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Water Needs Using Padi-Padi-Palawija Plants in Irrigation Area (DI) Sidopangus Regency, Semarang, Indonesia

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Abstract - The irrigation water discharge at the intake gate must be in line with the area of agricultural land. The dimensions of primary, secondary and tertiary irrigation canals must be in accordance with the area of agricultural land and the cropping pattern applied. The aims of this study are (1) to analyze the need for irrigation water at the intake of the Sidopangus Irrigation Area (DI) Semarang Regency; and (2) analyzing the dimensions of secondary irrigation channels in DI Sidopangus, Semarang Regency. This research was conducted at the Sidopangus DI whose source of water comes from the Sidomble Dam in Semarang Regency. Survey method was used in this research. Analysis of irrigation water needs and channel dimensions was done manually using the referral KP-01. The results of the study that can be stated was that the need for irrigation water in rice fields (NFR) was equal to 0.813 l/s/ha and the smallest maximum irrigation water demand (DR) was equal to 1.251 l/s/ha which occurs in late November to early December. The study also found that the dimensions in the secondary channel ie channel width (b) were 1.42 m; water level at the bed of the channel (h) is 0.71 m; slope of the irrigation channel (m) is 1; and irrigation canal height is 0.50 m.

Key words: Planting patterns; irrigation water requirements at the intake; secondary channel dimensions

I. INTRODUCTION

Irrigation is an effort to supply and regulate water to support agriculture which includes surface irrigation, swamp irrigation, underground water irrigation, pump irrigation, and pond irrigation. Irrigation is intended to support the productivity of farming in order to increase agricultural production in the context of national food security and community welfare, especially farmers, which is realized through the sustainability of the irrigation system.

Irrigation channel construction is very necessary to support the supply of food, so that the availability of water in the Irrigation Area will be fulfilled even though the Irrigation Area is far from surface water sources (rivers). This is inseparable from the business of irrigation techniques, namely providing water with the right conditions of quality, the right space and on time in an effective and economical way.

Irrigation Area (D.I.) is a land area whose water needs are met by an irrigation system. Irrigation areas are usually paddy fields that require a lot of water to produce rice. Increasing rice production in rice fields requires a reliable irrigation system, which is an irrigation system that can meet irrigation water needs throughout the year.

Water supply will always affect every stage of rice growth. Rice plants that lack water during planting will reduce their production. Based on Presidential Regulation Number 28 of 2012 concerning Spatial Planning for Java and Bali Islands and Central Java Provincial Regulation Number 6 of 2010 concerning Spatial Planning for Central Java Province in 2009-2029, the Semarang Regency is included in the Kedungsepur metropolitan area (Kendal - Demak - Ungaran - Semarang - Purwodadi) as a center for national activities. Therefore, to realize Semarang Regency as a buffer zone for the Capital of Central Java Province, one of the government's efforts in the agricultural sector is to increase food productivity through development and rehabilitation of irrigation (Syamsudin, A., 2012). A breakthrough made by the government in this program is to build reservoirs and irrigation areas in rural areas. One of them is the Sidopangus irrigation area (DI) (Prabowo, H., 2010).

Sidopangus irrigation area is one of the irrigation areas located in Semarang Regency. The Sidopangus irrigation area is designed with a technical irrigation system whose scope covers an area of 714 hectares covering several villages in the Semarang Regency and the Semarang City. Sidopangus irrigation consists of secondary channels, and tertiary channels. This channel drains water for agricultural purposes by supplying water and dividing it into paddy fields with regular schemes and in sufficient quantities. The irrigation area of Sidopangus is drained by water from the Sidomble weir that blocks the Kalipangus River in the village of Kalisidi, West Ungaran sub-district, Semarang Regency (Tim Sisda BPSDA Bodri Kuto, 2018).

High population growth in the Sidomble watershed has resulted in higher land use intensity. In addition, there is a tendency for wider land requirements for settlements. The above description triggers the unwise use of land by the community, especially those who live in the Sidomble watershed area. In general, the community changed the paddy fields to settlements. The impact is disruption to the water system in the Sidomble watershed, one of which is an excess of irrigation water which can cause flooding and erosion (BPS Kabupaten Semarang, 2017).

The description in the paragraphs above is about the background that supports the conduct of research on "Water Needs Using Padi-Padi-Palawija Plants in Irrigation Area (DI) Sidopangus Regency, Semarang, Indonesia". Thus, the objectives of this study are (1) to analyze the need for irrigation water at the intake of the Sidopangus Irrigation Area (DI) Semarang Regency; and (2) analyzing the dimensions of secondary irrigation channels in DI Sidopangus, Semarang Regency (Azizi, M. A. dan Sutopo, Y. 2020).

II. METHODS

The method used in this research was survey, because the data collection technique used were field observation equipped with document data. Some parameters were measured directly in the field, for example the dimensions of existing irrigation channels; while data that cannot be measured directly, documents were used.

This research was conducted in the Sidopangus irrigation area (DI) in the Kalisidi Village, Ungaran Barat District, Semarang Regency. Sidomble weir was located at coordinates 7 '9' 5.256 "South Latitude and 110" 21 "31.176" East Longitude. The rice fields served by the weir cover an area of 714 ha, of which upstream was located in Semarang Regency while the downstream was in Semarang City (Tim Sisda BPSDA Bodri Kuto, 2018). The research location is presented in Figure 1.

Tools and materials used to measure the dimensions of irrigation channels, for example the width of the canal base, depth of flow, slope of the channel wall, and the total area of rice fields in the Sidopangus irrigation area, namely (1) Global Positioning System (GPS) of the Garmin 64 S brand; (2) Arc View GIS software 3.2 (3) measuring bar of the Stanley brand; (4) grade rods of the Myzox brand; (5) saintifix calculator for Casio fx-115 ES brand; (6) Asus 412FA note book; (7) Samsung Galaxy A50 Android; (8) Microsoft Excel; (9) irrigation schemes; and (10) maps of the Sidopangus irrigation area (DI).

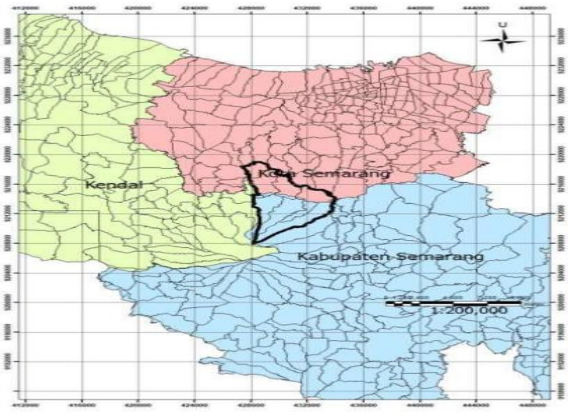

Figure 1. Sidopangus Irrigation Area (DI)

The type of data collected were primary and secondary. Primary data was the result of measurements made by the research team, for example the dimensions of irrigation channels. Secondary data was data that cannot be measured directly or for a moment, because the nature of the data was time series; which data was collected from various sources. Data and research data sources were presented in Table 1.

Table 1. Data and data sources

No.	Parameter	Type of data	Used for	Data source
1	Rice field area	Secondary data	Analysis of irrigation water needs	Water Resources Management Center Bodri-Kuto
2	Rainfall	Secondary data	Analysis of irrigation water needs	Water Resources Management Center Bodri-Kuto PT. Cengkeh Zanzibar, Kalisidi village, Semarang Regency
3	Climatology	Secondary data	Evapotranspiration Analysis	PT. Cengkeh Zanzibar, Kalisidi village, Semarang Regency
4	Dimensions of existing irrigation channels	Primary data	Channel dimension analysis	Measurement of parameters in the research field
5	Elevation of the existing flow elevation	Primary data	Channel dimension analysis	Measurement of parameters in the research field

Source: Azizi, M. A. et.al., 2020.

Analysis of the data used in this study are (1) average rainfall; (2) evapotranspiration; (3) irrigation water needs in the fields; (4) the need for irrigation water at the intake; and (5) irrigation channel dimension analysis. The Polygon Thiessen method was used to calculate average rainfall.

Monthly rainfall data was taken from 3 rain gauge stations for 10 years to obtain the average monthly rainfall value. The rain gauge used were Gunungpati Rain Station, Sumur Jurang, and PT. Cengkeh Zanzibar. Average rainfall was calculated by the following equation:

$$\bar{R} = C_1 R_1 + C_2 R_2 + \cdots \ldots . + C_n R_n \quad (1)$$

$$C_1 = \frac{A_1}{A_{Total}};\ C_2 = \frac{A_2}{A_{Total}} \qquad C_n = \frac{A_n}{A_{Total}}$$

Where:

R_1, R_2,. .. R_n	:	Rainfall observed at the ith station inside or outside the basin
C	:	weighted rainfall or Thiessen coefficient
A_i	:	In region portion of the area of the polygon surrounding the ith station, km^2
Atotal	:	the total catchment area, km^2
	:	The areal mean precipitation (mm)

Evapotranspiration (Eto) values were calculated based on climatological analysis. The modified Penman method was used to calculate the potential evpotranspiration (Eto), the formula of which was as follows (Hadisusanto, N. 2011):

$$Et_o = c[w.R_n + (1 - w).f(u).(e_a - e_d) \quad (2)$$

Where:

Et_o	:	potential evapotranspiration (mm d^{-1})
c	:	Penman value correction
w	:	weighting factor
R_n	:	net radiation (mm d^{-1})
f(u)	:	wind function (mm mb^{-1})
e_a	:	mean saturation vapour pressure (kPa)
e_d	:	actual vapour pressure (kPa)

Need for clean water in paddy fields (NFR) was influenced by factors Etc, P, WLR, and effective rainfall (Re). Irrigation water demand at the intake (DR), taking into account the NFR and overall irrigation efficiency factors (e). The need for irrigation water at the intake (DR) was calculated by the equation below (Pusat Pendidikan dan Pelatihan Sumber Daya Air dan Konstruksi, 2017).

$$NFR = E_{tc} + P + WLR - R_e \quad (3)$$

$$DR = \frac{NFR}{e} \quad (4)$$

Where:

NFR	:	Clean water needs in the fields (l/s/ha)
DR	:	Irrigation water needs for rice (l/s/ha)
E_{tc}	:	Consumptive use (mm)
P	:	Water loss due to percolation (mm/d)
WLR	:	Change the water layer (mm/d)
R_e	:	Effective rainfall (mm)

e : Irrigation efficiency (%)

The most economical cross section was the cross section that had a maximum discharge (Q) in a certain area (A). The maximum discharge (Q) was generated by the cross section of the flow with the value of R was the maximum or the value of P was the minimum. Discharge was calculated using the Strickler equation, as presented below (Standar Perencanaan Irigasi KP-03, 1986).

$$Q = VxA \quad (5)$$

$$V = k.R^{2/3}I^{1/2} \quad (6)$$

Where:

Q	:	
V	:	Flow velocity,, m/s
k	:	Strickler coefficient of roughness, (m$^{1/3}$/s)
I	:	Channel slope
m	:	Slope of the talud

III. RESULTS AND DISCUSSION

Evapotranspiration Analysis

Climatology data was needed to calculate the amount of evapotranspiration, which consists of (1) air temperature, (2) humidity, (3) duration of solar radiation, and (4) wind speed. Recapitulation of potential evapotranspiration calculations (mm d^{-1}) was presented in Table 2.

Analysis of irrigation water requirements at the intake

Irrigation water demand is the amount of water volume needed to meet the needs of evapotranspiration, water loss, water requirements for plants by taking into account the amount of water provided by nature through rain and the contribution of ground water. Paddy water requirements for rice are determined by the following factors: (1) land preparation, (2) consumptive use, (3) percolation and seepage, (4) water layer change, and (5) effective rainfall.

The minimum water discharge of Sidopangus Irrigation Area (DI) was at alternatives 7 and 8, amounting to 1,251 m^3/s; thus, the recommended cropping system and really cropping system for use in the Sidopangus Irrigation Area (DI) were alternatives 7 and 8 because the water discharge was the minimum. The smallest maximum water demand was made an option with consideration that during the dry season the availability of available water was sufficient to irrigate paddy fields. Calculation of the smallest maximum water needs that already meet the needs of irrigation water; in addition, the dimensions of the channel used will be more economical.

Table 2. Potential evapotranspiration

Month	Monthly average temperature (°C)	Relative humidity, R_H (%)	Wind Speed, U (km d^{-1})	Solar radiation, n/N (%)	C	ETo (mm d^{-1}
January	25.0	100	135.4	23.7	1.0	3.2
February	26.0	100	69.8	30.2	1.1	3.5
March	25.0	100	80.7	37.7	1.1	3.7
April	25.0	100	55.8	48.1	0.9	3.2
May	25.5	100	51.7	43.5	0.9	2.8
June	25.0	100	106.3	56.1	0.9	2.9
July	25.0	100	180.4	35.1	1.0	2.7
August	26.0	100	176.9	67.2	1.1	4.5
September	26.0	100	177.5	61.8	1.1	4.7
October	26.0	100	173.6	63.7	1.1	5.1
November	25.0	100	132.6	35.3	1.1	3.8
December	25.5	100	129.4	26.7	1.1	3.5

Source: Azizi, M. A. et al., 2020

Table 3. Recapitulation of NFR and DR calculation

Number	Alternative	NFR max l/s/ha	DR max m^3/s
1	August 2	1.323	2.036
2	September 1	1.277	1.964
3	September 2	1.277	1.964
4	October 1	1.277	1.964
5	October 2	1.277	1.964
6	November 1	0.849	1.306
7	November 2	0.813	1.251
8	December 1	0.813	1.251
9	December 2	0.908	1.397
10	January 1	0.934	1.437
Maximum		1.323	2.036
Minimum		0.813	1.251
Average		1.075	1.654

Source: Azizi, M. A. et al., 2020

Analysis of irrigation channel dimensions

According to Triatmodjo B., (2015) an economical open channel is a channel that can flow large discharges with a mininum wet circumference. Such a channel shape can be obtained from a semi-circular cross section. Channels that have a semicircular cross section are very difficult to construct when compared to channels that have rectangular or traceous cross sections. Therefore, although the semicircular canal shape is the most economical, it is rarely used in the field. Another alternative applied in the field is to use a rectangular channel for concrete walls and masonry, and the earth channel is designed in the form of a trapezoid. Thus in this study, the geometric shape of the selected irrigation channel is trapezoid.

Dimensions of secondary channels in the Sidopangus Irrigation Area (DI) which include elevation of the water level, width of the channel bottom and slope of the irrigation channel that have been adjusted to the needs of irrigation water were (1) 0.71 m for the elevation of irrigation water level from the bed of the channel; (2) the bed width of the irrigation channel was 1.42 m; and (3) the slope of the irrigation channel slab or m = 1 or 45 degrees; and (4) the height of irrigation free board was 0.5 m.

IV. CONCLUSION

The results of the study that can be stated was that the need for irrigation water in rice fields (NFR) was equal to 0.813 l/s/ha and the smallest maximum irrigation water demand (DR) was equal to 1.251 m^3/s which occurs in late November to early December. The study also found that the dimensions in the secondary channel ie channel width (b) were 1.42 m; water level at the bed of the channel (h) is 0.71 m; slope of the irrigation channel (m) is 1; and irrigation canal height is 0.50 m.

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