Study on the Performance of the Hydraulics System Planning of Swampy Irrigation Area of Dadahup, Kapuas District, Central Kalimantan Province

M I Arif1, D Legono1,*, D Luknanto1

1 Department of Civil and Environmental Engineering, Faculty of Engineering, Universitas Gadjah Mada, Jl. Grafika No.2, Yogyakarta, 55281, Indonesia

*Corresponding author: djokolegono@ugm.ac.id

Abstract. Swampy Irrigation Area (DIR) Technical Implementation Unit (UPT) Dadahup is a swampy irrigation area that needs serious handling of flood control. This flood is resulting in crop failure in several blocks. Furthermore, the malfunctioning of the main gates in controlling the entry and exit of water resulted in a long-standing inundation for the land. This paper presents the hydraulic system of the irrigation network of DIR UPT Dadahup by reviewing secondary data and documentation of field observations. Based on these parameters, the authors simulate the main primary channel using HEC-RAS to perform hydraulic analysis. The flow simulation results show that water entering the land inundated the three canal segments. One has the highest embankment elevation of 1,778 m, with the highest tide on the channel section of 2.25 m. Other results showed that water entering the land also inundated one channel section. The highest embankment elevation was 1,233 m, with the highest tide on the channel section being 1.4 m. From these results, the overflow of water was then eliminated by the heightening of the embankment.

Keywords: Lowland irrigation, inundation, flood control, HEC-RAS, embankment

1. Introduction

The million-hectare peatland project is a project initiated by the Indonesian government in 1995 to develop peatlands in Central Kalimantan Province. This project is known as the “Mega Rice Project”. Up to one million hectares of swamp and peatland have been converted for rice cultivation. Massive construction of thousands of kilometers of waterways was carried out. However, this project harmed land and forest damage due to massive land clearing resulting in drought and fires. About half of the 15,594-transmigrant families who placed in land development sites that year and then left because the land was not suitable for rice cultivation. The destruction of natural resources in the area and the hydrological impacts caused by the project make losses for the resident [1].

The Indonesian government is currently implementing several programs, one of which is the rehabilitation and improvement of swamp irrigation networks in accordance with the 2020-2024 National Medium-Term Development Plan (RJPMN) and the Strategic Work Plan established by the Ministry of Public Works and Public Housing. The Strategic Plan of the Ministry of Public Works and Public Housing is to build rice and non-rice irrigation networks covering an area of 500,000 hectares and rehabilitate 2,500 hectares of irrigated land to support food security. One of the programs implemented to support food security is the Food Supply Improvement Program in Central Kalimantan.
The Swampy Irrigation Area of the Dadahup Technical Implementation Unit is one of the locations included in the rehabilitation and improvement program for swamp irrigation networks in order to increase the food supply in Central Kalimantan. Swampy Irrigation Area is a former Peatland Development part of a million hectares peatland development project located in Central Kalimantan Province. DIR UPT Dadahup is located in Dadahup and Kapuas Murung sub-districts, Kapuas Regency, Central Kalimantan Province with an agricultural land area of 21.226 ha [2].

DIR UPT Dadahup is one of the swamp irrigation areas that require serious handling due to floods that every year hit the area resulting in crop failure so that farmers are hesitant to plant rice. The sluice building that functions as a flood control is now no longer functioning and causes the water entering and leaving the DIR UPT Dadahup to be irregular and uncontrolled. The broken embankment of the door building due to the river flow route used for transportation exacerbated the flooding at DIR UPT Dadahup. Hydraulic system planning is needed to deal with flood problems in the DIR UPT Dadahup, which made the authors take the title in making this paper, namely Study on the Performance of the Hydraulic System Planning of the Swampy Irrigation Area of Dadahup in Kapuas Regency, Central Kalimantan Province.

2. Material and Methods

The study conducted by the author uses a study methodology by collecting secondary data, field observations, and analyzing HEC-RAS by reviewing the following literature.

2.1. Swamp Development

A swamp is a container of water and the water and hydropower in it, which is inundated continuously or seasonally, naturally formed on relatively flat or sunken land with mineral deposits or peat, and overgrown with vegetation which constitutes an ecosystem. Swamps include tidal swamps and lebak swamps.

Tidal swamps, based on their hydrotopography, are grouped according to the type of overflow or the tide range, namely the type of overflow A, B, C, and D [3]. Type A land overflow is overflowed by high tide, both at high tide and low tide, while land type B overflows only during high tide. Land with type C overflow is not flooded with high tide, and the groundwater depth is less than 50 cm, while land type D overflow is not flooded with high tide, but the groundwater depth is more than 50 cm.

The hydrotopography of swamps is grouped into three categories: shallow lebak swamp, middle lebak swamp, and deep lebak swamp based on the height and duration of inundation [4]. The category of lowland swampland based on its hydrotopography is:

- A shallow lebak swamp is an area with a cohesive soil depth of less than 50 cm (fifty centimeters) with an inundation period of fewer than three months a year;
- A middle lebak swamp is a valley swamp area that has a stagnation height of 50 cm (fifty centimeters) to 100 cm (one hundred centimeters) with a stagnation length of 3 (three) to 6 (six) months in a year; and
- A deep lebak swamp is a valley swamp region with a stagnation height greater than 100 cm (one hundred centimeters) with a stagnation length greater than six months in a year.

Swamp development is an effort to increase the usefulness of the function of water resources in swamps. The development of swamps is carried out in a water-resource-based and non-water-based way. Water management arrangements for agricultural and non-agricultural activities are included in the development of swamps based on water resources [5].

The improvement of swamp irrigation networks plays an essential role in developing agriculture in Indonesia to implement a gradual swamp development approach as a form of sustainable development.

2.2. Flood risk on swamp area

Flood problems generally occur due to various causal factors, both natural and the impact of human activities. Natural factors can be divided into two groups. The first group concerns relatively static natural conditions, namely river channel conditions. The second group concerns dynamic natural events, namely high rainfall, damming of river mouths due to high tides, and sedimentation, development and
spatial planning in flood plains, cultivation and arrangement of watersheds that do not pay attention to soil and water conservation principles, construction of drainage systems for residential areas that do not have a conservation perspective [6].

Water-related disasters such as floods create water insecurity and cause negative impacts on agricultural areas and crop production, which can endanger food security. By learning and understanding the nature and distribution of floods and droughts from historical records, treatments can be implemented to reduce the risks [7].

The risk of natural flooding in tidal swamp areas is caused by overflowing water at high tide, overflowing water from upland areas and/or flooding from rivers. Meanwhile, in the lebak swamp area, it is caused by water overflow from the upland area and/or flood overflow from the river. In lebak swamps, flood risk is influenced by the hydro topographic class of the land, which can be divided into 3 (three) categories. Shallow lebak swamp embankments are inundated with water for a period of 0 (zero) to 3 (three) months a year. Middle lebak swamp is inundated with water for 3 (three) to 6 (six) months in a year. Deep lebak swamp is inundated with water for a period of 6 (six) to twelve) months in a year.

2.3. Embankment Construction

The embankment along the river is one of the essential structures to protect people's lives and property against inundation caused by floods and storms (tidal waves). The embankment was built mainly with earth fill construction; because the embankment is a very long continuous building and requires an enormous volume of fill material [8].

Design criteria for embankment dimensions (breadth width, guard height, and embankment slope) for each design flood discharge are presented in the following Table 1 below [9].

| Design flood discharge (m$^3$/s) | < 500 | 500 – 2.000 | > 2.000 |
|---------------------------------|-------|-------------|---------|
| Minimum crest width (m)         | 3     | 4           | 5       |
| Minimum freeboard height (m)    | 0.5 – 0.8 | 1           | 1.2     |
| Minimum embankment slope        | 1:02  | 1:02        | 1:02    |

Figure 1. Dadahup’s Swampy Irrigation Area Network Scheme
3. Results and Discussion

3.1. Condition of Existing Channel and Tidal Control Building

Dadahup DIR is located in Dadahup and Kapuas Murung sub-districts in Kapuas district, Central Kalimantan province. The existing DIR Dadahup Network Schematic is shown in Figure 1. The blue line on the network schematic shows the channel reach modeled using the HEC-RAS application.

The main primary channel experienced sedimentation at the bottom of the channel. The embankments on some of the channel segments were overgrown with plants. The condition of the main primary channel of DIR Dadahup is shown in Figure 2.

![Figure 2. Main Primary Channel](image)

In the upstream of the primary auxiliary channel, many embankments are overgrown with shrubs. The channel's primary auxiliary channel downstream has silting and narrowing; sedimentation and the embankment are overgrown with shrubs. The condition of the upstream auxiliary primary channel and the downstream auxiliary primary channel of DIR Dadahup is shown in Figure 3.

![Figure 3. Upstream Auxiliary Primary Channel and Downstream Auxiliary Primary Channel](image)

The middle secondary channel in block A5 is experiencing sedimentation; the water body is filled almost with plants near a residential area. The condition of the middle secondary channel of the Dadahup DIR is shown in Figure 4.

![Figure 4. Middle Secondary Channel on Block A5](image)
Sedimentation can cause the flow in the channel to be disturbed. It is because of increasing surface flow, expanding impermeable land, and decreasing groundwater levels. The channel will quickly flood during the rainy season due to overflowing river water held back by sediment [10].

The condition of the tidal control building in the Dadahup DIR is no longer functioning. The building door is missing, and there is sedimentation in the building and plants that grow around the building. The condition of several tidal control buildings in the Dadahup DIR is shown in Figure 5.

The tidal control building that lost the floodgates caused the tidal and flood control buildings to be lost. The overflow of water from the Barito, Kapuas Murung, and Mangkatip rivers that entered the channel could not be controlled, causing flooding that occurred for a long time.

3.2. Hydraulic Analysis of Dadahup’s Swampy Irrigation Area Network
DIR Dadahup’s existing network was analyzed using the HEC-RAS modeling application. The HEC-RAS program is a program package from ASCE (American Society of Civil Engineers). HEC-RAS was designed to create one-dimensional flow simulations. This software provides convenience with its graphical display. To trace the channel condition in terms of its hydrological and hydraulic effects and further treatment due to these effects as needed by using HEC-RAS Software. Functions in this software generally include file management, input and editing data, hydraulic analysis, output in tables, graphs, and images [11].

![Figure 5. Existing Condition of DIR Dadahup’s Tidal Control Building](image)

![Figure 6. DIR Dadahup’s Main Channel Flow Modelling Layout](image)
Existing network modeling was carried out to know the effect of tides that occur in the channel and the potential for an overflow that causes flooding. The modeling layout uses the DIR Dadahup’s main primary channel. Figure 6 shows the main primary channel flow-modeling layout in DIR Dadahup.

Cross-section data and boundary condition data that are entered into the modeling are data from secondary data collection. Figure 7 shows the input cross-section. Meanwhile, Figure 8 shows the boundary conditions in the form of discharge data at the upstream of the channel and tidal data at the downstream of the channel from the DIR Dadahup’s main primary channel modeling.

After entering the boundary condition data, the next step is to run a flow simulation. The flow simulation results are shown in Figure 9 for the discharge hydrograph and tidal hydrograph and Figure 10 for the flow simulation results displayed in the cross-section graph. Figure 11 shows the results of the flow simulation displayed in the form of the longitudinal segment.
Figure 9. The results of the flow simulation are in the form of a discharge hydrograph and a tidal hydrograph at cross section RS 27789.47

Figure 10. Maximum water surface elevation at cross-section RS 27789.47 and RS 12656.07

Figure 11. Longitudinal segment illustrating the portion of the right and the left banks that are overflowing
The flow simulation results show that the three canal sections are represented by one section. This section with the highest embankment elevation is 1.778 m and is inundated with the highest water tide on the channel section is 2.25 m. Other results show that one channel segment with the highest embankment elevation is 1.233 m inundated with water. The highest tide in the channel is 1.4 m.

Based on the results of this flow simulation, the overflowing channel was treated by raising the embankment in three channels from 1.778 m to 2.5 m. The overflowing channel is treated by raising the embankment in one channel from 1.233 m to 1.6 m. Figure 12 shows the channel section treated by raising the embankment to overcome the overflow of water that occurred in the channel section with the embankment elevation below the highest tide level.

![Figure 12. The Channel Section which is treated by raising the Embankment](image)

4. Conclusion and Suggestion
From the analysis results, several things concluded as follows:

- Sedimentation that occurs in several channels, including the main primary channel, causes the channel to be disrupted by increasing surface runoff, expanding impermeable land, and decreasing ground water level. The channel will quickly flood during the rainy season due to overflowing river water held back due to sediment.

- Tidal control buildings on the DIR Dadahup irrigation network that lost their function caused water overflow from the Barito River, Kapuas Murung River, and Mangkatip River. This overflow entering the channel uncontrollably so that flooding could occur in a long time.

- Simulation analysis of the main primary channel of DIR Dadahup’s irrigation network shows the results that several sections of the channel are inundated with overflowing water exceeding the elevation of the embankment of the channel section. The channel section is treated by raising the embankment to overcome the overflow of water that occurs in the channel section with the embankment elevation being below the highest tide level.

In the future, collecting the latest secondary data and simulation analysis using branching channels in the irrigation network can be an additional alternative for handling flood problems.

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