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Optimization of Water Utilization for Irrigation Networks (Case Study: Wawotobi Dam, Unaaha District, Konawe Regency)

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Abstract

Water is a very important natural resource. Water is needed for industrial, agricultural, fishery or pond activities, and other businesses. Planning and management of irrigation systems is one of the important stages to determine the overall demand for irrigation water.The Wawotobi Irrigation Area (DI) is the largest irrigation area in Southeast Sulawesi. Currently, this high water loss can lead to unfulfilled water needs in irrigated gardens, resulting in failure at harvest. This research was conducted by calculatingmainstay discharge to supply irrigation water needs,plan for cropping patterns in the irrigation area of the Wawotobi weir, Konawe Regency.This study also analyzes channel efficiency in the Wawotobi irrigation network by conducting field observations. The data from the observations are then analyzed so that it can be seen how much efficiency is in the distribution of irrigation water. In addition, this research also analyzes the water balance so that alternatives can be given in an effort to optimize the operation of water distribution in the irrigation network. Based on the analysis that has been done using the rice-paddy-palawija cropping pattern, the results of the calculation of the maximum water demand on the BW1 – B Un irrigation network are obtained. 5 Tg during the existing growing season was 9,477 L/sec, During the first growing season it was 9.998 L/sec, During the second growing season it was 7,452 L/second At the third growing season it was 9.998 L/second with a water balance rate which is quite high, namely 17.17 during land preparation. Irrigation network BW1 – B Un. 5 Tg has a network efficiency of 80%, which meets the irrigation planning standards of 80-90%.

Keywords
plant water needs; water balance; optimization of water distribution.

I. Introduction

The availability of water must be supported by good irrigation facilities and infrastructure (Syaifuddin et al., 2013). Irrigation efficiency can be used as an indicator of the performance of an irrigation area. The problem most often faced by many irrigation network operating systems is the low efficiency of water distribution (Komarudin, 2010). A study of the operational efficiency of irrigation canals to support the provision of national food is very necessary, so that the availability of water in the land will be fulfilled even though the land is far from surface water sources. This is inseparable from the business of irrigation techniques, namely providing water with the right quality conditions, in the right space and at the right time in an effective and economical way (Sudjarwadi, 1990). The contribution of irrigation infrastructure and facilities to food security so far is quite large, namely as much as 84% of national rice production comes from irrigation areas (Hasan, 2005). The business of utilizing water through irrigation requires a good management system, so that water utilization can be carried out effectively and efficiently.

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Syaifuddin et al., in 2013, stated that there was a very high-water loss/leakage before reaching the destination point in the Wawotobi irrigation area. This high enough water loss can lead to unfulfilled water needs in irrigated gardens, resulting in failure at harvest. So, it is necessary to conduct studies related to water balance, network efficiency, and optimizing water distribution.

The purpose of this research is to analyze the water demand for the area to be studied, to analyze the efficiency of the irrigation network channel BW1 – B UN. 5 TG. Provide an alternative for optimizing water distribution operations on the BW1 – B UN irrigation network. 5 TG.

II. Review of Literature

2.1 Irrigation

Irrigation is the efforts made to bring water from the source (providing business) and then given it to plants (irrigating) on agricultural land in an amount according to the needs of the plant (management effort). The irrigation canal consists of:

1) Primary Channel (Main Channel) is a channel that is directly related to the dam channel whose function is to channel water from the reservoir to a smaller channel.
2) Secondary channel is a branch of the primary channel that divides the main channel into smaller (tertiary) channels.
3) Tertiary canals are branches of secondary canals that are directly connected to the land or channel water into quarterly canals (Ansori, 2013).

Irrigation network is a unitary channel and building required for the regulation of irrigation water, starting from the supply, collection, distribution, distribution and use. And Based on the method of arrangement, measurement, and completeness of facilities, irrigation networks can be grouped into 3 (three) types, namely (1) simple irrigation networks, (2) semi-technical irrigation networks and (3) technical irrigation networks.

2.2 Water Needs in Paddy Fields

Irrigation water requirements are the volume of water needed to meet the needs of evapotranspiration, water loss, water needs for plants by taking into account the amount of water provided by nature through rain and the contribution of ground water. The water requirement for plants in an irrigation network is the water needed for optimal plant growth without water shortages. The water requirement in paddy fields for rice is determined by the following factors (SPI KP 1: 2013):

a. Land Preparation

The water requirement for land preparation is determined by the length of time it takes and the amount of water needed to prepare the land. Time that
It can take 30 days or 45 days and the amount of water needed during land preparation is calculated using the method developed by van de Goor and Zijlstra (1968), namely:

IR = ………………………………(2.1) $\frac{M.E^k}{E^k - 1}$

IR = irrigation water requirement at rice field level, l(mm/day)

M = water requirement to replace/compensate for water loss due to evaporation and percolation in saturated rice fields,

M = Eo+ P, (mm/day)

Eo= Evaporation of open water taken 1.1 x Eto during land preparation, (mm/day)

P = Percolation

k = MT/S

T = Time period for land preparation, (days)

S = Water requirement : = rice plant : for saturation added with a layer of water 50 mm, mm ie 200 + 50 = 250 mm; or it can be taken 250 + 50 = 300 mm for land that has been left undisturbed for a long period of time (2.5 months or more) = cropland: for saturation 50 to 100 mm of water is required.

b. Water Needs for Plant Consumption

The water requirement for crop consumption is the depth of water required to meet the evapotranspiration of disease-free plants, growing in agricultural areas in conditions of sufficient water from soil fertility with good growth potential and a good growth environment. Calculating water requirements for crop consumptive use the following empirical equation:

ET = Kc x Eto……………………………..(2.2)

with:

ET = consumption of water, (mm/day)

Kc = crop coefficient, (without units)

et0 = evapontranspiration, (mm/day)

c. Percolation and Seepage

Seepage occurs due to water seeping through the rice field embankments. Normal percolation rates on clay soils after inundation ranged from 1 to 3 mm/day. In areas with slopes above 5%, at least 5 mm/day will be lost due to percolation and seepage

d. Water Layer Alternation

Change of water layer on irrigated land conducted;

a) After fertilizing, try to schedule and replace the water layer as needed.

b) In the absence of such a schedule, 2 replacements were performed, each 50 mm (or 3.3 mm/day for month) during the month and two months after transplantation.

e. Effective Rainfall

Effective rainfall begins to be analyzed:

a) Completing the missing rainfall data

$$\frac{Px}{Nx} = \frac{1}{N}\left(\frac{P1}{N1} + \frac{P2}{N2} + \cdots \frac{Pn}{Nn}\right)\text{……………………(2.3)}$$

with:

px = Rain lost at station x (mm)

P1, P2, Pn = Rainfall data in surrounding stations in the same period (mm)

Nx = annual rain at station x (mm)

N1,N2,Nx = Annual rain at the station about x (mm)

N = Number of rain stations around x (without units)

b) Average rainfall

Rainfall required for the use of a water use plan and flood control design is the average rainfall over the entire area concerned, not rainfall at a certain point. This rainfall is called regional rainfall and is expressed in mm. The method of calculating this average rainfall is to use an algebraic arithmetic formula which can be seen as follows:

$$\frac{\sum Ri}{n}\text{………………………………..………..(2.4)}$$

with:

$\sum Ri$ = Total rainfall at station I (mm/day) n = Number of rainfall stations (without units)

c) Effective rainfall and reliable rainfall

Effective rainfall is rainfall that falls on an area and can be used by plants for its growth which can be calculated as follows:

$R_{80} = \frac{n}{s} + 1$……………………….…….(2.5)

with:

Re = R80 = Rainfall 80% (mm)

$\frac{n}{s} + 1$ = Ranking of effective rainfall calculated the smallest rainfall m (without units)

n = number of data (without units)

Analysis of effective rainfall is carried out with a view to calculating irrigation water needs. Effective rainfall is that part of the total rainfall that is effectively available for crop water needs. For rice irrigation, the monthly effective rainfall is taken as 70% of the minimum rainfall with a certain return period with a 20% probability of failure. (Rainfall R80). If the rain data used is 15 days, the equation becomes (SPI KP 01, 2013):

$R_e = 0.7 \times \frac{1}{15} \times R_{80}$……………………..….(2.6)

with:

Re = effective rainfall (mm/day)

R80 = Rainfall 80% (mm)

2.3 Irrigation Network Efficiency

Efficiency is the percentage ratio between the amount of water that can be used for plant growth and the amount of water removed from the intake gate. Not all of the water taken from water sources that flow into the irrigation area is utilized by plants.

In the practice of irrigation water loss occurs. in Rangga AP, 2012 The method that can be used to calculate the efficiency of irrigation channels using the Current Meter can be described as follows:

The irrigation efficiency value shows the number of usability of water use, which is the ratio between the amount of water used and the amount of water given which is expressed in percent (%). Mathematically it can be seen in the description below:

EPNG = (Asa/Adb) x 100%..........(2.7)

Where :

EPNG = Flow efficiency

Asa = Water that reaches irrigation

Adb = Water taken from the tapping building

3. Calculation of channel flow discharge, with the formula:

Q = vx A…………………………………………(2.8)

with :

Q = discharge in the channel (m3/s)

Vrerata= flow velocity in the channel ml(m/s)

A = wet cross-sectional area (m2)

III. Research Method

3.1. Description of Research Location and Time

This research was conducted in the Wawotobi Irrigation Area, Unaaha District, Konawe Regency, Southeast Sulawesi Province. Konawe Regency is located at 02º45' and 04º15' South Latitude 121º15' and 123º30' East Longitude, which is 73 km from Kendari City. With a case study on the BW 1 – B UN 5 Tg network. This research was conducted in December.

3.2 Data Collection

a. Primary Data

Primary data is data obtained and measured or observed in the field. The primary data required are:

1) Actual discharge on irrigation network
2) Planned cropping patterns in irrigated areas

b. Secondary Data

Secondary data is data obtained from relevant agencies, the data includes:

a) Climatological data for the Unaaha area for the last 18 years, namely 2000-2017.
b) Daily rainfall data at the nearest station in the Unaaha area, namely Abuki station, Lambuya station, Motaha station in 2000-2017.
c) Wawotobi irrigation network situation map
d) Wawotobi irrigation network scheme
e) Data on cropping patterns for irrigation areas (DI) Wawotobi.

3.3 Data Analysis Method

Data analysis that will be carried out in the study of optimizing the irrigation area network (DI) Wawotobi, Unaaha sub-district includes;Methods of data analysis on the calculations carried out include:

1) Hydrological Analysis.
   Hydrological analysis that will discuss the calculation:
   a) Effective rainfall, and
   b) Mainstay volume/discharge.
2) Analysis of irrigation water needs

Analysis of the water needs of each alternative cropping pattern presented. There are several things that affect the amount of water needed, namely:

   a) Plant type
   b) The amount of percolation that occurs in the field
   c) irrigation efficiency, and
   d) Evapotranspiration.

3) Irrigation Efficiency

In order for the water to reach the plants in the right amount as planned, the water discharged from the intake gate must be greater than required. The value of irrigation efficiency is influenced by the amount of water lost during the trip. Efficiency of water loss in primary, secondary, and tertiary channels varies in irrigation areas.

   a) Rainfall analysis

Rainfall was analyzed using algebraic methods. This method was used because of the limited primary data related to the area of the watershed. as for if the rainfall data is complete then it is analyzed with the following steps:

1) Completing the empty rainfall data
   Rainfall data sometimes experience voids caused by equipment failure or the absence of observers based on formula 2.3.
2) Average rainfall
   The average rainfall is calculated by the algebraic average method which can be seen in formula 2.4, because the rainfall data obtained from the relevant agencies is only for the last 18 years (2000-2017) and there is no watershed map.
3) Calculates 80% reliable rainfall based on formula 2.5.
4) Calculating Effective Rainfall with the formula 2.6.

b) Setting the percolation rate
   The percolation rate based on the rules in SPI KP 1 (2013) ranges from 1-3 mm/day.
c) Calculating water requirements during land preparation is calculated based on formula 2.1.
d) Calculating the need for water in the paddy fields.
e) Calculate the efficiency of irrigation canals. Calculating the efficiency of the irrigation network, measurements must be made in the irrigation canal which will support the data analysis. as for the method of data collection is done by measurement.

3.4 Research Flowchart

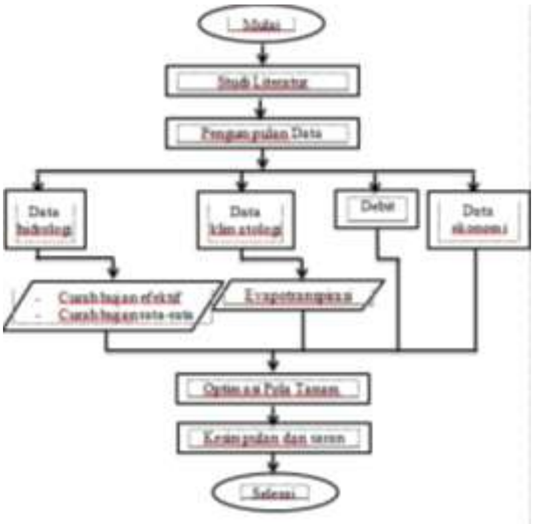

Figure 1.*Research Flowchart*

IV. Result and Discussion

4.1 Calculation of Regional Maximum Rainfall

Rainfall and discharge data are the most fundamental data in planning the construction of a reservoir.

The results of the calculation of the average rainfall in the Wawotobi watershed are presented in detail in the Hydrological Support Report.

The following shows the maximum rainfall in the calculated area as shown in Table 1 below.

Table 1. Maximum Rainfall Area Maximum

Tahun	Curah Hujan Harian (mm)			Rerata Hujan
	Abuki	Lambuya	Motaha	Maksimum
2000	80	95	27	67
2001	43	171	29	81
2002	47	63	23	44
2003	38	67	33	46
2004	88	69	26	61
2005	64	53	33	50
2006	67	1[illegible]	39	69
2007	70	85	33	63
2008	73	77	36	62
2009	62	91	28	60
2010	84	113	33	77
2011	50,9	138	28	83
2012	70	96	33	66
2013	110	135	29	91
2014	57	77	29	54
2015	86	61	23	57
2016	98,7	71	33	52
2017	60	55	33	49

Sumber: Analisa data, 2022

From the results of the average analysis taken from the three stations above, it can then be seen in table 2 below.

Table 2. Sorted Maximum Regional Daily Rainfall

No	Tahun	Curah Hujan (mm)
1	2013	91
2	2011	83
3	2001	81
4	2010	77
5	2006	69
6	2000	67
7	2012	66
8	2007	63
9	2008	62
10	2004	61
11	2009	60
12	2015	57
13	2014	54
14	2016	52
15	2005	50
16	2017	49
17	2003	46
18	2002	44

Sumber: Analisa data, 2022

1. Frequency Analysis

a) Rainfall analysis using the Log Person Type III method
Frequency analysis using the Log Person Type III method:

1) Standard deviation

$$S = \frac{\sum(Xi - \bar{X})^2}{n-1}$$

$$S = \frac{0{,}1378}{18-1}$$

$$S = 0{,}0900$$

a) Stiffness coefficient

$$G = \frac{n\,(Xi - \bar{X})^3}{(n-1)(n-2)(n-3)(S)^3}$$

$$G = \frac{18(0{,}0025)}{(18-1)(18-2)(0{,}0900)^3}$$

$$G = 0{,}2280$$

The results of further calculations can be seen in table 3 below:

Table 3. Calculation of Daily Planned Rainfall Using the Pearson Type III Log Method for DI Wawotobi, Konawe Regency

No	Tahun	Xi	log Xi	log Xi - log r Xi^2	log Xi - log r Xi^3
1	2013	91.33	1.9606	0.0291	0.0050
2	2011	83.00	1.9191	0.0166	0.0021
3	2001	81.00	1.9085	0.0140	0.0017
4	2010	76.67	1.8846	0.0089	0.0008
5	2006	68.67	1.8367	0.0022	0.0001
6	2000	67.33	1.8282	0.0015	0.0001
7	2012	66.33	1.8217	0.0010	0.0000
8	2007	62.67	1.7970	0.0000	0.0000
9	2008	62.00	1.7924	0.0000	0.0000
10	2004	61.00	1.7853	0.0000	0.0000
11	2009	60.33	1.7806	0.0001	0.0000
12	2015	56.67	1.7533	0.0013	0.0000
13	2014	54.33	1.7351	0.0030	-0.0002
14	2016	52.00	1.7160	0.0055	-0.0004
15	2005	50.00	1.6990	0.0083	-0.0008
16	2017	49.33	1.6951	0.0094	-0.0009
17	2003	46.00	1.6628	0.0162	-0.0021
18	2002	44.33	1.6467	0.0205	-0.0029
jumlah log		62.94	32.2208	0.1378	0.0025
log rata-rata			1.7900	0.0077	0.0001
Jumlah data (n)			18		
Standar Deviasi (S)			0.0900		
K. Kemencengan (Cs)			0.2		

Sumber: Hasil perhitungan, 2022

Where:

N = Total Rain Data

S = Standard Deviation (Standard Deviation)

Cs = Swelling Coefficient

Table 4. Daily Planned Rainfall in Wawotobi, Konawe Regency for Various Periods of Return

T	P(%)	G	K	Log X
2	50	-0.033	0.0000	1.7900
5	20	0.83	0.0000	1.7900
10	10	1.301	0.0000	1.7900
25	4	1.818	0.0000	1.7900
50	2	2.159	0.0000	1.7900
100	1	2.472	0.0000	1.7900

Sumber : Hasil Perhitungan,2022

Where:

T = Period T years

P = Probability

G = Stiffness coefficient

Then the price of G (coefficient of person) is obtained from the table for the price of Cs = 0.2 so that the value of G is obtained for a certain period plan as shown in table 5 below:

Table 5. LA-4 K Value For Log Person Type III Distribution

G	2	5	10	25	50	100
0.2	-0.033	0.83	1.301	1.818	2.159	2.472

Sumber: Analisa data, 2022

4.2. Rainfall analysis using the Normal Distribution method

The normal distribution or normal curve is also known as the Gaussian distribution. Calculation of planned rainfall according to the normal distribution method, has the following equation:

Standard Deviation

$$S = \frac{\sum(Xi - \bar{X})^2}{n - 1}$$

$$= \frac{0{,}1378}{18 - 1}$$

$$maka, S = 177{,}480$$

The results of further analysis can be seen in table 6 and table 7 below:

Table 6. Rainfall Plan with Normal Distribution Method

No	Tahun	Xi	$(Xi - \bar{X})^2$
1	2013	91	805.929
2	2011	83	402.225
3	2001	81	326.003
4	2010	77	188.299
5	2006	69	32.744
6	2000	67	19.262
7	2012	66	11.485
8	2007	63	0.077
9	2008	62	0.892
10	2004	61	3.781
11	2009	60	6.818
12	2015	57	39.410
13	2014	54	74.151
14	2016	52	119.781
15	2005	50	167.559
16	2017	49	185.262
17	2003	46	287.114
18	2002	44	346.373
	Jumlah	1133	3017.167
	$\bar{X}$	62.944	
	SD	177.480	

Sumber: Hasil perhitungan, 2022

Table 7. Planned Rainfall with Normal Distribution Method

Tahun	Xi	X	$(Xi - \bar{X})^2$	$(Xi - \bar{X})^3$	$(Xi - \bar{X})^4$
2000	44	62.94	346.37	-6446.39	119974.6
2001	46	62.94	287.11	-4864.99	82434.56
2002	49	62.94	185.26	-2521.63	34322.14
2003	50	62.94	167.56	-2168.95	28075.9
2004	52	62.94	119.78	-1310.94	14347.46
2005	54	62.94	74.15	-638.52	5498.406
2006	57	62.94	39.41	-247.41	1553.187
2007	60	62.94	6.82	-17.80	46.48378
2008	61	62.94	3.78	-7.35	14.29493
2009	62	62.94	0.89	-0.84	0.79562
2010	63	62.94	0.08	-0.02	0.005954
2011	66	62.94	11.48	38.92	131.8953
2012	67	62.94	19.26	84.54	371.038
2013	69	62.94	32.74	187.37	1072.158
2014	77	62.94	188.30	2583.89	35456.66
2015	81	62.94	326.00	5886.17	106278
2016	83	62.94	402.23	8066.85	161785.2
2017	91	62.94	805.93	22879.43	649521.6
Jumlah			3017.17	21502.31	1240884
SD		177.48			
CV		2.82			
CK		1.57578E+14			
CS		783467166.9			

Sumber: Hasil perhitungan, 2022

Where:

$\bar{X}$ = Average Score
SD = Standard Deviation
SD = Standard Deviation
CV = Coefficient of variation
CK = Kurtosis Coefficient
CS = Coedition of Distension

4.3. Rainfall analysis using the Gumbel method

The calculation of the planned rainfall according to the Gumbel Method, has the following formulation:

XT = (X + K) x (S)
= (94.706 + (-0.148) x (28.340)
= 94.558 x 28.340
= 2679,797 mm

The results of the calculation of rainfall analysis using the Gumbel method can then be seen in table 8 as follows:

Table 8. Rainfall Plan with Gumbel Method

Hujan Rencana Periode Tahun Metode Gumbel							
Tahun	YN	SN	YT	K_T	S	$\bar{X}$	X_T/mm
2	0.524	1.063	0.367	-0.148	28.340	94.706	2679.797
5	0.524	1.063	1.499	0.918	28.340	94.706	2709.996
10	0.524	1.063	2.250	1.625	28.340	94.706	2730.027
25	0.524	1.063	3.185	2.504	28.340	94.706	2754.954
50	0.524	1.063	5.296	4.490	28.340	94.706	2811.245
100	0.524	1.063	6.214	5.354	28.340	94.706	2835.725

Sumber: Data pribadi, 2022

Where:

YN = The mean value of the reduction of the variate

SN = Standard deviation of the reduced variance (the value depends on the amount of data)

YT = Variate reduction value (of the variables expected to occur in the T-year return period)

KT = Distribution characteristics

S = Standard deviation

$\bar{X}$ = Average rain

XT =An estimate of the expected value occurs with an annual return period T.

4.4. Rainfall Analysis with Normal Method

The normal distribution or normal curve is also known as the Gaussian distribution. Calculation of planned rainfall according to the normal distribution method, has the following equation:

XT = (S + KT) x (X)

= (28,340 + 0,000) x (94,706)

= 28,340 x 94.706

= 2683.986mm

The results of further analysis can be seen in table 9 as follows:

Table 9. Rainfall Plan with Normal Method

Hujan Rencana Periode Tahun Metode Normal				
Tahun	K_T	$\bar{X}$	S	X_T (mm)
2	0.000	94.706	28.340	2683.986
5	0.840	94.706	28.340	2763.539
10	1.280	94.706	28.340	2805.209
25	1.690	94.706	28.340	2844.038
50	2.050	94.706	28.340	2878.132
100	2.330	94.706	28.340	2904.650

Sumber: Data pribadi, 2022

Where:

KT =An estimate of the expected value occurs with an annual return period T.

$\bar{X}$ = Average rain

S = Standard deviation

XT =Frequency factor

4.5. Mainstay Debit Analysis

1. Mainstay Debit Calculation

The mainstay discharge is planned with an 80% probability of occurrence, or with a 20% failure. The calculation is carried out using the basic month method, where the average monthly river discharge during the recording period (2010 – 2018), for each month is arranged in order from large to small.Next, the probability of occurrence is calculated using the formula:

$$P = \frac{m}{(n+1)} 100\%$$

Where :

P = Probability (%)

m = Data serial number

n = Amount of data

Determine Q80 . Mainstay Debitand sort the data from the smallest discharge to the largest discharge and then calculate the probability with the formula:

$$P = \frac{8}{(9+1)} \times 100\%$$

$$P = \frac{8}{10} \times 100\%$$

$$P = 0{,}80\ \%$$

So, the mainstay discharge or Q80 in September the second period is 145.35 liters/second. The calculation for the next month can be seen in the following table 12:

Table 10. 80% Debit Calculation After Sorting

Bulan		Probabilitas(%) 80%	Bulan		Probabilitas(%) 80%
Jan	I	17,17	Jul	I	0,00
	II	45,05		II	0,00
Feb	I	58,65	Agt	I	5,06
	II	59,08		II	51,00
Mar	I	100,30	Sep	I	105,61
	II	106,51		II	145,35
Apr	I	108,38	Okt	I	119,68
	II	89,59		II	91,80
Mei	I	99,17	Nov	I	76,50
	II	0,00		II	76,50
Jun	I	0,00	Des	I	44,09
	II	0,00		II	3,06

Sumber : Analisa data, 2022

4.6. Planting Pattern

In carrying out this work, the appropriate cropping pattern for DI Wawotobi is Padi-Padi-Palawija. The cropping pattern is the result of several alternative cropping patterns and the best cropping pattern is taken. The pattern of cropping plans for each irrigation area is presented in table 11 below.

Table 11. Planned Planting Patterns for Each DI

No	Type of activity	Planting Pattern
1	Existing MT	Paddy-Palawija-Rice
2	MT I	Padi-Rice-Palawija
3	MT II	Palawija-Palawija-Rice
4	MT III	Palawija-Rice-Rice

Source: PP-Jakon KSO, 2021

With this cropping pattern, the functional irrigation area will be seen that can be irrigated optimally (maximum).The results of the analysis of the planned cropping pattern can be seen in table 12 as follows:

Table 12. Planned Cropping Patterns and Irrigation Water Needs in Wawotobi

Periode		Efisiensi Irigasi Q80% (L/detik)				Kebutuhan Air Irigasi Netto Pola Tanam (L/detik)			
		Eks	I	II	III	Eks	I	II	III
Jan	I	17,17	58,65	100,30	108,38	0.000	0.054	0.805	1.311
	II	45,05	59,08	106,51	89,59	0.851	0.047	0.547	0.874
Feb	I	58,65	100,30	108,38	99,17	0.862	0.522	0.072	0.805
	II	59,08	106,51	89,59	0,00	0.474	0.851	0.047	0.547
Mar	I	100,30	108,38	99,17	0.00	0.513	0.862	0.522	0.072
	II	106,51	89,59	0,00	0.00	0.487	0.474	0.851	0.047
Apr	I	108,38	99,17	0.00	0.00	0.216	0.513	0.000	0.522
	II	89,59	0,00	0.00	0.00	0.048	0.487	0.000	0.851
Mei	I	99,17	0.00	0.00	5.06	0.000	0.216	0.000	0.000
	II	0,00	0.00	0.00	51,00	0.000	0.048	0.000	0.000
Jun	I	0.00	0.00	5,06	105,61	0.000	0.000	0.000	0.000
	II	0.00	0.00	51,00	145,35	0.000	0.777	0.000	0.000
Jul	I	0.00	5,06	105,61	119,68	0.000	1.538	0.054	0.000
	II	0.00	51,00	145,35	91,80	0.000	1.311	0.000	0.000
Agt	I	5,06	105,61	119,68	76,50	0.000	0.874	0.000	0.054
	II	51,00	145,35	91,80	76,50	0.054	0.805	0.000	0.862
Sep	I	105,61	119,68	76,50	44,09	0.78	0.547	0.000	0.474
	II	145,35	91,80	76,50	5,06	1.538	0.072	0.000	0.513
Okt	I	119,68	76,50	44,09	17,17	1.311	0.000	0.000	0.487
	II	91,80	76,50	5,06	45,05	0.874	0.000	0.054	0.216
Nov	I	76,50	44,09	17,17	58,65	0.805	0.000	0.777	0.048
	II	76,50	5,06	45,05	59,08	0.547	0.000	1.538	0.000
Des	I	44,09	17,17	58,65	100,30	0.07	0.000	1.311	0.777
	II	5,06	45,05	59,08	106,51	0.047	0.000	0.874	1.538
Total						9.477	9.998	7.452	9.998

Sumber: Analisa data, 2022

From the results of the analysis of water needs, it is found that the water requirement is quite efficient, which is 7,452 liters/day in the second cropping pattern. Based on the results of the above analysis with the optimization scenario of the operation of the right water distribution. In this condition, the right scenario is the simultaneous distribution of water. However, it should be noted that the amount of water released at the door must be in accordance with the growing phase of the plant.

a) Water Balance Analysis (water balance)

In this water balance analysis, it takes into account the highest amount of water (Q80%) minus the water demand (Existing Qir) of a system and the stored water reservoir should not run out. The following is a water balance analysis which can be seen as follows:

1. Calculation analysis

Example 1:

WB = Q80% - Qir Ex (Jan I)

WB = 17.17 – 0.00

WB = 17.17 mm/day

Example 2:

WB = Q80% - Qir Ex (Jan II)

WB = 14.05 – 0.851

WB = 44,199 mm/day.

For further calculations can be seen in table 13 as follows

Table 13. Water Balance in Weirs in Wawotobi, Konawe Regency and Functional Areas Served

Ket	Jan I	Jan II	Feb I	Feb II	Mar I	Mar II
Q 80 (%)	17.17	45.05	58.65	59.08	100.3	106.51
Qir Eks. (L/det)	0	0.851	0.862	0.474	0.862	0.474
Qir I	0.054	0.047	0.522	0.851	0.862	0.474
Qir II	0.805	0.547	0.072	0.047	0.522	0.851
Qir III	1.311	0.874	0.805	0.547	0.072	0.047
WB (L/det)	17.17	44.199	57.79	58.61	99.438	106.04
WB I	17.116	45.003	58.128	58.229	99.438	106.036
WB II	16.365	44.503	58.578	59.033	99.778	105.659
WB III	15.859	44.176	57.845	58.533	100.23	106.463
Ket	Apr I	Apr II	Mei I	Mei II	Jun I	Jun II
Q 80 (%)	108.38	89.59	99.17	0.00	0.00	0.00
Qir Eks. (L/det)	0.22	0.05	0.00	0.00	0.00	0.00
Qir I	0.51	0.49	0.22	0.05	0.00	0.78
Qir II	0.00	0.00	0.00	0.00	0.00	0.00
Qir III	0.52	0.85	0.00	0.00	0.00	0.00
WB (L/det)	108.16	89.54	99.17	0.00	0.00	0.00
WB I	107.867	89.103	98.954	-0.048	0.00	-0.777
WB II	108.38	89.59	99.17	0.00	0.00	0.00
WB III	107.858	88.739	99.17	0.00	0.00	0.00
Ket	Jul I	Jul II	Agt I	Agt II	Sep I	Sep II
Q 80 (%)	0.00	0.00	5.06	51.00	105.61	145.35
Qir Eks. (L/det)	0.00	0.00	0.00	0.054	0.78	1.538
Qir I	1.538	1.311	0.874	0.805	0.547	0.072
Qir II	0.05	0.00	0.00	0.00	0.00	0.00
Qir III	0.00	0.00	0.05	0.86	0.47	0.51
WB (L/det)	0.00	0.00	5.06	50.95	104.83	143.81
WB I	-1.538	-1.311	4.186	50.195	105.06	145.278
WB II	-0.054	0.00	5.06	51.00	105.61	145.35
WB III	0.00	0.00	5.006	50.138	105.14	144.837
Ket	Okt I	Okt II	Nop I	Nop II	Des I	Des II
Q 80 (%)	119.68	91.8	76.50	76.50	44.09	3.06
Qir Eks. (L/det)	1.31	0.87	0.81	0.55	0.07	0.05
Qir I	0.00	0.00	0.00	0.00	0.00	0.00
Qir II	0.00	0.05	0.78	1.54	1.31	0.87
Qir III	0.49	0.22	0.05	0.00	0.78	1.54
WB (L/det)	118.37	90.93	75.69	75.95	44.02	3.01
WB I	119.68	91.8	76.5	76.5	44.09	3.06
WB II	119.68	91.746	75.723	74.962	42.779	2.186
WB III	119.193	91.584	76.452	76.5	43.313	1.522

Sumber: Data Eksisting, 2021

Where :
Q80% = Mainstay Debit
Qir = Irrigation Water Needs
WB = Water Equilibrium (*water balance*)

In Figure 4.1 below, it can be concluded that the water demand (Qir) with reliable discharge data (Q 80%) has a fairly high graph, so the availability of water needed is quite abundant.

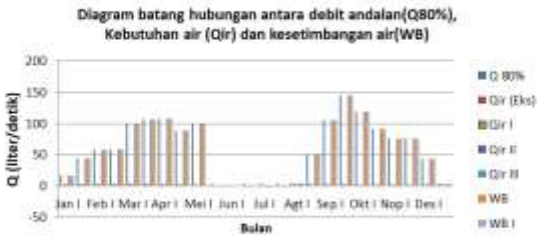

Figure 2. *Water Balance in Wawotobi (11,959 Ha) Konawe . Regency*

V. Conclusion

Based on the results of calculations and data analysis in previous chapters, the following conclusions can be drawn:

1. The mainstay discharge with the largest 80% reliability is 145.35 L/second and the smallest 80% mainstay discharge is 3.06 L/second to meet irrigation needs.
2. The plan for the cropping pattern in the Wawotobi weir irrigation area, Konawe Regency is as follows:

1) Existing planting season with cropping pattern (paddy-palawija-paddy) and planting month data (February I-December I) = 9,477 L/second.

2) Planting Season 1 with a planned cropping pattern (paddy-padi-palawija) and with data for planting months (March I-January I) = 9.998 L/second.
3) Planting Season 2 with a planned cropping pattern (palawija-palawija-paddy) and with planting month data (April I-February I) = 7,452 L/second.
4) Planting Season 3 with a planned cropping pattern (palawija-paddy-paddy) and with planting month data (May I-March I) = 9.998 L/second.

From the results of the above cropping patterns, it can be concluded that the appropriate cropping pattern for DI Wawotobi is Planting Season II, namely Palawija-Palawija-Rice with a water requirement of 7.452 L/second. The cropping pattern is the result of several alternative cropping patterns and a more efficient or best cropping pattern is taken.

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