Song River discharge utilization analysis for Bunutin Rice Fields irrigation system

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Abstract. Song River is a small river with a wide variety of 5 to 18 meter of water sourced from Lake Batur to the south through Bunutin Village in Kintamani District, Bangli Regency. The existence of this river is important because it is the main source of irrigation water in the Bunutin agricultural land which covers about 152 ha of rice fields. Utilization of Song river discharge for irrigation on Bunutin agricultural land has relied on water from community rock piles with water extraction in the form of 1.2 km of land tunnel. The tunnel has a high variable dimension of 0.75 to 1 meter and a varied width of 0.6 to 0.8 meter. This research was conducted through the stages of observation, measurement and analysis of river characteristics. The results of the flood analysis showed Q50 is equal to 21.81 cubic meter per second. Based on the existing situation, the placement of weirs is placed behind a tunnel with a width of 18 meter in the form of ogee crest weir. Weir material in the form of stone pairs.

1. Introduction

Song River with the main source of water originating from Lake Batur has a varied width between 5-18 meters flowing to the south in Bunutin Village, Kintamani District, Bangli Regency has become the main source of irrigation activities in the Bunutin Rice Field area (*Subak*). Through preliminary research, the current conditions show that the planting intensity in *Subak* Bunutin is only 100% -200% of the maximum conditions that can be reached around 250% to 300%. This is caused by the absence of a permanent dam or technical weir as a taker of water in the river. Song River extraction for irrigation purposes in *Subak* Bunutin is currently only relying on traditional / empirical weirs in the form of rock piles through the left or right intake in the form of a very simple ground tunnel. The condition of traditional weirs that have conditions is very improper because they are often washed away during rain and during the dry season the water is difficult to get into and some of the water is wasted downstream.

Looking at the current conditions it is very difficult to develop the *Subak* Bunutin because the main irrigation building is in the form of a dam, not in the form of a technical building. Therefore, it is very important to do an analysis of comprehensive water utilization so that the existing water can really provide additional value in the development of irrigation in the *Subak* Bunutin.

Based on the explanation above, it can be conveyed several problems related to water utilization in Song River as follows: How to use Song River for water irrigation purposes and How to develop irrigation system at Song River in *Subak* Bunutin.

The purpose of this study is to obtain answers to the problems presented, i.e.: mapping the current conditions related to the uses of Song River water for irrigation purposes and determine the Song River water utilization system for irrigation development in *Subak* Bunutin Rice Field area.

2. Methodology

The outline implementation is carried out by preliminary research, collection of primary and secondary data related to building and irrigation conditions, data analysis and design stages. Survey, field observation and data collection consist of primary and secondary data collection of building that bending directly in the field from Bangli Public Work office. Collection of secondary and primary data on irrigation conditions through *Subak* Complaints and Bangli District Public Works Service, collection of annual maximum daily rainfall data, dam site measurement and retrieval of soil sample data. The analysis consists of hydrological analysis, hydraulics analysis, dam site analysis, analysis of soil mechanics and design analysis.

3. Results and discussion

The river is a unit of drainage system with an ecosystem contained in it which flows to the estuary as a disposal. With this condition, each river has different forms of watersheds which will determine the flood characteristics of each river. In river flood analysis the dominant factors that are taken into account are the length of the main river, the watershed area and the condition of vegetation in the watershed area. Al-Assadi said that in determining the design of flooding is influenced by several factors such as watersheds, river lengths and catchment conditions [1].

Hydrological analysis is carried out to obtain the planned discharge amount that will occur according to the planned return period. Hydrological analysis includes analysis of regional average rainfall, design rain, design flooding. In the design of rain analysis there are several methods that can be used in accordance with the characteristics of the existing rainfall. For conditions in Indonesia the most widely used method is the Gumbel method and the Log Pearson Type III method.

Flood analysis is carried out to obtain the amount of flooding at a certain point. This analysis was carried out after a design rainfall analysis was carried out. In this analysis the magnitude of the design flood will be obtained according to the planned return period. In the planning of fixed weirs, the return period used is 50 years (Q50) or 100 years (Q100). In this case the method used to calculate the design flood discharge is the Nakayasu method. This method is used in areas with large catchments, usually in the main dump or river. Limantara and Indonesian Public work take into account the magnitude of the flood plan based on the influence of the catchment area, unit rainfall and the drainage coefficient in this case the authors use the Nakayasu method [2, 3].

$$\mathrm{Qp} = \frac{C\ A\ Ro}{3{,}6(0{,}3\ Tp + T0{,}3)} \tag{1}$$

Where:
Qp = peak discharge (m^3 / dt)
C = flowing coefficient
A = catchment area (Km^2)
Ro = unit rainfall (mm)
Tp = peak discharge time (minutes)
0.3 *TP* = the time needed to reach the condition of 30% of peak discharge

3.1. Determining high water at downstream of weir

Determination of the height of water in the Lower Dam is determined based on the manning equation based on the existing cross section [4, 5].

$$\mathrm{Q} = \mathrm{AV} \tag{2}$$

$$\mathrm{V} = \frac{1}{n} R^{2/3} S^{1/2} \tag{3}$$

Where
Q: water discharge on the river (m^3 / dt)
A: wet cross-sectional area (m^2)
V: water speed (m / dt)
R: hydraulic radius (m)
S: slope of the riverbed

3.2. Crest elevation
In planning to increase weir, the elevation refers to the existing elevation. Whereas if the weir is new then the elevation of the lighthouse is the same as the highest elevation between what is needed by the elevation of the paddy fields after adding all the pressure loss on the carrier system. For the purposes of pre weir plans, the highest elevation of paddy fields can be as follows [6].

- The highest elevation of paddy fields = *x*
- Rice field height = 10 cm
- Loss of pressure on the entry point
- in all channels = 50 cm
- Pressure loss along the channel = 15 cm
- Pressure loss in buildings -
- cross building and measuring instrument = 65 cm
- Inventory pressure for exploitation = 10 cm

Dam elevation = *x* + 1.50 m
If the weir is carried out as an increase or upgrading, the old weir elevation is a reference in planning.

3.3. Weir width
Weir width is the distance between the base wall on one side to the base wall on the other side, which is between 1 to 1.20 times the normal width of the river. The normal width of the river with a cross-sectional area equal to the cross-sectional area on the planning discharge. The effective width of the weir is the width of the weir minus the influence of the rinse door and pillars. Indonesia Public work provides estimates that can be used as a basis for determining an effective width greater than 1.2 times the width of a normal river [6].

$$B > 6/5\ Bn \tag{4}$$

Where
B = weir width (m)
Bn = normal river width (m)

While the effective width of the weir is the width of the weir after being deducted by pillars and other buildings [1].

$$Be = B - 2\,(n\ Kp + Ka).\ He - n.p \tag{5}$$

Where
Be = effective weir width (m)
B = total width (m)
n = number of pillars
Kp = pillar contraction coefficient
Ka = weir contraction coefficient
He = high energy

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The location of the weir site can be seen in Figure 2. The formula above is used to estimate the effective width of the plan dam.

3.4. Crest weir

Based on data from USBR, the Army Corps of Engineers have compiled several standard forms in the Waterways Experiment Station (WES) about the possible forms of overflow lighthouses. The overflow forms of WES are expressed as Harrold equations as follows. Chow provides a way to determine the magnitude of the slope by entering the height of the water above the weir height and the coefficient form factor of the weir height [5]:

$$Xn = K\ HDn - 1Y \tag{6}$$

Where:
X, Y = lighthouse coordinate with the highest starting point of the lighthouse
HD = draft height without height (m)
K, n = variable which depends on the slope of the face of the upstream part of the overflow.

3.5. Water level in the upper weir

Meant here is the water level above the crest weir during the planning flood. The determining factor besides the magnitude of the planned flood discharge is also the form of the crest weir. With the form of mercury Ogee used formulas. Indonesia public work determines the discharge plan that is influenced by the effective width and height of water above the beam and the efficiency of weir height [6].

$$Q = C \times Be \times H \tag{7}$$

Where:
Q = planning discharge (m3 / dt)
Be = effective weir width (m)
H = water level above the crest weir including high energy (m)
The transverse position of the weir can be seen in Figure 4

3.6. Length and scour

The flow of water from upstream of the river will bring material that moves downstream which rolls on the riverbed. This condition will lead to scouring.

3.6.1. Scour length. Estimated scour length on a weir is based on the Angerholzer method as follows [6][7]:

$$L = \sqrt{(V1 + 2gH)}\sqrt{\frac{2P+H}{g}} \tag{8}$$

Where:
L = scour length (m)
$V1$ = water velocity next to the upstream weir (m / dt)
H = height of water above the lighthouse (m)
P = weir height (m)
g = gravity acceleration (m / dt2)
The downstream weir length can be seen in Figure 3.

3.6.2. In scour. Use the Schoklish approach as follows:

$$T = \frac{4{,}75}{d^{0.32}} h^{0.2} q^{0.57} \tag{9}$$

Where:
T = in scour (m) is calculated from the elevation of the river in the downstream of the weir
d = diameter of transported material (mm)
h = upstream and downstream elevation differences (m)
q = wide unity debit (m2 / dt)

3.7. Rainfall analysis of the log Pearson type III method design
In the design of the rain analysis with the Log Pearson Type III method, the annual maximum annual rainfall data from the Kintamani Rain Station will be converted into logarithmic data. Then an analysis was carried out to get the design rainfall data in a number of times. The result of the rain design: R2 = 102.11 mm, R5 = 116.69 mm, R10 = 125.02, R20 = 131.16 mm, R25 = 134.40 mm, R50 = 140.46 mm and R100 = 146.26 mm.

3.8. Design flood analysis
Flood plan is the maximum discharge in a river or natural channel with a predetermined return period that can be flowed without endangering the stability of the building. Husain, Nyman and El Hazek provided the necessity of calculating a reliable discharge analysis in determining the weir design [8-10]. Analysis of design flood discharges with various times can be displayed in one graph. The results of the analysis can be seen in Figure 1. The topographic analysis of the bending location is shown in Figure 2 and the longitudinal and cross section of the weir can be seen in Figure 3 and Figure 4.

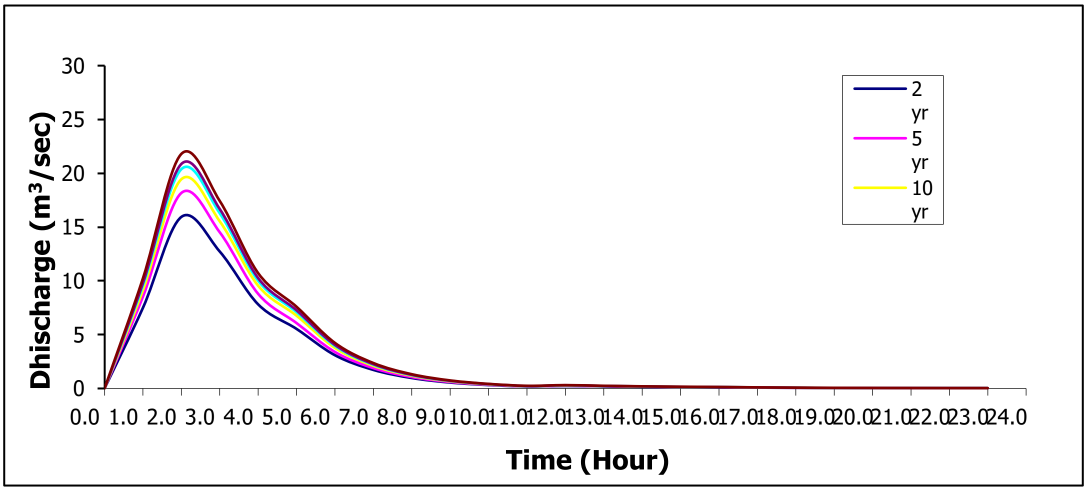

Figure 1. Flood hydrograph.

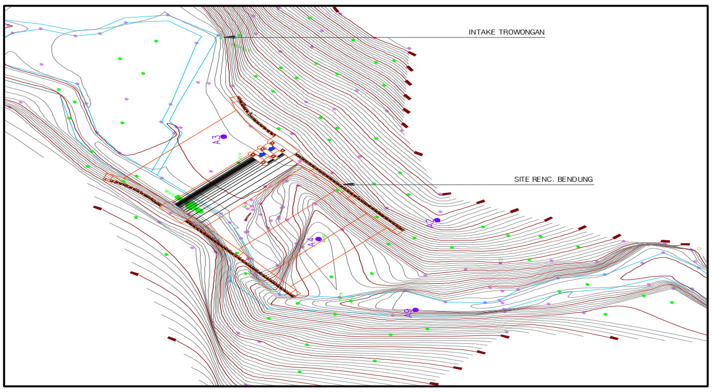

Figure 2. Site plan.

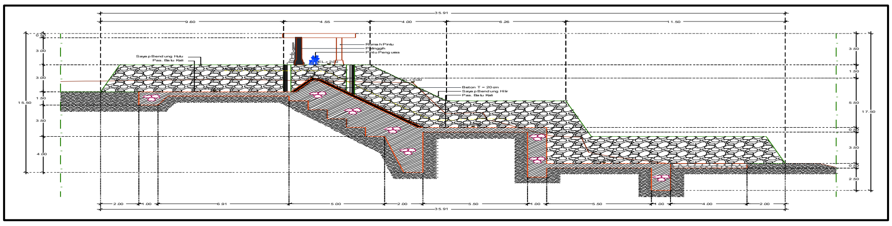

Figure 3. Long section.

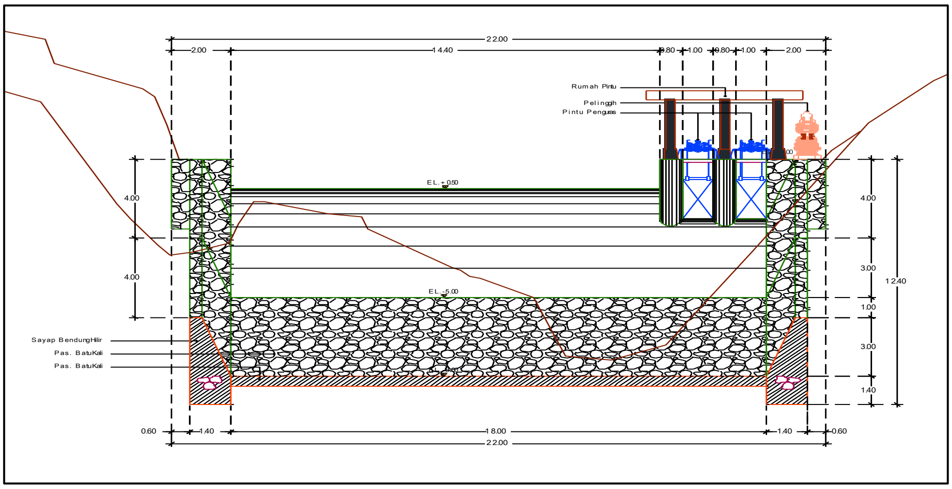

Figure 4. Site from behind.

4. Conclusions

Utilization of water in Song River for irrigation purposes in the Bunutin Rice Field currently only relies on free intake with the taking of a land tunnel. With this condition, several constraints become obstacles to the use of water, i.e., The reliability of water availability is limited because most of the water is wasted downstream; If there is a flood, there will be a build up of sediment in front of the tunnel which blocks the entry of water into the agricultural land; During the dry season the amount of water that can be channelled into the tunnel becomes hampered due to the limited water level.

From the analysis carried out related to the hydrological conditions, the condition of carrying capacity of land and location of the existing free intake, the proper water utilization system carried out in this area is by constructing fixed weirs for flood of 50-year return period, where weir width of 18 m dam height of 7 m.

5. References

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