Simulation of Irrigation Area by Using a Dependable Flow Basic Month and Basic Year

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Abstract

The purpose of this study was to analyze the availability of irrigation water from the reservoir by using a dependable flow of basic month, analyze the availability of irrigation water from the reservoir by using the dependable flow of basic year and compare the calculation of the availability of irrigation water from the reservoir by using a dependable flow of basic month and the basic year, where which is more effective. The research was conducted using secondary data, the research location was in Way Rarem Reservoir, data obtained from the Mesuji-Sekampung River Basin Center and the North Lampung Geophysics Station UPT. Analysis of the data calculates the availability of irrigation water and irrigation water needs, to determine the maximum irrigation area that can be irrigated. The availability of irrigation water is made of two types of calculations, first using the basic month dependable flow with a reliability of 40%, 50%, and 60%, and the second with the basic year dependable flow from 2011-2020. Irrigation water needs are calculated using a modified penman, with a cropping pattern used of Paddy-Paddy-secondary crop and 4 groups. The results of this study are the basic year dependable flow gets an irrigation area of 1328,65 Ha and the basic month dependable flow gets an area of 11186,83 Ha, the basic dependable flow area gets a larger area than the basic month dependable flow, the maximum area of dependable flow basic month and basic year in Group IV started on the 1st January of the year.

Keywords: *dependable flow, basic month, basic year, water irrigation*

I. INTRODUCTION

Rice is one of the cultivated plants in Indonesia. The majority of Indonesia people consume rice which is the result of processed rice. Indonesia is known as an agricultural country where most of the population is farmers [1].

In agricultural activities, reservoirs are used for irrigation to support increased rice production. The efforts were made to up rice productivity in cropping patterns using irrigation water for the growing season, as well as regulating irrigation water requirements during the rice and secondary planting seasons. The cropping pattern in the growing season will be adjusted to the availability of water in water sources. Irrigation is the provision of water to plants for the water needs of their growth [2].

To calculate the ability of water sources to irrigation water needs in an irrigation area, it is usually with a water balance analysis. The dependable flow is the flow that is expected to exist or be available within a certain peri. This study is using the calculation method based on the dependable flow as the most effective way to calculate the availability of irrigation water from the reservoir [2,3].

II. MATERIALS AND METHODS

The research location is the Way Rarem Reservoir, 36 km from the district capital, and 113 km from the provincial Lampung, the location of the Way Rarem Reservoir can be seen in Figure 1. In this study, the data obtained were secondary data from the Mesuji-Sekampung River Basin Center and North Lampung Geophysical Station UPT. The data obtained from the Mesuji-Sekampung River Basin Center is rainfall data for 10 years from 2011-2020 from 5 rain posts (Kelapa Tujuh, Subik, Kebon Tebu, Bukit Kemuning and Perukun). The data obtained from the UPT Geophysics Station of North Lampung are air temperature (^{0}C), wind speed (m/s), humidity (%), duration of sunshine (hours), and solar radiation (mm. day), as on Fig. 1.

Figure 1. Way Rarem Reservoir

2.1. Availability of Irrigation Water

Calculating the availability of irrigation water is using the FJ Mock concept. Rainfall data from the Mesuji-Sekampung River Basin Center is calculated annually. Then the dependable flow calculation with two types, first using the basic year dependable flow method from 2011-2020, and second using the basic month dependable flow method with a reliability of 40%, 50%, and 60%.

2.2. Irrigation Water Needs

Analysis of irrigation water needs is calculating the inflow and outflow on agricultural land, the inflow into agricultural land is the discharge from the water source from effective rain, while the outflow out of agricultural land is evapotranspiration, percolation, water for land preparation.

The need for irrigation water is using empirical theoretical formulas taking into account meteorological factors. From the meteorological data, evapotranspiration was calculated using the modified Penman method. After getting the evapotranspiration value, land preparation (LP) was calculated using the method developed by van de Goor-Zijlstra, then calculated the effective rainfall [2-3].

Calculation of irrigation water needs is using a cropping pattern. The cropping pattern aims to get the minimum amount of irrigation water needed in the dry season. In the preparation of this cropping pattern, four initial planting groups with simulated,

a. Group I started on November I,
b. Group II started on December I,
c. Group III started on December II, and
d. Group IV started on January I.

From these four groups, it is known that the need for irrigation water and the area that can be irrigated (Ha).

III. Results and Discussions

3.1. Availability of Irrigation Water

To calculate the availability of irrigation water, the other concept is used [3]. Mock is used to estimate the discharge of a watershed based on the concept of water balance. The availability of irrigation water uses two models, the first is the basic year dependable flow from Y2011 to Y2020 and the second is the basic month dependable flow with a reliability of 40%, 50% and 60%. The results of the calculation of the basic year dependable flow in table1.

Table 1. Dependable flow basic year (m3/s)

Year	Jan	Feb	Mar	Apr	May	Jun
2011	7,57	7,84	8,22	8,24	7,15	6,13
2012	7,12	9,19	6,42	8,37	7,56	6,42
2013	10,12	8,61	7,95	8,14	7,17	6,93
2014	7,91	9,37	7,91	8,03	7,33	6,24
2015	9,98	9,77	9,18	8,13	6,35	5,91
2016	8,89	9,72	9,16	7,90	6,55	6,20
2017	7,67	8,88	8,19	8,18	6,14	6,61
2018	6,84	10,79	9,01	8,13	6,71	6,43
2019	7,71	10,87	9,66	8,21	6,08	5,73
2020	9,42	7,71	9,14	9,85	8,71	6,80

continued..

Jul	Aug	Sep	Oct	Nov	Dec	Quantity
5,81	5,01	5,35	6,12	7,90	7,83	83,18
5,43	4,99	5,31	6,07	8,28	9,15	84,31
7,80	5,88	6,11	7,75	7,49	10,64	94,58
5,93	6,48	5,20	5,65	7,23	9,61	86,89
5,24	5,03	5,13	5,06	6,80	8,55	85,13
6,32	5,97	7,72	8,09	8,44	7,79	92,75
5,76	5,75	5,92	7,83	8,15	9,71	88,81
5,34	5,79	5,75	5,58	7,77	7,35	85,49
5,48	4,96	5,15	5,20	5,98	9,56	84,60
6,52	6,11	6,38	6,90	6,43	8,08	92,05

From the above data it is known that the dependable flow of basic year highs in 2013 is 94,58 m^3/s, lowest was in 2011 at 83,18 m^3/s.

The calculation of the basic month is sorting the discharge from the largest to the smallest by month, then calculations are determined the level of reliability based on the probability of occurrence following the Weibull formula, as presented by other [4]. Basic month dependable flow with a reliability of 40%, 50% and 60% can be seen in Table 2.

Table 2. Dependable flow basic month (m^3/s)

Dependable flow	Jan	Feb	Mar	Apr	May	Jun
40%	8,50	9,58	9,09	8,20	7,16	6,43
50%	7,81	9,28	8,62	8,16	6,93	6,33
60%	7,69	9,01	8,21	8,13	6,62	6,22

continued..

Dependable flow	Jul	Aug	Sep	Oct	Nov	Dec
40%	5,88	5,84	5,85	6,59	7,85	9,40
50%	5,79	5,77	5,55	6,10	7,63	8,85
60%	5,59	5,32	5,33	5,82	7,33	8,27

From the above data to the highest discharge in the dependable flow of 40% amounting to 9,58 m3/s in February, and the lowest at 60% dependable flow in the month of August at 5,32 m3/s.

3.2. Irrigation Water Needs

The need for irrigation water is the volume of water needed to meet the needs of evaporation, water loss, water needs for plants by taking into account the amount of water provided by nature through rain and the contribution of groundwater [5]. In this study, evapotranspiration using the Modified Penman method. The results of the calculation of evapotranspiration can be seen in table 3.

Table 3. Evapotranspiration, ETO (mm/day)

Month	Jan	Feb	Mar	Apr	May	Jun
ETO	4,71	4,43	4,40	3,47	3,44	3,33

continued..

Month	Jul	Aug	Sep	Oct	Nov	Dec
ETO	3,48	4,48	5,28	5,16	4,75	4,29

the calculation results

From the results, the highest evapotranspiration in September was 5,28 mm/day, and the lowest was 3,33 mm/day. The results of daily evapotranspiration using the Penman-Mointeinth method vary from 3,2 mm/day to 5,2 mm/day [6].

Land preparation (LP) is the work of wet soil processing starting from the first application of water, cleaning the straw and roots of the remaining rice plants until they are planted. The results of the calculation of land preparation can be seen in table 4.

Table 4. Land Preparation (mm/day)

Month					
Jan	Feb	Mar	Apr	May	Jun
13,71	14,52	13,50	13,19	12,86	13,10

continued…

Month					
Jul	Aug	Sep	Oct	Nov	Dec
12,89	13,55	14,40	14,02	14,04	13,42

The calculation method using van de Goor and Zlklstra is based on a constant water rate during the land preparation period. From the data above, it is known the highest land preparation in February was 14,52 mm/day and the smallest in July was 12,89 mm/day [6].

Analysis of irrigation water needs using a cropping pattern with four groups. The results of the calculation of four simulations of irrigation water needs with the paddy-paddy-secondary crops, irrigation water needs in table 5.

Table 5. Irrigation water needs (l/s/ha)

Month	Irrigation Water Needs			
	Group I	Group II	Group III	Group IV
Nov-01	2,80	1,07	1,51	1,33
Nov-02	2,75	2,75	0,68	1,47
Dec-01	1,28	2,64	2,64	1,39
Dec-02	1,24	1,24	2,60	0,97
Jan-01	1,55	1,37	1,37	2,69
Jan-02	1,32	1,54	1,37	2,69
Feb-01	1,22	1,26	1,47	1,30
Feb-02	0,59	1,20	1,25	1,27
Mar-01	0,00	0,62	1,22	1,48
Mar-02	2,63	0,00	0,60	1,25
Apr-01	2,63	2,63	0,00	1,04
Apr-02	1,14	2,67	2,67	0,56
May-01	1,16	1,16	2,63	0,00
May-02	1,34	1,15	1,15	2,57
Jun-01	1,13	1,34	1,16	2,64
Jun-02	1,10	1,13	1,34	1,16
Jul-01	0,62	1,14	1,17	1,20
Jul-02	0,00	0,62	1,14	1,39
Aug-01	0,89	0,00	0,70	1,36
Aug-02	1,13	0,90	0,00	1,33
Sep-01	1,43	1,21	0,93	0,78
Sep-02	1,63	1,42	1,21	0,00
Oct-01	1,55	1,56	1,36	0,88
Oct-02	1,11	1,58	1,59	1,18

From the calculation results, it is known that the highest irrigation water requirement in November-01 of 2,80 l/s/ha in group I.

To find out the area of irrigation that can be irrigated, use the formula [7]:

$$A = (Qand / DR) * 1000 \quad (1)$$

where:

A : The area that can be drained for a certain alternative during a certain period of time, ha

Qand : Mainstay discharge over a period of time, m 3 /s

DR : The demand for water intake is l/sec/ha

Based on the calculation of the highest minimum area from the sum of the planting period in Group I, Group II, Group III and Group IV, the maximum yield is obtained in Group IV, both basic year mainstay discharge and Basic month mainstay discharge with a reliability of 40%, 50% and 60%. The data from the calculation of the highest minimum area for the sum of the planting period in group IV of the basic year dependable flow can be seen in table 6 and the basic month dependable flow, as presented on the table 7.

The maximum area that can flow through the area for the basic month dependable flow is 1186.83 Ha and the basic year dependable flow is 13286.65 Ha. the greater the dependable flow and the smaller the demand for water intake, the greater the area of land that can be drained [7].

The Way Rarem Reservoir has a main function as a water supply with a certain designation, namely flood control, water reservoir during the rainy season, irrigation and tourist attraction [8].

Based on the Regional Regulation of North Lampung Regency No. 4 of 2014 concerning the spatial plan of the North Lampung Regency in 2014-2034 that the Way Rarem Irrigation Area has an area of 9259 Ha. Thus, when compared with the calculation area, the highest minimum area of the total planting period for Groups I, II, III, and IV, the basic year dependable flow and the basic month dependable flow have a greater value compared to the planned area based on regional regulations.

Table 6. The area that is flowed in the fourth category of basic year dependable flow**.**

Month	Group IV				
	2011	2012	2013	2014	2015
Nov-01	5948,53	6232,41	5635,78	5444,13	5116,14
Nov-02	5368,95	5625,17	5086,68	4913,69	4617,67
Dec-01	5649,13	6604,79	7678,70	6930,53	6171,95
Dec-02	8076,25	9442,51	10977,8	9908,21	8823,70
Jan-01	2812,96	2644,15	3756,49	2937,51	3707,49
Jan-02	2818,15	2649,03	3763,42	2942,93	3714,33
Feb-01	6035,25	7078,80	6631,14	7215,60	7524,09
Feb-02	6148,57	7211,71	6755,64	7351,08	7665,36
Mar-01	5558,02	5654,74	5505,00	5428,69	5492,04
Mar-02	6580,61	6695,12	6517,83	6427,48	6502,49
Apr-01	7902,70	7245,52	6876,86	7025,12	6093,10
Apr-02	14761,53	13533,97	12845,36	13122,28	11381,36
May-01	0,00	0,00	0,00	0,00	0,00
May-02	2776,91	2493,28	2693,13	2425,42	2294,34
Jun-01	2318,56	2055,42	2949,97	2243,77	1981,33
Jun-02	5265,36	4667,78	6699,29	5095,51	4499,52
Jul-01	4842,95	4161,02	4898,77	5402,91	4192,80
Jul-02	4193,61	3603,12	4241,95	4678,49	3630,63
Aug-01	3686,38	3904,08	4494,17	3827,28	3773,99
Aug-02	3773,88	3996,75	4600,84	3918,13	3863,57
Sep-01	6835,74	7749,60	9889,36	7208,74	6463,90
Sep-02	0,00	0,00	0,00	0,00	0,00
Oct-01	6991,62	6929,25	8842,51	6445,65	5779,66
Oct-02	5202,84	5156,43	6580,19	4796,55	4300,95
MIN MT 1	2812,96	2644,15	3756,49	2937,51	3707,49
MIN MT 2	2318,56	2055,42	2949,97	2243,77	1981,33
MIN MT 3	5202,84	5156,43	6580,19	4796,55	4300,95
Result	10334,35	9856,00	13286,65	9977,83	9989,77

continued..

Month	Group IV				
	2016	2017	2018	2019	2020
Nov-01	6355,90	6137,78	5846,69	4505,88	4839,48
Nov-02	5736,63	5539,76	5277,03	4066,87	4367,96
Dec-01	5620,12	7002,67	5303,30	6899,45	5829,10
Dec-02	8034,78	10011,34	7581,84	9863,76	8333,55
Jan-01	3302,60	2848,55	2540,80	2864,25	3500,03
Jan-02	3308,69	2853,81	2545,49	2869,53	3506,49
Feb-01	7486,97	6842,07	8310,70	8374,86	5938,31
Feb-02	7627,54	6970,53	8466,73	8532,10	6049,80
Mar-01	5336,54	5532,35	5492,04	5552,51	6654,68
Mar-02	6318,38	6550,22	6502,49	6574,09	7879,03
Apr-01	6283,85	5891,47	6435,07	5832,17	8349,51
Apr-02	11737,66	11004,74	12020,13	10893,97	15596,12
May-01	0,00	0,00	0,00	0,00	0,00
May-02	2407,34	2568,17	2498,66	2227,48	2643,47
Jun-01	2390,00	2180,20	2021,88	2074,14	2465,26
Jun-02	5427,60	4951,16	4591,62	4710,29	5598,52
Jul-01	4976,93	4789,36	4824,91	4130,96	5094,59
Jul-02	4309,62	4147,20	4177,99	3577,09	4411,51
Aug-01	5681,40	4358,59	4228,51	3788,10	4693,21
Aug-02	5816,26	4462,05	4328,88	3878,01	4804,62
Sep-01	10328,89	9994,64	7129,78	6633,66	8811,58
Sep-02	0,00	0,00	0,00	0,00	0,00
Oct-01	9235,51	8936,64	6375,05	5931,44	7878,82
Oct-02	6872,64	6650,23	4744,01	4413,91	5863,05
MIN MT 1	3302,60	2848,55	2540,80	2864,25	3500,03
MIN MT 2	2390,00	2568,17	2021,88	2074,14	2465,26
MIN MT 3	5736,63	5539,76	4744,01	4066,87	4367,96
Result	11429,23	10956,49	9306,70	9005,25	10333,25

Table 7. The area flowed in group IV basic month dependable flow

Month	Group IV		
	Dependable Flow 40%	Dependable Flow 50%	Dependable Flow 60%
Nov-01	5907,79	5741,23	5520,79
Nov-02	5332,18	5181,85	4982,89
Dec-01	6781,58	6388,37	5966,24
Dec-02	9695,26	9133,11	8529,61
Jan-01	3156,56	2900,88	2854,83
Jan-02	3162,39	2906,23	2860,10
Feb-01	7378,42	7147,20	6936,77
Feb-02	7516,95	7281,39	7067,00
Mar-01	6143,92	5824,84	5546,48
Mar-02	7274,31	6896,52	6566,95
Apr-01	7865,73	7829,17	7798,73
Apr-02	14692,48	14624,18	14567,33
May-01	0,00	0,00	0,00
May-02	2782,38	2691,98	2570,29
Jun-01	2431,30	2395,12	2503,16
Jun-02	5521,41	5439,23	5340,20
Jul-01	4902,21	4822,34	5179,02
Jul-02	4244,92	4175,76	4036,54
Aug-01	4299,60	4244,77	4116,22
Aug-02	4401,65	4345,52	4005,89
Sep-01	7472,96	7086,63	6790,05
Sep-02	0,00	0,00	0,00
Oct-01	7523,94	6960,44	6639,09
Oct-02	5598,97	5179,63	4940,50
MIN MT 1	3156,56	2900,88	2854,83
MIN MT 2	2431,30	2395,12	2503,16
MIN MT 3	5598,97	5179,63	4940,50
Result	11186,83	10475,63	10298,50

IV. CONCLUSIONS

The conclusions in this study are based on the irrigation water needs and the existing dependable flow, calculations have found the maximum area of each alternative. The basic month dependable flow can an irrigation area of 11186,83 Ha and the basic year dependable flow can an irrigation area of 13286,65 Ha. The maximum area of basic year and basic month dependable flow is obtained in group IV starting in January 1st week (first). The area that flows through the land area using the basic year dependable flow can flow through a wider irrigation area than using the basic month dependable flow.

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