DETERMINATION OF DEPENDABLE FLOW FOR MICROHYDRO POWER PLANT IN IRRIGATION NETWORK

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ABSTRACT

Electrical energy at this time has become one of the basic needs of society. Along with economic growth, people's electricity needs have increased. This needs to be met by increasing capacity to provide electricity. One of the electricity sources that can be developed is micro hydro power plant. Irrigation networks have the potential to develop micro hydro power plants if they have water availability indicated by dependable flow in irrigation networks and have a minimum head of 2 meters in irrigation networks. Dependable flow in irrigation networks shows the availability of water supplies to irrigation channel. Calculation of dependable flow on irrigation networks is influenced by the schedule of water supply. This study explains some approaches that can be used in determining dependable flow. Determination of dependable flow in irrigation networks at this time is still constrained by data availability. The approach in determining dependable flow in irrigation networks is divided into two i.e. information on discharge data in irrigation buildings available and information on discharge data in irrigation weirs available. Dependable flow in the irrigation networks used to calculate the energy potential of micro hydro power plant is determined using the flow duration curve method in the irrigation channel. The results of the study indicate that the most optimum probability of discharge for micro hydro potential applied in the Tajum Irrigation Area is 50% (Q50). Q50 can produce electrical power according to the micro hydro criteria based on water availability for 6 months.

Keywords: micro hydro, electricity, dependable flow, irrigation networks, flow duration curve

1. INTRODUCTION

Energy is a basic requirement that is needed to meet the needs of growing population, industrialization, and modernization (Anaza et al. 2017). The production of energy is going on from many years to meet the need of energy in the world but the whole world is currently facing energy crisis in spite of numerous energy sources (Abdullah et al. 2014). To full-fill the increasing energy demand, alternative forms of energy such as renewable energy are needed. One of the electricity sources that can be developed is micro hydro power in the form of Micro Hydro Power Plants (Mahmud et al. 2012). Micro Hydro Power Plants produces energy from water movements due to differences in elevation and discharge (Kougias et al. 2014).

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Irrigation channels have the potential of water resources that can be used for hydroelectric power plants. If added together, the potential of water resources in irrigation channels to generate electricity is quite large (Pranoto et al, 2018). Irrigation networks have the potential to develop micro hydro power plants if they have water availability indicated by dependable flow in irrigation networks, not interfere with water use in irrigation network systems, have a minimum head of 2 meters in irrigation networks, are located in primary or secondary channels, and the power produced is 5 kW - 1 MW.

The potential of microhydro electrical power in irrigation networks is generated from two factors, that is dependable flow and head. dependable flow in irrigation networks shows the availability of water supplies to an irrigation channel. Calculation of the dependable flow in irrigation networks is not the same as the calculation of the dependable flow in the river. Calculation of the dependable flow on irrigation networks is influenced by the schedule of water supply. This study explains some approaches that can be used in determining the dependable flow for micro hydro power plant in irrigation network.

2. METHODS

2.1 Case Study

The research location is in the Tajum Irrigation Area. Research locations are adjusted by the availability of data to be used i.e. daily discharge data in the irrigation building, discharge data in the weir, irrigation water planning data, irrigation network schemes, and irrigation building data. The condition of water that can be used as a power source is one that has a certain flow capacity and height. That is because the electricity produced by micro hydro depends on the height of waterfall and the water discharge. The greater flow capacity and height of the installation, the greater the electrical energy that can be produced. Therefore, the topography of the area is an important consideration in the selection of locations for micro hydro power plants.

Tajum Irrigation Area is located in Banyumas Regency, Central Java Province. The condition of the area consists of land, mountains and the Serayu River valley. Tajum Irrigation Area is the second largest Irrigation Area after Serayu Irrigation Area in Banyumas Regency. Based on the PUPR Regulation number 14 / PRT / M / 2015, the potential area in Tajum is 3200 Ha. Tajum Irrigation Area is planned to irrigate agricultural areas Wangon District, Jatilawang District, and Rawalo District. The Tajum irrigation service area is shown in Figure 1.

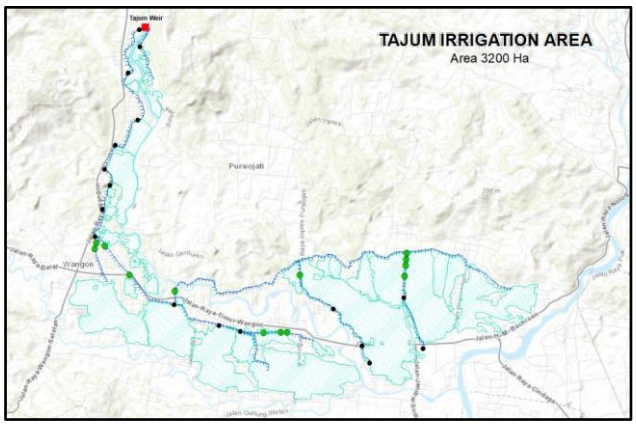

Figure 1. Map of Tajum Irrigation Area

The intake of the Tajum Irrigation Area are Tajum weir sourced from the Tajum river. Tajum weir is located in Tipar Kidul Village, Ajibarang Subdistrict, is the oldest dam of the new era and was officially opened by the then Indonesian President (Mr. Suharto).

The development of irrigation operations in the Tajum Irrigation Area has experienced many changes that adversely affect the availability of water including frequent lack of water in the dry season. Therefore, micro hydro development in irrigation networks needs to focus on the availability of water in each channel or building. The capacity of the irrigation channel discharge has been determined at the time of planning and the provision is adjusted to the water requirements in the paddy fields.

2.2 Discharge Data in Irrigation Buildings Is Available

Daily discharge data used is the irrigation operation discharge that recorded on blank 06-O according with PUPR Regulation number 12 / PRT / M / 2015 for one year. Data from blank 06-O is obtained from the interpreter who manages the irrigation area. Dependable flow in irrigation networks was used for calculating the potential of micro hydro energy is determined based on a discharge probability of 50% (Q50). Dependable flow with a 50% probability is obtained based on the duration of the discharge curve in each irrigation building. The procedure for making the flow duration curve to determine the dependable flow refers to SNI 6738: 2015 about Calculating River Dependable Flow with a Flow Duration Curve. Q50 is determined as the dependable flow in irrigation networks that is suitable for the application of micro hydro due to fluctuations in the discharge found in irrigation networks. The discharge fluctuations are influenced by the operation pattern of irrigation water supply.

2.3 Discharge Data in Irrigation Weirs Is Available

If in an irrigation area there is only a record of discharge data at the weir or intake while the discharge information in other irrigation buildings is not available. Determination of the dependable flow in the micro hydro location plan in irrigation networks is calculated based on the flow duration curve the weir with several considerations (correction). Dependable flow in irrigation networks that was used for calculating the potential of micro hydro energy is determined based on a 50% discharge probability (Q50). Q50 in irrigation was then corrected by comparing the area of paddy fields in the channel which has micro hydro potential with the total irrigated area. This value can be determined as dependable flow for potential locations of micro hydro plant installation.

The methods used for determining of dependable flow in irrigation network can be seen in Figure 2.

3. RESULTS AND DISCUSSION

3.1 Dependable Flow Analysis In Iriigation Network

Dependable flow is one of the factors used to determine the potential of micro hydro in irrigation networks. Dependable flow on irrigation channels shows the availability of water flow to an irrigation channel, which is influenced by the water supply schedule or irrigation operation pattern. Therefore, micro hydro development in irrigation networks needs to pay attention to the availability of water in each channel or building. The capacity of the irrigation channel discharge has been determined at the time of planning, it adjusted to the water requirements in the paddy fields. Recording of discharge data at the time of irrigation operations is very necessary as a dependable flow calculation data.

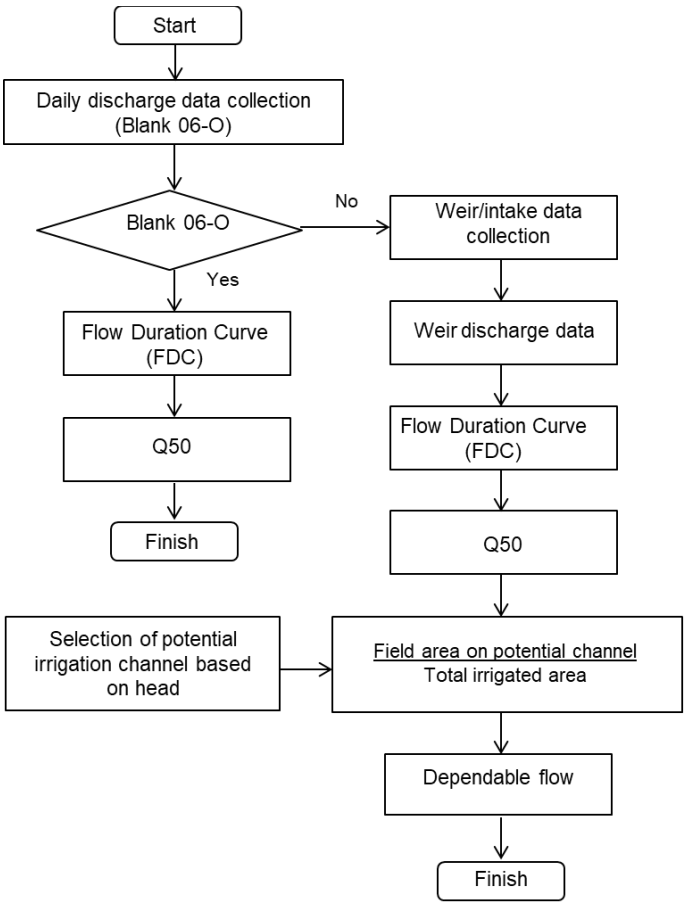

Figure 2. The methods used tor determining the dependable flow in irrigation networks

There are several approaches in determining the dependable flow in irrigation networks that are adjusted to the availability of data. The discharge data used is data for five years or according to the availability data in irrigation area that represents the wet year and dry year. The approach in determining the mainstay discharge in irrigation networks is divided into two approaches.

If an irrigation area has daily discharge data or biweekly average discharge data for each irrigation building, at upstream of previously chosen waterfall, then the data is said to be complete. Analysis of the irrigation dependable flow based on the results obtained from the calculation of discharge. The location selection is based on an irrigation network scheme where the irrigation canal has waterfall or sloping ditch. The data for 2015, 2016, and 2017 were used. The primary channel discharge values in BTa10 building within 3 years are shown in Figure 3.

The selection of BTa10 building is due to there is waterfall building after BTa10. The flow rate conditions are known to have significant fluctuations. In 2016 and 2017 March to June show no availability of water. It's because these months are the harvest and land preparation season. Drying takes place in August to September where irrigation canal maintenance activities are carried out.

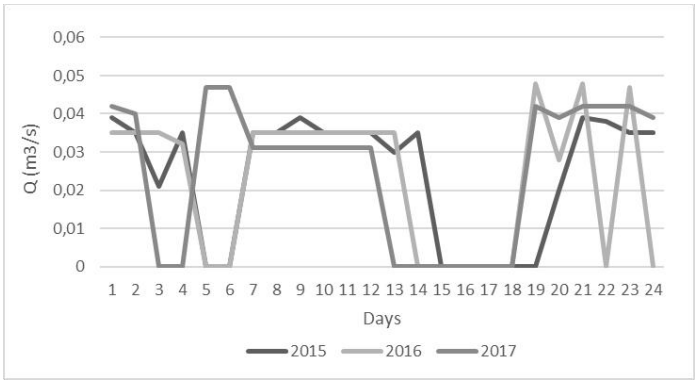

Figure 3. Discharge Data Fluctuation in Bta10 Building for 2015, 2016, and 2017

Flow Duration Curve (FDC) is used to determine the probability of discharge based on irrigation operation patterns. The results of Flow Duration Curve (FDC) based on data for BTa10can be seen in Figure 4.

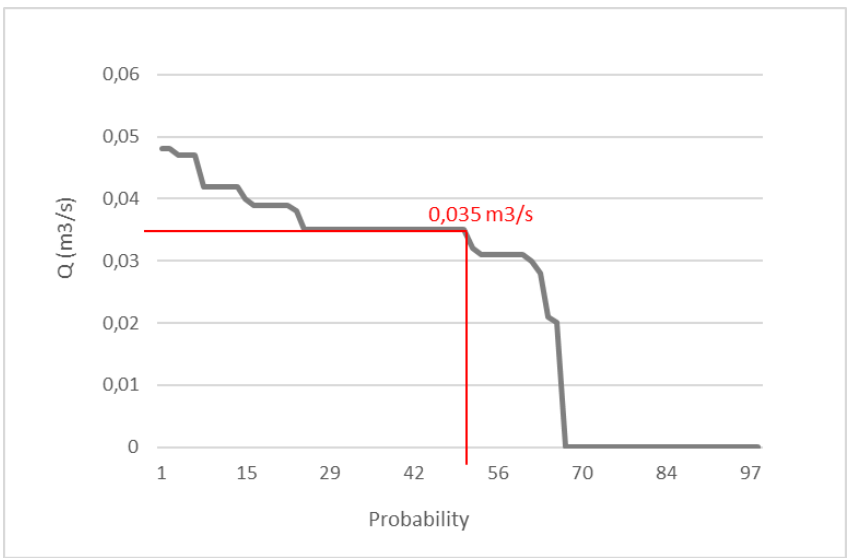

Figure 4. FDC from daily discharge data with 50% discharge probability

The 50% probability discharge is considered the optimal discharge that can be used for micro hydro through the availability of water in the irrigation network. Dependable flow for micro hydro in irrigation networks at BTa10 is 0,035 m3/s. By using that value of dependable flow, if at one time 50% the amount of discharge is not fulfilled, the generator turbine stops and at that time maintenance is also carried out.

3.2 Discharge Data Plan to Determine Dependable Flow In The Irrigation Networks

Recorded discharge data on the weir can be used as planning data on the irrigation channel discharge. If the data provided is weir discharge data, the making of FDC can be done using that data. The results of the FDC of the weir discharge data in 2015, 2016 and 2017 are shown in Figure 5.

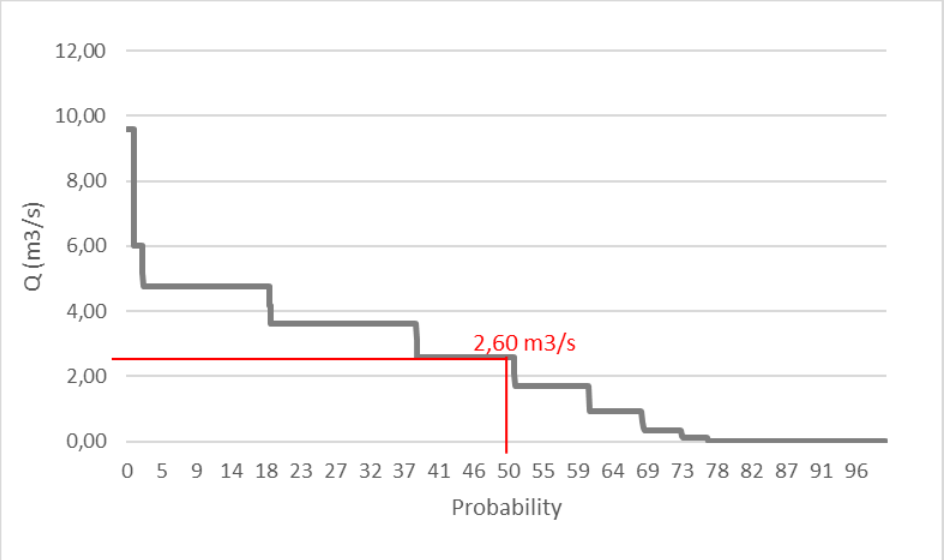

Figure 5. FDC from weir discharge data with 50% discharge probability

The Q50 value on the FDC of discharge data in the weir is 2,60 m3/s. This value needs to be corrected by irrigated area on the primary channel that have micro hydro potential. This is because the discharge value in the weir is the overall discharge that flowed into the irrigation network. Location of the channel segment that has the potential for micro hydro development is shown in Figure 6.

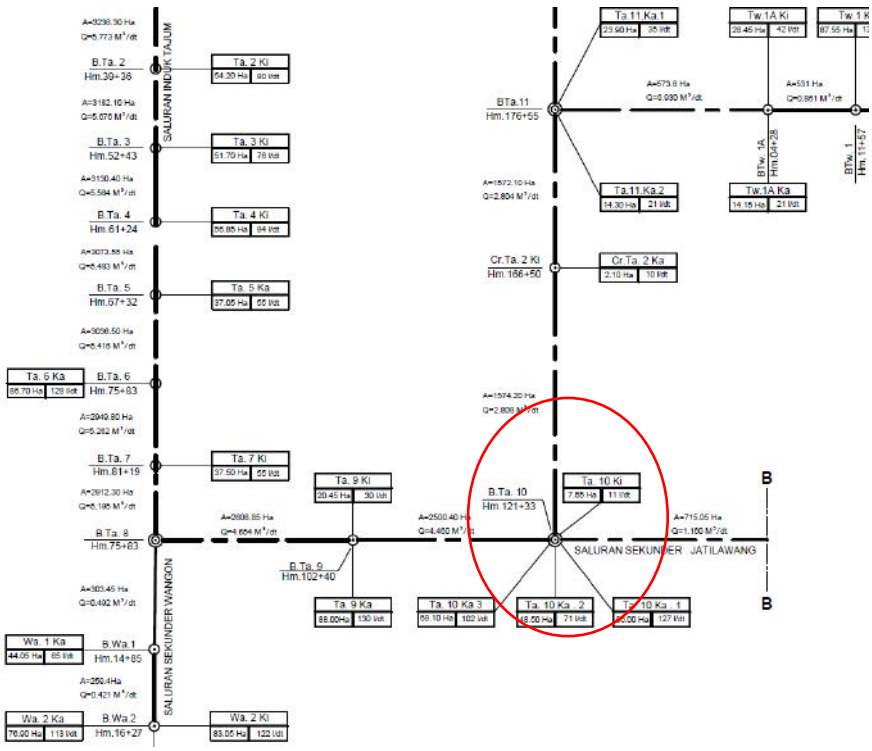

Figure 6. Part of irrigation network scheme wich shows primary channel segment in the case study

Irrigated area on the primary channel segments 121+33 to 166+50 is 1.574,20 Ha. Water requirements on that area are 2,808 m3/s. Therefore, Q50 can be fulfilled by the existing water allocation to irrigate the field and running the micro hydro power plant.

4. CONCLUSIONS

The dependable flow in irrigation networks can be calculated by considering the availability of irrigation data. Calculation of the dependable flow is done by determining 50% of discharge probability (Q50) on the flow duration curve. Tajum Irrigation Area is considered to represent these two methods because of data availability. Selection of Q50 is based on the pattern of daily discharge data. Irrigation channels are considered to have maximum water availability within 6 months. This condition can be seen from the pattern of horseshoe-shaped discharge fluctuations. Irrigation channel has no discharge during the field preparation and harvesting. While the availability of discharge data is in the planting period.

Using the dependable flow, if the amount of discharge is not fulfilled, the generator turbine will stop and at that time maintenance is also carried out. Both methods of determining the dependable flow show the discharge value of a probability of Q50 can be used as a parameter to determine the micro hydro potential in the irrigation network at the pre-feasibility study stage. For further development processes will be carried out in the feasibility study by doing a hydrological feasibility study.

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