Central Kalimantan. DIR Dadahup has a potential area of 21,226 hectares with the condition of the irrigation system in moderate to severe damage. The need for irrigation water to irrigate rice fields in tidal swamp land is supplied from the Barito River. The problem is that the tidal water level on agricultural land cannot be controlled so that most of the rice fields cannot be planted. The purpose of this study was to examine the pattern of river flow at the point of view and to determine the water level of the irrigation canal. Tidal analysis of the canal is carried out by making a model using software HEC-RAS 6.0 under main canal and secondary canal existing cross section. The canal water level data used are in the dry season and the wet season as a boundary. Based on the modeling results, 53% or 11,223 hectares of agricultural land cannot be irrigated by gravity, because the canal elevation is lower than the land elevation, namely in Block A1, A2, A4, A5, A6, A7, A8, and A9. To overcome these problems, a pump and a sluice gate are needed that are able to regulate the water supply of the Barito River that enters from the inlet point of the DIR Dadahup.

1. Introduction

World food security remains largely dependent on irrigated lowland rice, which is the main source of rice supply [1]. Water is one of the most important components for rice production in the world since it consumes the highest amount of water than any other crop in the agricultural sector [2]. Fresh water for irrigation is becoming scarce because of population growth, increasing urban and industrial development, and the decreasing availability resulting from pollution and resource depletion [3] [4]. About 34 to 43% of the total world's irrigation water or 24 to 30% of the world available fresh water is used for rice production [5]. Traditionally, rice is cultivated under continuously flooded condition in irrigated areas, which results in high amount of water used. About 75% of the global rice production comes from irrigated lowland areas [6].

The Food Estate Program is one of the National Strategic Projects 2020-2024 which aims to build a national food barn on an ex-MRP (Mega Rice Project Area) or Proyek Lahan Gambut (PLG) area of 165,000 hectares in Central Kalimantan [7]. This is an attempt by the Government of Indonesia to anticipate the threat of a food crisis by building an integrated food area. This program is hampered by the condition of the existing irrigation system in moderate to severe damage, thus requiring rehabilitation to restore the function of the network in swamp irrigation areas. The government will rehabilitate and improve agricultural areas in Central Kalimantan starting in 2020, especially in the area of the Ex-MRP, which was opened in 1995 to 1998. The project which was previously aimed to be a national food security, has failed in its implementation because cause various technical, social, economic, cultural and ecological problems [8].

According to Haryanti (2020) and Euroconsult (2008), the Ex-MRP Zone has 5 blocks which are Blocks A, B, C, D and E [9] [10]. On the Ex-MRP Block A area, there is the Dadahup Swamp Irrigation Area (DIR Dadahup) which is the study location for this research. The DIR Dadahup area is a swamp irrigated area that is included in the transitional category between tidal swamps and non-tidal swamps [9]. The hydrology of this area is determined by tides entering from the sea into the rivers that reaches into the Ex-MRP area, the flow of the main rivers, and wetfall in the area [11]. There are several river flows that affect DIR Dadahup, one of which is the Barito River which is also the main water source for its irrigation system. The situation in the field shows that the tidal conditions of the Barito River and the elevation of the canal water level to the elevation of agricultural land affect the irrigation system management plan and also affect the water supply system to reach the entire agricultural land area of DIR Dadahup. In certain areas during the dry season, water cannot flow in or inundate the land, causing drought and farmers failing to harvest [12].

This study aims to create an overview of the effect of tidal elevation from the Barito River on the DIR Dadahup land to support the Food Estate program. Tidal analysis was carried out using HEC-RAS 6.1 software. The hydraulic analysis component used in HEC-RAS in this study is one-dimensional (1D) modeling with an unsteady flow simulation type. The results of this hydraulic analysis finding out the depth of water in the canal, so that this study can be revealing the elevation of the water level of the canal to elevation of the agricultural land.

2. Study Area

The study area of this research is Barito River, with the focus of research on DIR Dadahup. The upstream part Barito River is located in the Schwaner Mountains (Central Kalimantan) and the downstream part is in the Java Sea (South Kalimantan). The length of the Barito River is about 838.23 km with a river width of 600-4000 m, and its depth ranges from 4 m - 20 m. The area of the Barito watershed is approximately 62,347.43 km^2. Barito River is the main source of water for DIR Dadahup [13].

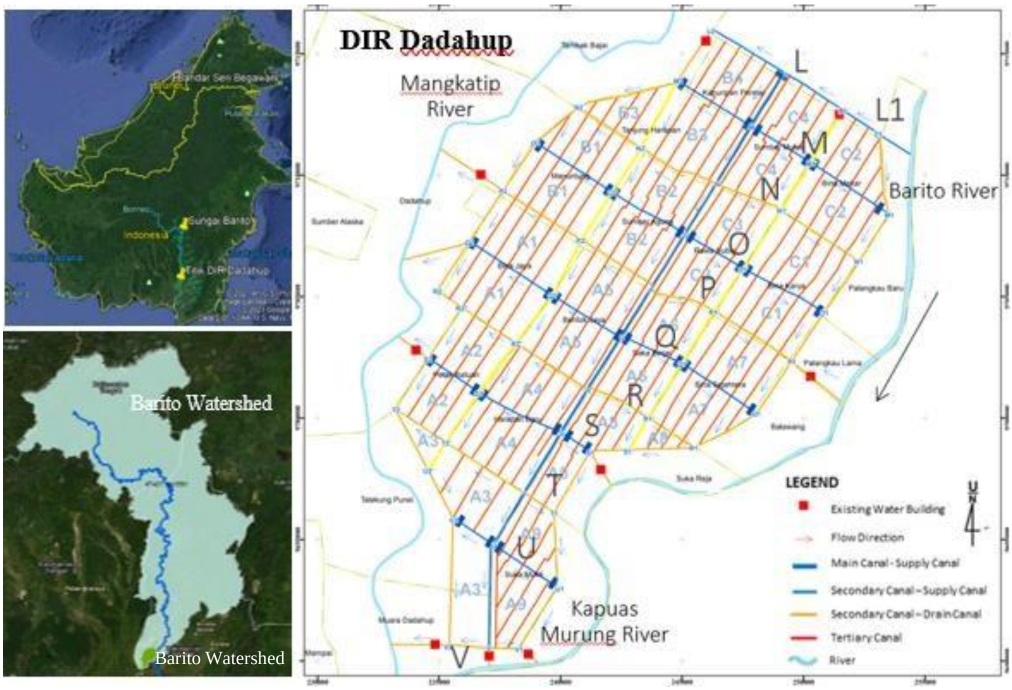


Figure 1. Barito Watershed Map and DIR Dadahup Map [12]

DIR Dadahup is one of the swamp irrigation areas in Block A - *Food Estate* located in Dadahup District and Kapuas Murung District, Kapuas Regency, Province Central Kalimantan. The potential area of DIR Dadahup is about 21,226 Ha. The original design of this system was a box-shaped network of canals consisting of main and secondary canals with an open connection with collector canals surrounding the area with its flow direction parallel to the flow direction of the main river [11]. The main canal is from point L1 (upstream) to point V (downstream). The secondary canals consist of Canal M, N, O, P, Q, R, S, T, U, as can be seen in Figure 1. The main rivers in DIR Dadahup are the Barito River and Kapuas Murung River on the east side and the Mangkatip River on the west side.

3. Material and Methods

The stages in this study consist of literature study, data collection, data analysis, discussion, and conclusion. The data used in this study are hydrotopographic data, tidal data of the Barito River, water level elevation data of canals, geometry data of primary and secondary canals, land elevation data, and other irrigation data. The flow chart of this study described in Figure 2.

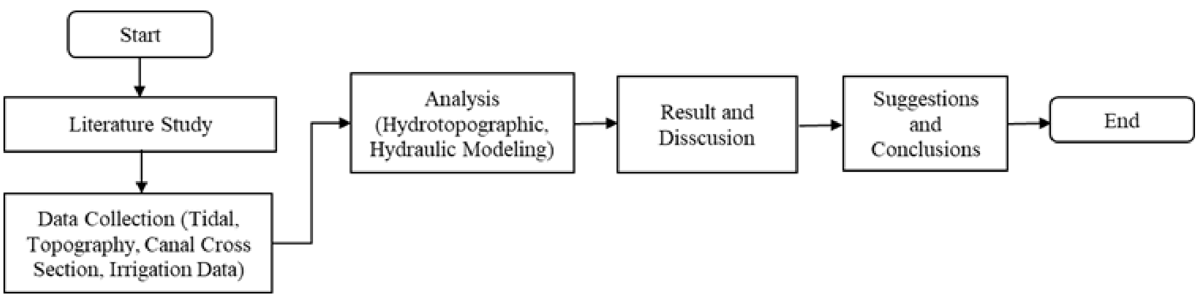


Figure 2. Flow Chart of Study

Tidal elevation data of Barito River was obtained from the website of the Indonesian Geospatial Information Agency (BIG), for 31 days in October 2021. Using the Least Square method, it is known the type of tides of the Barito River. The Least Square is exceptionally easy to program on a digital computer, most efficient when used to obtain a fixed number of tidal constituents from a fixed number of discrete tidal height (or current) measurements representing a standard series length [14]. The tidal types is mixed-predominantly semi diurnal [16]. Tidal elevation data shown in Table 1.

Table 1. Tidal Elevation Data

	Symbol	Elevation (m)
Highest High Water Level	HHWL	1.47
Mean Sea Level	MSL	0
Lowest Low Water Level	LLWL	-1.47

Hydraulic analysis was performed using HEC-RAS 1D software with conditions unsteady flow. Based on user's manual of Hec-Ras (2021), unsteady flow data contain flow hydrographs at the upstream boundaries, starting flow conditions, and downstream boundary conditions [17]. The upstream modeling boundary condition is the canal tidal elevation at point L1 (inlet), and the downstream modeling boundary condition is the canal tidal elevation at point V (outlet), as can be seen in Figure 3 and Figure **4.** Tidal elevation data are the result of measurements made by Balai Teknik Rawa for 15 days: November 27, 2020 – December 11, 2020 during the wet season and May 28, 2020 – June 11, 2020 during the dry season. The geometric data used in the model is the existing condition.

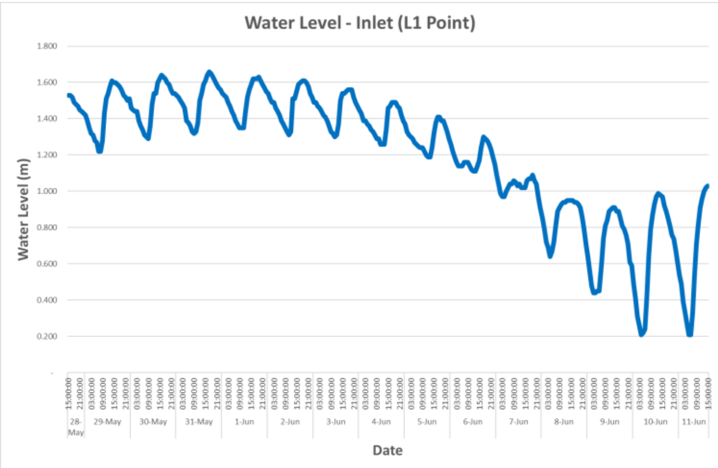


Figure 3. Tidal Elevation in L1 Point (Inlet)

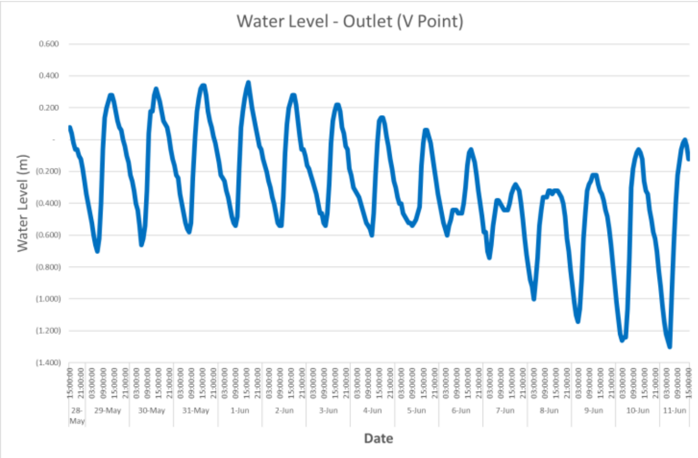


Figure 4. Tidal Elevation in V Point (Outlet)

4. Results and Discussions

4.1 Hydrotopographic Analysis

Hydrotopographic analysis was carried out using land elevation data for each tertiary block with hydrometric data in the form of canal water level. Based on the results of the analysis, it is known that the Dadahup area has hydrotopographic classes A, B, and C. The broad division of the three hydrotopographic classes shows that class B has the largest area. The hydrotopography of the area is one of the factors to be considered in planning operations in tidal swamp land and determining cropping patterns [15]. Based on the hydrotopographic classification, the proposed cropping pattern during the first planting season is rice, and the second planting season is rice and *palawija*. The Planting Pattern Plan for rice is on area with hydrotopographic classification A and B (upstream and middle), while for *palawija* is on area with hydrotopographic classification C (downstream).

4.2 Hydraulic Modeling

Analysis was performed using HEC-RAS one-dimensional (1D) software. The unsteady state HEC-RAS model was developed by US Army Corps of Engineers (2001) to perform 1D hydraulic calculations for a full network of earth and constructed channels [18]. In this study, modeling was carried out on the existing conditions of DIR Dadahup during the dry season and wet season. The data used for geometry are data for the long and cross section of Main Canal and Secondary Canals (Figure 5). Boundary condition used in upstream and downstream is tidal data.

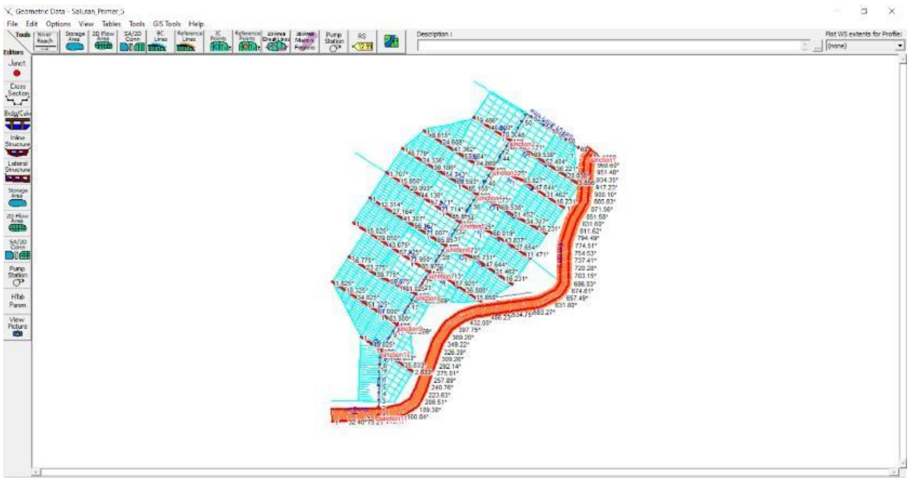


Figure 5. Set Up Modeling

After running using the set up model and boundary above, with a simulation time of 15 days, a computation interval of 1 minute, and a mapping interval output 1 hour, the results for the Main Canal are shown in Figure 6 and Figure 7.

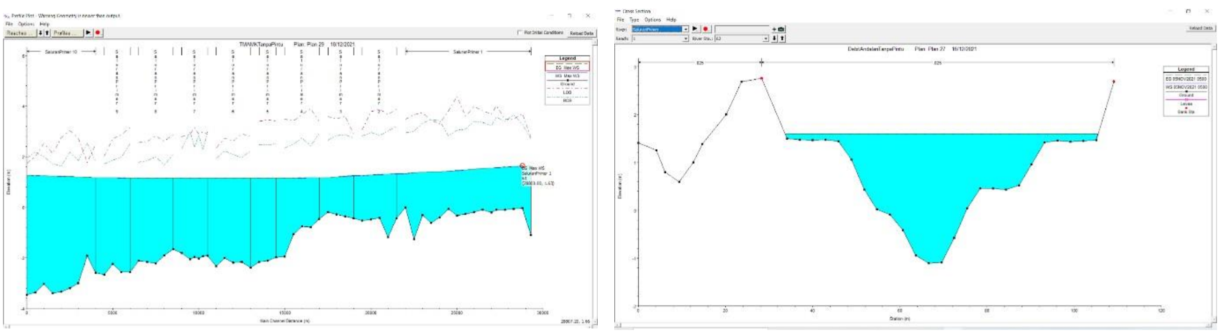


Figure 6. Main Canal in Dry Season

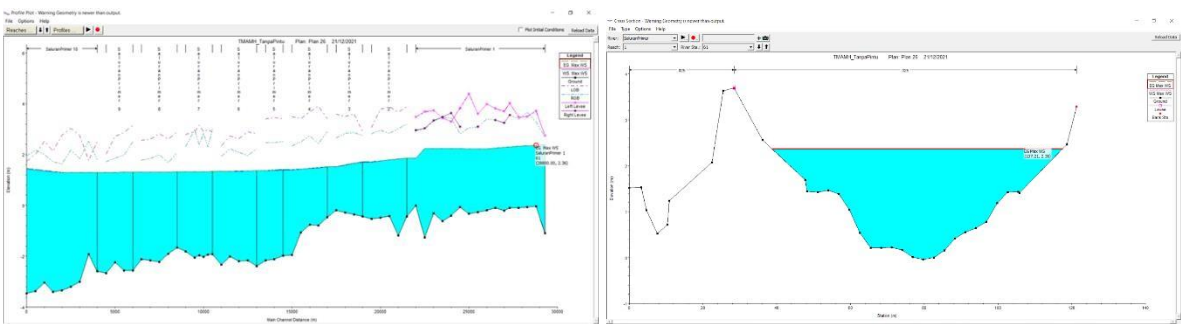
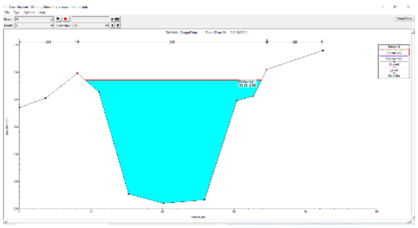
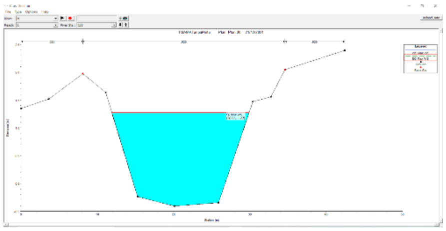
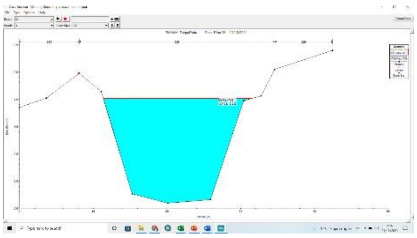
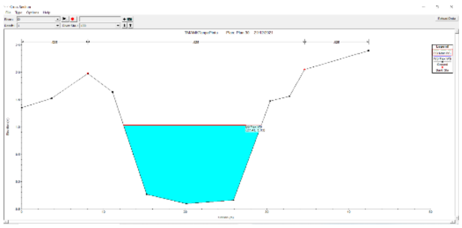
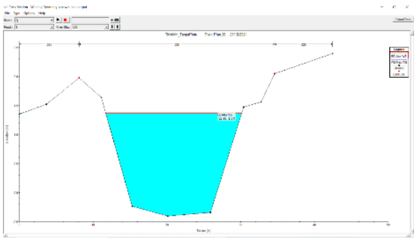
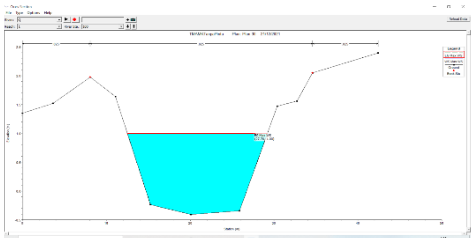
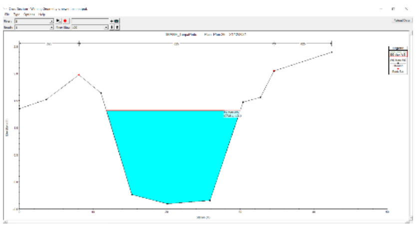
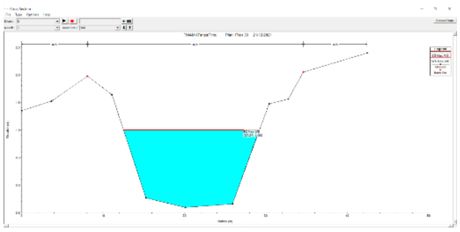


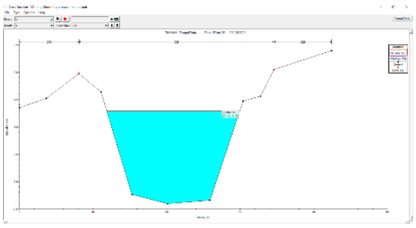
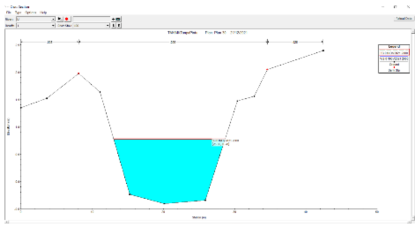
Figure 7. Main Canal in Wet Season

The highest water level elevation at high tide is in the Main Canal in the dry season at +1.64 msl and during the wet season at +2.36 msl. The movement of water in the Main Canal is still going back and forth towards upstream and downstream. This causes the Barito River water cannot fully flow to the downstream point.

During the dry season and wet season, there is a difference in water level in the secondary canal, about 0.31-0.59 meters. From the modeling results, it can be seen that not all of the water level elevations are higher than the land elevation. During the dry season, the elevation of the secondary canal Q, R, S, T, and U is lower than the elevation of the surrounding land. This causes the agricultural land in the block (Block A1, A2, A3, A4, A5, A6, A7, A8, A9) cannot be irrigated by gravity. The results of secondary canal modeling during the wet season and dry season can be seen in Table 2.

Table 2. Secondary Canal on Wet and Dry Season

Canal	**Wet Season**	**Dry Season**
M	 Max. Water Level: +1.85 msl	 Max. Water Level: +1.27 msl
O	 Max. Water Level: +1.51 msl	 Max. Water Level: +1.03 msl
Q	 Max. Water Level: +1.37 msl	 Max. Water Level: +1.00 msl
S	 Max. Water Level: +1.31 msl	 Max. Water Level: +1.00 msl

Canal	Wet Season	Dry Season
U	 Max. Water Level: +1.29 msl	 Max. Water Level: +0.7 msl

The model calibrated and validated using data on Canal Q on May 30, 2020. Calibration was carried out to obtain manning values, computational interval values and also the geometry of the created canal. In canal simulation, channel roughness is a sensitive parameter in the development of hydraulic model [19]. After trial and error to get the manning value, computational time and the right geometry, the computational interval is 1 minute and manning value is 0.025. The error calculation of the model calibration was also carried out using the Root Mean Square Error (RMSE) method [20]. The RMSE value of 0.037 is obtained, which means that the validation of the model is good because it has an error that has started to approach the value of 0. Then a manning value of 0.025 is used with a computational interval of 1 minute.

From the modeling results, there is a relationship between depth (water level) and discharge in the canal which can be seen from the rating curve (Figure 8).

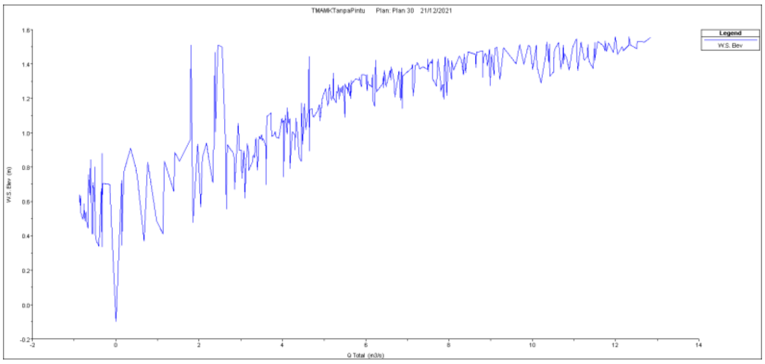


Figure 8. Rating Curve in Main Canal

Based on rating curve above, it can be seen that the discharge in the secondary canal is greater than the irrigation water requirement. This shows that the availability of water in the canal is sufficient to supply the irrigation water needs of each tertiary block even during the dry season. However, the land elevation which is higher than the water level causes the land to be unable to be irrigated by gravity. The total area is 8,343 ha of land that requires a pump, and 13,664 ha of land that can be irrigated by gravity.

5. Conclusions

From this study we can conclude that the discharge of the Barito River is sufficient to supply the irrigation of the DIR Dadahup area even during the dry season. However, the elevation of the land which is higher than the elevation of the water table causes not all agricultural land to be irrigated during the dry season. During high tide conditions in the wet season, the water level elevation of all canals is above the elevation of agricultural land, but at low tide conditions in the dry season, the elevation of the all canals is lower than the elevation of agricultural land. This shows that all agricultural land cannot be irrigated at low tide conditions in the dry season. Total area of 11,223 ha of agricultural land that requires pumps, namely the Block A1, A2, A3, A4, A5, A6, A7, A8, and A9. Hydrotopography affects the DIR Dadahup Planting Pattern. During the wet season, the hydrotopographic areas A (upstream), B (middle) and C (downstream) are planted with rice. In the dry season, the hydrotopographic areas A and B are planted with rice, while the hydrotopographic lands C are planted with *palawija*. Further development of this study can be conducted by planning a closed network irrigation system with sluice gates.

6. Acknowledgements

Authors wishing to acknowledge assistance or encouragement from graduate advisors Mr. M. Farid and Mrs. Winskayati, colleagues, special work by staff of Water Resources Engineering and Management Program and financial support from Ministry of Public Works and Housing.

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