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Study of Deep Water Needs For the Development of Irrigation Network in Sigulai Village, Simeulue Regency

Hani Fadlina[1] ,Dian Febrianti [2], Zulyaden[3]
[1,2,3]*Faculty of Engineering, Civil Engineering Study Program, Teuku Umar University*
Sigulai Village, Simeulue District.
Email : hanifalinasimbar@gmail.com

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ABSTRACT

The irrigation area in Sigulai Village is a rain-fed rice field whose irrigation water depends on rainwater and mountains. So that during the dry season, the rice fields cannot be planted due to a lack of water availability. The purpose of this analysis is to determine the need for deep water for the construction of irrigation networks, the capacity of the pumps used and to analyze the rotation of the water supply to each paddy field. The results showed that the irrigation network in Sigulai Village, Simeulue Regency had 1 water pump to irrigate the rice fields. The irrigated rice fields are located on the back (back) of the technical irrigation network in Sigulai Village, Simeulue Regency, so that even though there is a technical irrigation network, irrigation water has not been able to reach all of the rice fields because the rice field elevation is higher than the canal elevation. The amount of water needed for one harvest is 22,809,600 M^3/one harvest for a paddy field area of 42 Ha (rice, horticulture, crops). The time required for pump operation to irrigate 42 hectares of rice fields is 23 hours 45 minutes/day with a pump capacity of 8000 (ltr/hour)

1. Introduction

Simeulue Regency is known for its rich culture, customs, tourist attractions, as well as land or land which is one of the economic sources for the community, Simeulue Regency. Simeulue Regency consists of 9 (nine) sub-districts, one of which is West Simeulue District with a total of 14 (fourteen) villages and one of them is Sigulai Village. Sigulai village has a land area of 756.6 hectares which is used by the community as plantation land, agriculture which is used as a village community as one of the community's economic resources. At the (upstream) end of Sigulai Village there is also vacant land that has not been cultivated by the village community for a long time, and many people do not know who owns this land. So that the land is often referred to by the community as shared land. (RPJMG 2021)

In meeting the need for water, especially for water needs in rice fields, it is necessary to establish irrigation systems and weir buildings. The need for water in rice fields is then

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called the need for irrigation water. For irrigation, the meaning is the business of supplying, regulating and disposing of irrigation water to support agriculture, the types of which include surface irrigation, swamp irrigation, underground water irrigation, pump irrigation and pond irrigation. The aim of irrigation is to use the available irrigation water correctly, namely as efficiently and effectively as possible so that agricultural productivity can increase as expected.[1]

The amount of water needed in the irrigation area varies according to the area of the paddy fields. Irrigation water requirement is the total volume of water needed to meet evaporation needs, water loss, water needs for plants by taking into account the amount of water provided by nature through rain and the contribution of groundwater. The amount of irrigation water needed also depends on how the land is cultivated. If the magnitude of the need for irrigation water is known, it can be predicted at a certain time, when the availability of water can meet and cannot meet the need for irrigation water as much as needed. If the availability cannot meet the needs, a solution can be found for how these needs must still be met. The need for irrigation water as a whole needs to be known because it is one of the important steps needed in the planning and management of irrigation systems. (Juan. 2010)

The purpose of this study is to analyze the need for irrigation water with the aim of getting predictions of the value of the maximum and minimum irrigation water needs in the Irrigation Network Development Area in Sigulai Village, Simeulue Regency. a. This research only discusses the need for irrigation water b. The need for irrigation water only takes into account the need for rice fields that use irrigation water from the Air Keban River.

2. Research Method

Place and time of research

This research took place from September 2022 and was conducted in Sigulai Village, Simeulue Barat District, Simeulue Regency.

Data analysis method

Data analysis is divided into several stages, including:

a. Climatological Analysis Determining the magnitude of the evapotranspiration value of the Air Keban River Irrigation Area uses the Penman Modification method because the data obtained is in accordance with this method.

b. Rainfall Analysis Determines the mid-month average rainfall. The calculation of average rainfall uses the algebraic average method for the last 10 years. Determine the effective rainfall of R80 then determine the effective rainfall for rice and secondary crops

c. Calculation of the need for irrigation water Land preparation Determining the need for water during land preparation Crop coefficients Determine crop coefficients based on the table.

Consumptive use Determining the consumptive use of plants / the amount of water used by plants Percolation Determining the percolation capacity in irrigated areas is taken from the table. Replacement of the water layer Replacement of the water layer is done as needed. If no such schedule is available, perform 2 replacements, 50 mm* each (or 3.3 mm/day for 1/2 month) for one month and two months after transplant.

Plant water needs

a. The net water requirement in paddy fields (NFR) is calculated.

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b. The irrigation water requirement (IR) for rice and secondary crops is calculated. The need for water withdrawal at the source The need for withdrawal (DR) is the amount of irrigation water needed divided by the irrigation efficiency

3. Description and Technical

Consumptive use Determining the consumptive use of plants / the amount of water used by plants Percolation Determining the percolation capacity in irrigated areas is taken from the table. Replacement of the water layer Replacement of the water layer is done as needed. If no such schedule is available, perform 2 replacements, 50 mm* each (or 3.3 mm/day for 1/2 month) for one month and two months after transplant.

Plant water needs

c. The net water requirement in paddy fields (NFR) is calculated.
d. The irrigation water requirement (IR) for rice and secondary crops is calculated. The need for water withdrawal at the source The need for withdrawal (DR) is the amount of irrigation water needed divided by the irrigation efficiency

4. Results and Discussions

Average And Effective Rainfall Analysis

For this purpose, rainfall data will be used from 3 rainfall recording stations, namely the Rainfall Station with a station recording period of 5 years from 2022. The results of calculating the average and effective monthly rainfall can be seen in the following table:

Calculation of Evaportranspiration

Work steps to calculate evaportranspiration using the modified Panman method from the results of the data as follows:

Calculating Rs = [0.258 + 0.54 x n/N] x Ra ....(1)
= [0.258 + 0.54 x 29.0] x 15.69
= 15.9 x 15.69
= 249.8 mm/day

Calculating Ed = ea x Rh ....(2)
= 29.2 x 90.2
= 26.4 mbar

Calculating f(ed) = 0.34 - 0.44 x (ed)0.5 ....(3)
= 0.34 - 0.44 x [26,40,5]
= 0.1 mbar

Calculate f(n/N) = 0.1 + 0.9 x n/N ....(4)
= 0.1 + 0.9 x 29.0
= 29.0

Calculating f(u) = 0.27 x [1 + 0.9 x u] ....(5)
= 0.27 x [1 + 0.9 x 0.8]
= 0.5m/sec

Calculating Rn 1 = f(t) x f(n/N) ....(6)
= 15.5 x f(ed) x f(n/N)
= 51.5 x 0.1 x 29.0
= 51.1 mm/day

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Calculating ea-ed = ea – ed .... (7)
= 29.2 - 26.4
= 2.9 mbar

Calculating ET* = w [0.75 x Rs - Rn1] + [1-w x f(u) x ea-ed]................................ (8)
= 0.7 [0.75 x 249.8 - 51.1] + [0.3 x 0.5 x 2.9]
= 100.4 mm/day

Calculating Eto = c x ET*.. (9)
= 1.1 x 100.4/15
= 2.2 mm/day

For Eto in mm/month then multiplied by the number of days in each month
Eto = 68.51 mm/month

For further calculations can be seen in the table below.

Table 1 . Evapotranspiration Calculation of Modified Penman Method

No	Parameter	Unit	Jan	Feb	Marc	Apr	May	Jun	Jul	Augs	Sep	Oct	Nov	Dec
1	Suhu	°C	23.7	24	24.1	24.1	24.3	23.8	23.6	23.7	23.6	24	24	23.5
2	Sinar Matahari (n/N)	%	29	29	40	50.3	52.4	46.8	60.9	66.5	62.4	53.1	42.4	26.2
3	Kelembaban Relatif (Rh)	%	90.2	89	87.7	86.6	85.9	84.9	82.2	79.8	79.8	82.9	86.6	90.8
4	Kecepatan Angin (u)	m/dt	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.7	0.9	0.9	0.8	0.8
5	w		0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
6	Ra	mm/hari	15.7	16	15.6	14.8	13.5	12.9	12.8	14.1	15	15.7	15.7	15.6
7	Rs = (0.258+0.54 n/N)Ra	mm/hari	250	254	341	405	386.5	330.1	425.6	510.2	510.9	453.3	363.7	224.6
8	f(t)		15.5	15	15.6	15.6	15.6	15.5	15.4	15.5	15.4	15.5	15.5	15.4
9	ea	mbar	29.2	29	30	30	30.4	29.5	29	29.3	29.1	29.8	29.8	29
10	ed = ea x Rh	mbar	26.4	26	26.3	26	26.1	25.1	23.9	23.4	23.2	24.7	25.8	26.3
11	f (ed) = 0.34 - 0.44(ed)^0.5	mbar	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
12	f (n/N) = 0.1 + 0.9 n/N		29	26	36.1	45.3	47.2	42.2	54.9	60	56.3	47.9	38.3	23.7
13	f (u) = 0.27(1 + 0.864 x u)	m/dt	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
14	Rn 1 = f (t) x f (ed) x (f (n/N)	mm/hari	51.1	47	64.2	81.6	84.8	78.2	105.8	117.9	111.2	90.4	69.4	41.7
15	ea - ed	mbar	2.9	3.4	3.7	4	4.3	4.5	5.2	5.9	5.9	5.1	4	2.7
16	ET* = w (0.75Rs - Rn 1) + ((1-w) (f (u))(ea-ed))	mm/hari	100	106	142	165	152.9	125.5	157.5	195.9	200.8	185.3	151	93.6
17	c	mm/hari	1.1	1.1	1	0.9	0.9	0.9	0.9	1	1.1	1.1	1.1	1.1
			2.21	2.3	2.85	2.97	2.75	2.26	2.84	3.92	4.42	4.08	3.32	2.06
18	Eto = c x ET	mm/bln	**6.8**	**7.2**	**8.8**	**9.2**	**8.5**	**7**	**8.8**	**12.1**	**13.7**	**12.6**	**10.3**	**6.4**

Source: 2022 Research Data

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Calculation of Water Needs in the Paddy Fields

The steps for calculating water needs in the fields are as follows:

a. Analysis of water needs in the rice fields

Cr = LP ....(10)

Etc = 1.1 + eto
= 1.1 + 3.3
= 4.42mm/day

Nfr = etc + p + WLR – Re ....(11)
= 4.42 + 2 + 0 – 1.0
= 5.42mm/day

Analysis of rice cropping patterns, horticulture and secondary crops

DR = Nfr / (1.35 x 8.64) ....(12)
= 5.42 / (1.35 x 8.64)
= 0.46 mm/day

Table 2 . The results of the analysis of water needs in the rice fields

Moth	Eto (mm/day)	P (mm/day)	Re (mm/day)	WLR	C1	C2	C3	Cr	Etc	NFR	Pola Tanam
Nov	3.3	2	1		1.1	LP	LP	LP	4.42	5.42	
			1.5		1.1	1.1	LP	LP	1.1	1.6	
Dec	2.1	2	4.8	1.1	1.05	1.10	1.1	LP	3.16	1.46	
			3.7	1.1	1.05	1.1	1.1	1.1	1.1	0.5	
Jan	2.2	2	3.3	2.2	0.05	1.1	1.05	1.1	3.31	4.21	paddy
			5.7	1.1	0	0.6	1.05	0.7	1.1	1.01	
Feb	2.3	2	5.7	1.1		0	0.95	0.6	3.43	2.6	
			4.1				0	0.3	1.1	3.35	
Marc	2.9	2	2.7					0	0	0.7	
			1.7		LP	LP	LP	LP	1.1	1.4	
Apr	3	2	1.5	1.1	0.5	LP	LP	LP	4.07	5.67	
			1.8	1.1	0.51	0.5	LP	LP	1.1	0.4	
May	2.8	2	1	2.2	0.69	0.5	0.5	0.6	3.85	7.05	h o rtikulture
			0.2	1.1	0.9	0.7	0.51	0.7	1.1	2	
Jun	2.3	2	0.7	1.1	0.95	0.9	0.69	0.9	3.36	5.76	
			0.1		0	1	0.9	0.6	1.1	1	
Jul	2.8	2	0			0	0.95	0.5	3.94	5.94	
			0.7				0	0.4	1.1	0.4	
Aug	3.9	2	0					0	0	0.7	
			0	1.1	1	1	0.75	1	5.02	8.12	
Sep	4.4	2	0.1	1.1	0.82	1	1	0.9	5.52	8.52	palawija
			0	2.2	0.45	0.8	1	0.8	5.52	9.72	
Oct	4.1	2	0.5	1.1	0	0.5	0.82	0.4	5.18	7.78	
			1.5			0	0.45	0.2	5.18	5.68	

Source: 2022 Research Data

ISSN (*Online*) 2620-7222
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Table 3 . The results of the analysis of rice, secondary crops and horticultural cropping patterns

Mont	NFR G_1	G_2	G_3	Gaverage	DR	Pola Tanam
	5.42			1.81	0.46	
Nov	1.6	5.42		2.34	0.2	
	1.46	1.6	5.42	2.83	0.24	paddy
Dec	0.5	1.46	1.6	1.19	0.1	
	4.21	0.5	1.46	0.98	0.08	
Jan	1.01	4.21	0.5	0.76	0.06	
	2.6	1.01	4.21	1.81	0.15	
Feb	3.35	2.6	1.01	2.32	0.2	
	0.7	3.35	2.6	2.22	0.19	
Mar	1.4	0.7	3.35	1.82	0.16	
	5.62	1.4	0.7	2.57	0.22	
Apr	0.4	5.62	1.4	2.47	0.21	h o r
	7.05	0.4	5.62	4.36	0.37	h o rtikulture
Mei	2	7.05	0.4	3.15	0.27	
	5.76	2	7.05	4.94	0.42	
Jun	1	5.76	2	2.92	0.25	
	5.94	1	5.76	4.23	0.36	
Jul	0.4	5.94	1	2.45	0.21	
	0.7	0.4	5.94	2.35	0.2	
Aug	8.12	0.7	0.4	3.07	0.26	
	8.52	8.12	0.7	5.78	0.5	palawija
Sep	9.72	8.52	8.12	8.79	0.75	
	7.78	9.72	8.52	8.67	0.74	
Oct	5.68	7.78	9.72	7.73	0.66	

Source: 2022 Research Data

Calculation of Pump Capacity

Based on data from the field that: static suction head (Hs) = 7.5 m, static exhaust pressure (Hd) = 0.5 m, design discharge (Q) = 0.0022 m^3/s, pipe diameter (D) = 0.05008 m, suction pipe length (L) = 18 m, inter/discharge pipe length (Exhaust) = 10 m.

1. Debit water demand (Qt)

1 hectare can irrigate 1.35 ltr/second rice fields

Qt = A x e..(13)
= 42 x 1.35
= 56.7 l/sec
= 0.0567 m3/s

Because the water demand discharge
(Qt) = 56.7 l/s, the pipe used is 125 inches.

2. Total static pressure height (total Hs)

Total Hs = Hs + Hd..(14)
= 7.5 + 0.5
= 8 m

3. Manometric pressure height (Hm) Flow rate(V)

V = Q/A..(15)
= Q/ π .r2

ISSN (*Online*) 2620-7222
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r = D/2 (16)
= 0.0508/2
= 0.0254 m

V = 0.0022 / (3.14 . 0.02452) ....(17)
= 1.085 m/s

4. Calculation of pump operating time

Water requirement in 1 day = Q. 24 hours ....(18)
= 0.0022 x (60 x 60 x 24)
= 0.0022 x 86400
= 190.08 m3/day of

water requirement in 4 months (1 rice harvest): ....(19)
= 190,080 x (30 x 4)
= 190,080 x 120
= 22,809,600 m3

Available pump capacity (ltr/hour) = 8,000 (ltr/hour)..(20)
Pump operational time (T) = 190.080/8000
= 23.76 hours
= 23 hours 45 minutes

Implementation of the turn of giving water

The provision of irrigation water is carried out according to the water flow schedule which has been prepared and mutually agreed upon by the Pump Management Group (KP2). The water distribution schedule is carried out according to the pump operational system or water distribution is carried out in rotation according to the agreement of the members regarding the arrangement of the flow schedule for the Balla Romang Pump Management Group (KP2) starting from the box for 1 left then the box for 1 right then the box for 2 left and to the box for 2 right.

The results of the rotational analysis of tertiary plots with a land area of 42 Ha consist of:

Sub tertiary A covering an area of 12 Ha requires 16.2 l/sec/ha of water
Sub tertiary B covering an area of 7 Ha requires 9.45 l/sec/ha of water
Sub tertiary C covering an area of 12 Ha requires 16.2 l/sec/ha of water
Sub tertiary D covering an area of 11 Ha requires 14.85 l/sec/ha of water

Plan discharge analysis

Boundary conditions: if the available discharge is > 65% Q max, then the administration is carried out continuously.

Giving water (Q), if 100 % Q max.

Block A gets water = 12 x 16.2 = 194.4..(21)
Block B gets water = 7 x 9.4 = 66.4
Plot C gets water = 12 x 16.2 = 194.4
Plot D gets water = 11 x 14.9 = 163.4 +

Σ Q max = 618.6 l/s

Giving water if Q = 65 %

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Qmax. 65/100 x 618.6 = 371.2 l/sec.
Then the provision of water using sub-tertiary rotation method 1
Giving water if Q = 35 % Qmax.
As much as 35/100 x 618.6 = 216.5 l/s,

then the water is given using the second sub-tertiary rotation method.

Water = 216.5 l/s

cannot be distributed professionally at the same time, so that each sub-tertiary is given a rotational method with scheduling and the length of time it is given is calculated according to the proportion of each area.

Table 4. The results of calculating the delivery of water can be summarized as follows

Plot Sub tersier	Luas Ha	Qmaks			Q Planning
		100%	65%	35%	
A	12	194,4	222,7	216,5	222,7
B	7	66,4	136,8	216,5	136,8
C	12	194,4	222,7	216,5	222,7
D	11	163,4	193,7	216,5	193,7

Source: 2022 Research Data

Discussion result

The need for irrigation water is determined by various factors such as the method of preparing the land, the need for water for plants and the replacement of layers of water and effective rainfall. From the beginning of the calculation to analyze rainfall using 3 stations, namely the Manjalling rainfall station, the Pallangga rainfall station and the Tamanyeleng rainfall station. The results of calculating effective rainfall can be seen in graph 1 on page 39. Taitu where from July to October the amount of water is very less so a water pump is needed to meet irrigation water needs.

The water requirement for Eto plants = 4.42 mm/day, can be seen on pages 43 and 44 and the value of kc = 1.30 is taken from the coefficient price of rice plants at 2.5 months for superior varieties (rice varieties with short growth periods).

For the analysis of pump capacity, water demand discharge (Qt) = 0.0567 m3/sec, total static pressure head (Hs total) = 8 m, flow velocity (V) = 1085 m3/sec, manometric pressure loss (Hm) = 9.118 m/sec, power (D) = 196.784 watts, pump operating time (T) = 23 hours 45 minutes
Schedule of water administration Give water if

Q = 35 % Qmax.
As much as 35/100 x 618.6 = 216.5 l/s,

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Table 5. The results of calculating the provision of water can be summarized as follows:

Petak	Luas Ha	Q maks			Q Planning
		100%	65%	35%	
A	12	194,4	222,7	216,5	222,7
B	7	66,4	136,8	216,5	136,8
C	12	194,4	222,7	216,5	222,7
D	11	163,4	193,7	216,5	193,7

Source: 2022 Research Data

Based on the table above, the calculation results for giving water are 35/100 x 618.6 = 216.5 l/s, then the water is given using the sub-tertiary II rotation method. Water = 216.5 l/s cannot be distributed professionally at the same time, so that each sub-tertiary is given a rotational method with scheduling and the length of time it is given is calculated according to the proportion of each area.

5. Conclusion and Suggestion

5.1 Conclusion

The irrigation network in Sigulai Village, Simeulue Regency has 1 water pump, to irrigate the rice fields. The irrigated rice fields are located on the back (back) of the technical irrigation network in Sigulai Village, Simeulue Regency, so that even though there is a technical irrigation network, irrigation water has not been able to reach all of the rice fields because the rice field elevation is higher than the canal elevation. The amount of water needed for one harvest is 22,809,600 m3/one harvest for a paddy field area of 42 Ha (rice, horticulture, crops). The time required for pump operation to irrigate 42 hectares of rice fields is 23 hours 45 minutes/day with a pump capacity of 8000 (ltr/hour).

5.1 Suggestion

1. Distribution of water starts from the box for 1 left, then the box for 1 right, then the box for 2 left and finally the box for 2 right.
2. The distribution of water is carried out according to the flow schedule that has been prepared and agreed upon by the Pump Management Group (KP2).

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