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Study of Water Use Optimization with a Linear Program at Raknamo Dam, East Nusa Tenggara Province

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Abstract — *This research was conducted with the aim of knowing the Study of Optimizing Water Utilization with a Linear Program at the Raknamo Dam, East Nusa Tenggara Province. The Raknamo Dam in Raknamo Village, Amabi Oefeto District, Kupang Regency, East Nusa Tenggara Province, is the place where the research was conducted. The data analysis method used includes determining the need for irrigation water based on the annual cropping pattern, determining whether the available discharge is sufficient to meet this need, then optimizing the calculation with a linear program to ensure the most efficient use. irrigation water is reached. This study aims to determine the best way to optimize the Raknamo Dam so that it can meet future irrigation water needs by analyzing the current state of the 1,323 hectare Raknamo irrigation area and developing a model to optimize the use of water resources for irrigation. using Linear Programming. 1,323 ha. So that the maximum area of land that must be planted is known thanks to optimization findings that take into account the water discharge for filling the Raknamo Dam reservoir and the water demand discharge that will be needed to meet the irrigation water needs for agricultural land. . The results of the optimization identified the best planting order which consisted of: the order of planting rice in the first planting season December I to March II with a rice planting area of 556.40 ha and a grain-planting area of 535.71 ha; During the second planting season from April I to July II, rice was not planted, only crops were planted with a palawija planting area of 2.94 ha. Optimization generates a profit of Rp. 23,336,445,000.*

Keywords— *Optimizing water use, Linear Program on the Raknamo Dam.*

I. INTRODUCTION

Background

For human life to exist, water is a necessity. Water has numerous advantages for human life, including agricultural needs, industrial needs, hydroelectric power needs, as well as domestic needs like toilets and drinking water. Water is a naturally occurring resource that can be replenished through hydrological processes. The amount of water on earth, however, fluctuates drastically depending on the place and the time of year. In comparison to deserts or arid regions, the availability of water in the tropics is quite high. The wet season (wet season) has more water availability than the dry season (dry season), when water availability starts to decline. Utilization of water resources needs to be done in order to further optimize the existing water resources. Optimization of water resources can be done by changing the distribution of natural water into an artificial water distribution, namely by carrying out human engineering, including by building dams. Dam is one of the water structures used to accommodate excess water discharge during the wet season so that it can be utilized during low water discharge during the dry season.

Kupang Regency has the Tilong Dam which was built in 1998, to meet the raw water needs of Kupang city residents and irrigation water needs. However, due to the increasing population growth and increasing irrigation potential in irrigation potential areas, the Kupang city government is trying to meet the water needs of the residents of Kupang City, both for raw water needs and for irrigation water needs with the construction of the Raknamo Dam in 2014. With the Raknamo Dam, it is hoped that it will be able to meet the water needs of the residents of Kupang City. In order to balance the water needs of the present and the future, good management of water resources is required to meet these needs. Finding out the water availability and demand in a region with Raknamo Dam-based water resources is one of the initiatives being made. Then, a study is required to construct an optimization model with an algorithm that is in line with the probabilistic nature, namely the Linear model, for the use of water resources in the Raknamo Dam.The output of the optimization of the Linear model is expected to produce a better operational pattern for the Raknamo Dam to be used to meet the needs of irrigation water and to know the availability of existing water.

Formulation of the problem

1. What is the existing condition of the 1,323 ha Raknamo Potential irrigation area?
2. What is the model for optimizing the utilization of water resources for irrigation using the Linear Program and the results?
3. What is the optimal operational pattern for the Raknamo Dam to meet the supply of potential irrigation water needs of 1,323 ha?

II. LITERATURE REVIEW

1. General

The primary river water potential is meant to supply raw water and irrigation water requirements. Similar to people, plants require a certain amount of water to survive. The amount of water needed for irrigation has an impact on how much water should flow to paddy fields. (Suhardjono, 1994: 6).

Irrigation is channeling the water necessary for plant growth to the tilled soil and distributing it systematically. Irrigation design is prepared mainly based on meteorological conditions in the area concerned and the water content needed for plant growth (Sosrodarsono, 1976: 216).

2. Hydrological Analysis

To determine the hydrological and climatic features of the river flow, hydrological analysis was conducted. In order to lay the groundwork for subsequent investigation, it is important to identify the features of rain, severe water discharge, and reasonable water discharge.

A. Rain Data

Rain data is rainfall data obtained from the rain gauge station closest to the Raknamo Dam location.

B. Rain Data Consistency Test

The method used to test data consistency is the RAPS (Rescaled Adjusted Partial Sums) method, which is a test using the average annual rainfall data from the station itself, namely by testing the cumulative squared deviation of the average value. (Sri harto, 1993)

C. Rainfall Frequency Analysis

a. Rainfall analysis, using many parameters.
b. Discharge analysis (flow), using a few parameters.

3. Effective Rainfall

Effective rainfall is only a fraction of real rainfall. The amount of effective rainfall for rice plants is determined by 70% of the average monthly rainfall with a 20% probability of failure (KP 01, 1986:106). While the amount of R80 is obtained using the Basic Year method. Thus the effective rainfall for rice plants is obtained from the following equation (KP 01, 1986:106):

$$Re = 0.7 \times R_{80}$$

As for palawija crops, effective rainfall is 50% of the monthly rainfall.

$$Re = R_{50}$$

Where:
R_{80} = rainfall with 80% probability of occurrence (mm)
R_{50} = rainfall with 50% probability of occurrence (mm)
Re = effective rainfall (mm)

4. Mainstay Debt

The primary debt can be calculated in a number of different ways, each of which has unique properties. The suitable strategy is typically chosen after taking into account the sorts of interests, experience, and data that are accessible. This is how it's done.:

- Minimum Qrerata method
  ▪ Maximum or minimum debit fluctuations are not too large per year.
  ▪ Needs are relatively constant throughout the year.
- Flow characteristic method
  ▪ Maximum or minimum debit fluctuations are too large per year.
  ▪ Relatively not constant demand throughout the year.
  ▪ The available data is quite extensive.
- Basic month method (Basic Month)

This method is similar to the flow characteristics method but only selects a certain month as the basis for planning.

- Base year method (Basic Year)

This method determines a certain year as the basis for planning. The calculation of the mainstay debit is carried out using the Basic Year method, which is taking one debit pattern from a certain year. The probability of its occurrence is calculated by the Weibull equation (Subarkah, 1980: 111):

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

With:
P = Probability (%)
m = serial number of debit data
n = amount of discharge data.

The base year used is the year in which the debit data has a reliability of 80% (Q80), meaning that the risk to be faced is that there are debits that are smaller than the mainstay discharge of 20% of the number of observations (Soemarto, 1986: 214).

The mainstay debit calculation procedure is as follows:
1. Calculate the total debit in one year for each known data year.
2. Sort data from large to small.
3. Calculate the probability for each data using the Weibull equation above.

Table of Reliability for Various Uses

No _	Utility	Reliability
1	provision of drinking water_	9 9%
2	industrial water supply	(95% - 98 %)
	provision of irrigation water for:	
3	humid climate area	(70% - 85 %)
	light climate area	(80% - 95 %)
4	hydroelectric center	(80% - 90 %)

5. Irrigation Water Needs

The need for water in paddy fields for rice plants is determined by several factors, including (Anonymous, 1986):
- Land preparation
- Consumptive use
- Percolation and seepage
- Alternation of layers of water
- Effective rainfall

6. Optimization Models

In this study, the use of optimization models is one of the efforts to overcome problems in water management and utilization. In addition, it is also aimed at developing the study area, so that the area can generate maximum production benefits

In this study to obtain an optimal solution is done with the optimization model. The equation used is a linear equation, so it is called Linear Programming.

7. Harvest Productivity

With this optimization model, it is hoped that the Raknamo irrigation area will get optimized yields.

8. Linear Program Optimization

- Mathematical Linear Program Optimization Model
- Linear Program Completion Method
- Process Simplex Method.

III. RESEARCH METHODS

A. Study Area Location

Optimizing the utilization of water resources in this study was carried out at the Raknamo Dam which is located in

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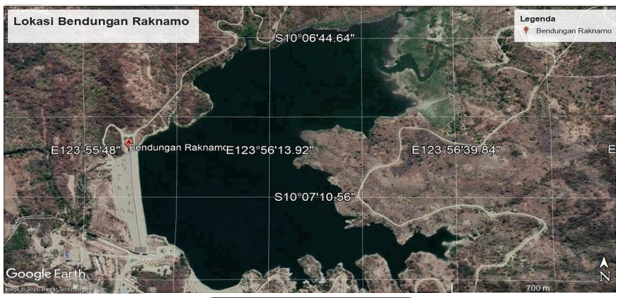
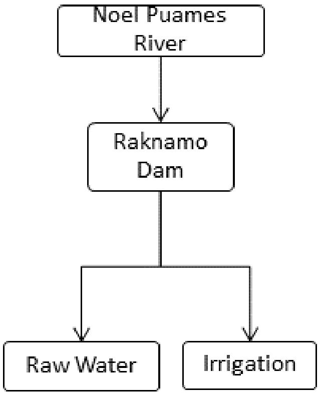
Raknamo Village, Amabi Oefeto District, Kupang Regency, East Nusa Tenggara Province. The location of the Raknamo Dam can be seen in Figure.





Schematic drawing of the Raknamo Dam System

B. Method of collecting data

- Rain Data and Climatology
  Rainfall and climatology data are obtained from the station closest to the Dam.
- Plant Data and Cropping Patterns
  The cropping pattern data used is the annual cropping pattern data used in the study area. The data was obtained from the Kupang District Agriculture Office.
- Irrigation Area Network Scheme
  Schematic data of irrigation area networks are used to determine the area of irrigated land to be irrigated.

C. Data Analysis Techniques

1. Calculating the need for irrigation water according to the annual cropping pattern .
2. Calculating the water balance to find out whether the available discharge can meet the needs of irrigation water.
3. Optimization calculations with Linear Programming so that the use of irrigation water is obtained with optimal results .

IV. RESULTS AND DISCUSSION

1. Hydrological Analysis

Hydrological analysis is used to determine the amount of discharge needed to irrigate the 1,323 ha Raknamo irrigation area.

- Rain Data Analysis

Annual Maximum Rainfall Table

No.	Year	Maximum Rainfall(mm)
1	2012	84
2	2013	192.5
3	2014	96.9
4	2015	126.7
5	2016	81.5
6	2017	94.8
7	2018	170.2
8	2019	71.8
9	2020	78.2
10	2021	305,7
Σ Rainfall		1302,3
Rainfall Rerara		130,23

- Rain Data Consistency Test

Table of rain data consistency test at Eltari Kupang meteorological station

No.	Year	X	$(X_i - \bar{X})$	sc*	$(X_i - \bar{X})^2$	$\sqrt{\Sigma(X_i - \bar{X})^2/n}$	Sk**
1	2012	84	-46.23	0.00	2137,21	73.99	0
2	2013	192,5	62,27	46,23	3877,55	73,99	0,62
3	2014	96,9	-33,33	-16,04	1110,89	73,99	-0,22
4	2015	126,7	-3,53	17,29	12,46	73,99	0,23
5	2016	81,5	-48,73	20,82	2374,61	73,99	0,28
6	2017	94,8	-35,43	69,55	1255,28	73,99	0,94
7	2018	170,2	39,97	104,98	1597,60	73,99	1,42
8	2019	71,8	-58,43	65,01	3414,06	73,99	0,88
9	2020	78,2	-52,03	123,44	2707,12	73,99	1,67
10	2021	305,7	175,47	175,47	30789.72	73.99	2.37

Table of critical values Q/√n and R/√n

n	$Q/\sqrt{n}$			$R/\sqrt{n}$		
	90%	95%	99%	90%	95%	99%
10	1.05	1.14	1.29	1.21	1.28	1.38
20	1,1	1.22	1.42	1.34	1.43	1,6
30	1,12	1.24	1.46	1,4	1.50	1,7
40	1,13	1.26	1.5	1.42	1.53	1.74
50	1.14	1.27	1.52	1.44	1.55	1.78
100	1.17	1.29	1.55	1.5	1.62	1.86
∞	1.22	1.36	1.63	1.62	1.75	2

at 95% with the amount of data (n) = 10, obtained:

1) Q_{kritis} 95% $= \frac{Q_{kritis}}{\sqrt{n}}$

$1{,}14 = \frac{Q_{kritis}}{\sqrt{10}}$

$Q_{Kritis} = 1{,}14 \times \sqrt{10}$

$Q_{Kritis} = 3{,}6$

2) R_{kritis} 95% $= \frac{R_{kritis}}{\sqrt{n}}$

$1{,}28 = \frac{R_{kritis}}{\sqrt{10}}$

$R_{Kritis} = 1{,}28 \times \sqrt{10}$

$R_{Kritis} = 4{,}05$

Sehingga diperoleh: $Q = 2{,}37 < Q_{kritis} = 3{,}6$

$R = 2{,}59 < R_{kritis} = 4{,}05$

So it can be concluded that the rain data from the Kupang Meteorological Station is consistent.

- Rainfall Frequency Analysis
  - Gumbel Frequency Distribution
  - Calculation of the value of the average annual rainfall ("x"̅)

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n} = \frac{1302{,}3}{10} = 130{,}23 \text{ mm}$$

Gumbel Probability Distribution Calculation Table

No	Year	Rainfall (Xi) (mm)	Xi - $\bar{X}$	(Xi - $\bar{X}$)^2
1	2012	84	-46.23	2137,21
2	2013	192.5	62,27	3877.55
3	2014	96.9	-33,33	1110,89
4	2015	126,7	-3,53	12,46
5	2016	81,5	-48,73	2374,61
6	2017	94,8	-35,43	1255,28
7	2018	170,2	39,97	1597,60
8	2019	71,8	-58,43	3414,06
9	2020	78,2	-52,03	2707,12
10	2021	305,7	175,47	30789.72
Σ		1302,3		49276.52
$\bar{X}$		130,23		

- Calculation of Standard Deviation (Sd), referring to the table above

$$S_d = \sqrt{\frac{\sum_{i=1}^{n}(X_i-\bar{X})^2}{n-1}} = \sqrt{\frac{49276{,}52}{10-1}} = \sqrt{\frac{49276{,}52}{9}} = 73{,}99$$

- Calculating design rainfall (X_t) or discharge with return period (T_r)

$$X_t = \bar{X} + \frac{Y_t - Y_n}{S_n} x\, S_d$$

With

$\bar{X}$= average value of Xi = 130.23 mm

Yt = *reduced* variate

Yn = reduced variate mean

Sn = reduced variate standard deviation

Based on the known amount of data (n) = 10, the values of Yn and Sn can be seen in the table

So that the design rain (Xt) or discharge with a return period (Tr) (5 year return period) can be calculated:

$$X_t = \bar{X} + \frac{Y_t - Y_n}{S_n} \text{ x } S_d$$
$$= 130{,}23 + \frac{1{,}4999 - 0{,}4952}{0{,}9497} \text{ x } 73{,}99$$
$$= 208{,}51 \text{ mm}$$

Table of relationship n (sample size) with Yn and Sn

n	Yn	Sn	n	Yn	Sn	n	Yn	Sn
8	0,4843	0,9043	39	0,543	1,1388	70	0,5548	1,1854
9	0,4902	0,9288	40	0,5436	1,1413	71	0,555	1,1863
10	0,4952	0,9497	41	0,5442	1,1436	72	0,5552	1,1873
11	0,4996	0,9676	42	0,5448	1,1458	73	0,5555	1,1881
12	0,5035	0,9833	43	0,5453	1,148	74	0,5557	1,189
13	0,507	0,9972	44	0,5458	1,1499	75	0,5559	1,1898
14	0,51	1,0095	45	0,5463	1,1519	76	0,5561	1,1906
15	0,5128	1,0205	46	0,5486	1,1538	77	0,5563	1,1915
16	0,5157	1,0316	47	0,5473	1,1557	78	0,5565	1,1923
17	0,5181	1,0411	48	0,5477	1,1574	79	0,5567	1,193
18	0,5202	1,0493	49	0,5481	1,159	80	0,5569	1,1938
19	0,522	1,0566	50	0,5485	1,1607	81	0,557	1,1945
20	0,5235	1,0628	51	0,5489	1,1623	82	0,5572	1,1953
21	0,5252	1,0696	52	0,5493	1,1638	83	0,5574	1,1959
22	0,5268	1,0754	53	0,5497	1,1658	84	0,5576	1,1967
23	0,5283	1,0811	54	0,5501	1,1667	85	0,5578	1,1973
24	0,5296	1,0864	55	0,5504	1,1681	86	0,558	1,198
25	0,5309	1,0915	56	0,5508	1,1696	87	0,5581	1,1987
26	0,532	1,0961	57	0,5511	1,1708	88	0,5583	1,1994
27	0,5332	1,1004	58	0,5515	1,1721	89	0,5585	1,2001
28	0,5343	1,1047	59	0,5518	1,1734	90	0,5586	1,2007
29	0,5353	1,1086	60	0,5521	1,1747	91	0,5587	1,2013
30	0,5362	1,1124	61	0,5524	1,1759	92	0,5589	1,202
31	0,5371	1,1159	62	0,5527	1,177	93	0,5591	1,2026
32	0,538	1,1193	63	0,553	1,1782	94	0,5592	1,2032
33	0,5388	1,1226	64	0,5533	1,1793	95	0,5593	1,2038
34	0,5396	1,1255	65	0,5535	1,1803	96	0,5595	1,2044
35	0,5402	1,1285	66	0,5538	1,1814	97	0,5595	1,2049
36	0,541	1,1313	67	0,554	1,1824	98	0,5598	1,2055
37	0,5418	1,1339	68	0,5543	1,1834	99	0,5559	1,206
38	0,5424	1,1363	69	0,5545	1,1844	100	0,56	1,2065

Table of Planned Rainfall Value with Return Period (Tr) based on Gumbel Probability Distribution

No.	Period e Repeat (Tr)	$\bar{X}$	S_d	S_n	Y_n	Y_n	X_t
1	5	130,23	73.99	0.9497	0.4952	1.4999	208,51
2	10	130,23	73,99	0,9497	0,4952	2,2504	266,98
3	25	130,23	73,99	0,9497	0,4952	3,1985	340,86
4	50	130,23	73,99	0,9497	0,4952	3,9019	395,66
5	100	130,23	73,99	0,9497	0,4952	4,6001	450.06

- Frequency Distribution of Log Person Type III

Pearson Type III Log Probability Distribution Calculation Table

No	Year	Xi Rainfall (mm) (sorted)	Log Xi	$(\text{Log Xi} - \overline{\text{LogX}})^2$	$(\text{Log Xi} - \overline{\text{LogX}})^3$
1	2013	71.8	1.8561	0.0437	-0.0091
2	2019	78.2	1.8932	0.0296	-0.0051
3	2020	81.5	1.9112	0.0237	-0.0037
4	2016	84	1,9243	0,0198	-0,0028
5	2012	94,8	1,9768	0,0078	-0,0007
6	2017	96,9	1,9863	0,0062	-0,0005
7	2014	126,7	2,1028	0,0014	0,0001
8	2015	192,5	2,2844	0,0481	0,0105
9	2018	170,2	2.2310	0.0275	0.0046
10	2021	305,7	2.4853	0.1765	0.0742
Σ			**20.6514**	**0.3843**	**0.0675**
Average			**2.0651**		

Calculation of the average value

$$\overline{LogX} = \frac{\sum_{i=1}^{n} \text{LogX}}{n} = \frac{20,6514}{10} = 2,0651 \text{ mm}$$

No	Return Period (Tr)	LogX	Standard Deviation (Sd)	Cs	G	xt(mm)
1	5	2.0651	0.21	1.06	0.7499	166.00
2	10	2.0651	0.21	1.06	1.3406	219.88
3	25	2.0651	0.21	1.06	2.0086	302,14
4	50	2.0651	0.21	1.06	2.4356	370,22
5	100	2.0651	0.21	1.06	2.7979	439.88

Calculation of Standard Deviation (S_d)

$$S_d = \sqrt{\frac{\sum_{i=1}^{n}(\text{LogXi} - \overline{\text{LogXi}})^2}{n-1}} = \sqrt{\frac{0,3843}{10-1}} = \sqrt{\frac{0,3843}{9}} = 0,21$$

Calculating the scatter coefficient (C_s)

$$C_s = \frac{n\sum_{i=1}^{n}(\text{LogXi} - \overline{\text{LogXi}})^3}{(n-1)(n-2)S^3} = \frac{10 \times 0,0675}{(10-1)(10-2)0,21^3} = 1,06$$

Finding the value of G (factor of the log person type III distribution)

To find the return period G value of 5, 10, 25, 50 and 100 years, mathematically it is formulated as follows:

$$G = Y_1 + \frac{(X_n - X_1)}{(X_2 - X_1)} \times (Y_2 - Y_1)$$
$$= 0,745 + \frac{(1,06 - 1,1)}{(1 - 1,1)} \times (0,758 - 0,745)$$
$$= 0,7499$$

Table of Characteristic Factors of Pearson Log Type III Distribution for Positive Cs

Skew Coef. (Cs)	1,0101	1,053	1,1111	1,25	2	5	10	25	50	100	200
	99	95	90	80	Percent Change			4	2	1	0,5
					50	20	10				
3.0	-0,667	-0,665	-0,66	-0,636	-0,396	0,42	1,18	2,278	3,152	4,061	4,97
2.9	-0,69	-0,688	-0,681	-0,651	-0,39	0,44	1,196	2,277	3,134	4,013	4,909
2.8	-0,714	-0,711	-0,702	-0,666	-0,384	0,46	1,21	2,275	3,114	3,973	4,847
2.7	-0,74	-0,736	-0,724	-0,681	-0,376	0,479	1,224	2,272	3,097	3,932	4,783
2.6	-0,769	-0,762	-0,747	-0,695	-0,368	0,499	1,238	2,267	3,071	3,889	4,718
2.5	-0,799	-0,79	-0,771	-0,711	-0,36	0,518	1,25	2,262	3,048	3,845	4,652
2.4	-0,832	-0,819	-0,795	-0,725	-0,351	0,537	1,262	2,256	3,029	3,8	4,584
2.3	-0,867	-0,85	-0,819	-0,739	-0,341	0,555	1,274	2,248	2,997	3,753	4,515
2.2	-0,905	-0,882	-0,844	-0,752	-0,33	0,574	1,284	2,24	2,97	3,705	4,454
2.1	-0,946	-0,914	-0,869	-0,765	-0,319	0,592	1,294	2,23	2,942	3,656	4,372
2.0	-0,99	-0,949	-0,896	-0,777	-0,307	0,609	1,302	2,219	2,912	3,605	4,298
1.9	-1,037	-0,984	-0,92	-0,788	-0,294	0,627	1,31	2,207	2,881	3,553	4,223
1.8	-1,087	-1,02	-0,945	-0,799	-0,282	0,643	1,318	2,193	2,848	3,499	4,147
1.7	-1,14	-1,056	-0,97	-0,808	-0,268	0,66	1,324	2,179	2,815	3,444	4,069
1.6	-1,197	-1,093	-0,994	-0,817	-0,254	0,675	1,329	2,163	2,78	3,388	3,99
1.5	-1,256	-1,131	-1,018	-0,825	-0,24	0,69	1,333	2,146	2,745	3,33	3,91
1.4	-1,318	-1,163	-1,041	-0,832	-0,225	0,705	1,337	2,128	2,706	3,271	3,828
1.3	-1,388	-1,206	-1,064	-0,838	-0,21	0,719	1,339	2,108	2,666	3,211	3,745
1.2	-1,449	-1,243	-1,086	-0,844	-0,195	0,732	1,34	2,087	2,626	3,149	3,661
1,1	-1,518	-1,28	-1,107	-0,848	-0,18	0,745	1,341	2,066	2,585	3,087	3,575
1,0	-1,588	-1,317	-1,128	-0,852	-0,164	0,758	1,34	2,043	2,542	3,022	3,489
0.9	-1,66	-1,353	-1,147	-0,854	-0,148	0,769	1,339	2,018	2,498	2,967	3,401
0.8	-1,733	-1,388	-1,166	-0,856	-0,132	0,78	1,336	1,993	2,453	2,891	3,312
0.7	-1,806	-1,423	-1,183	-0,857	-0,116	0,79	1,333	1,967	2,407	2,824	3,223
0.6	-1,88	-1,458	-1,2	-0,857	-0,099	0,8	1,328	1,939	2,359	2,755	3,123
0.5	-1,965	-1,491	-1,216	-0,856	-0,083	0,808	1,323	1,91	2,311	2,686	3,041
0.4	-2,029	-1,524	-1,231	-0,855	-0,066	0,816	1,317	1,88	2,261	2,615	2,949
0.3	-2,104	-1,555	-1,245	-0,853	-0,05	0,824	1,309	1,849	2,211	2,544	2,856
0.2	-2,175	-1,586	-1,258	-0,85	-0,033	0,83	1,301	1,818	2,159	2,472	2,763
0.1	-2,225	-1,616	-1,27	-0,846	-0,017	0,836	1,292	1,785	2,107	2,4	2,67
0	-2,326	-1,645	-1,282	-0,842	0	0,842	1,282	1,751	2,064	2,064	2,576

Calculating design rainfall (X_t) or discharge with return period (T_r)

Mathematically the formula for calculating design rain (Xt) based on the frequency distribution of type III log person is:

$$X_t = 10^{\overline{LogXi} + G \times Sd}$$
$$= 10^{2,0651 + 0,7499 \times 0,21}$$
$$= 166 \text{ mm}$$

- Normal Log Distribution

Table of Calculation of Normal Log distribution

No	Year	Xi Rainfall (mm)	Log Xi	$(\text{Log Xi} - \overline{\text{LogX}})^2$
1	2012	84	1,9243	0,0198
2	2013	192,5	2,2844	0,0481
3	2014	96,9	1,9863	0,0062
4	2015	126,7	2,1028	0,0014
5	2016	81,5	1,9112	0,0237
6	2017	94,8	1,9768	0,0078
7	2018	170.2	2.2310	0.0275
8	2019	71.8	1.8561	0.0437
9	2020	78.2	1.8932	0.0296
10	2021	305,7	2.4853	0.1765
Σ			20,651 4	0.3843
Average			2.0651	

i. Calculation of the average value

$$\overline{LogX} = \frac{\sum_{i=1}^{n} \text{LogX}}{n} = \frac{20,6514}{10} = 2,0651 \text{ mm}$$

Zenobius Ara, Lily Montarcih Limantara, and Widandi Soetopo, "Study of Water Use Optimization with a Linear Program at Raknamo Dam, East Nusa Tenggara Province," *International Research Journal of Advanced Engineering and Science*, Volume 8, Issue 1, pp. 122-132, 2023.

Table of Planned Rainfall Calculation based on Log Normal Distribution

No	Periodically Ulang (T_r)	("LogXi" $\overline{)}$	Standard Deviasi (S_d)	C_s	etc _	x_t (mm)
1	5	2.0651	0.21	0	0.842	173.39
2	10	2.0651	0.21	0	1,282	213.78
3	25	2.0651	0.21	0	1,751	267,23
4	50	2.0651	0.21	0	2,056	309.08
5	100	2.0651	0.21	0	2,261	340.62

ii. Calculation of Standard Deviation (Sd)

$$S_d = \sqrt{\frac{\sum_{i=1}^{n}(\text{LogXi} - \overline{\text{LogXi}})^2}{n-1}}$$
$$= \sqrt{\frac{0,3843}{10-1}}$$
$$= \sqrt{\frac{0.3843}{9}}$$
$$= 0,21$$

iii. The sloping coefficient (Cs) for the Log Normal Distribution is 0

iv. Look for the value of K_t through the value Cs = 0

Skew Coef (Cs)	1,0101	1,053	1,1111	1,2500	2	5	10	25	50	100	200
	99	95	90	80	Percent Change			4	2	1	0,5
					50	20	10				
0,1	-2,225	-1,616	-1,27	-0,846	-0,017	0,836	1,292	1,785	2,107	2,4	2,67
0	-2,326	-1,645	-1,282	-0,842	0	0,842	1,282	1,751	2,064	2,064	2,576
0	-2,336	-1,645	-1,282	-0,824	0	0,842	1,282	1,75	2,054	2,326	2,576
-0,1	-2,4	-1,673	-1,292	-0,836	0,017	0,846	1,27	1,716	2	2,252	2,482

v. Calculating design rainfall (Xt) or discharge with return period (Tr)

- Test the Probability Distribution of Planned Rainfall

Kolmogorof's Smirnov test

✓ Gumbel Probability Distribution Test Smirnov Kolmogorof Method

NO	Xi	P (Xi)	F(t)	Yt	T	P' (Xi)	P (Xi) - P' (Xi)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
1	305,7	0,091	2,371	2,747	16,106	0,062	0,029
2	192,5	0,182	0,842	1,294	4,172	0,240	-0,058
3	170,2	0,273	0,540	1,008	3,271	0,306	-0,033
4	126,7	0,364	-0,048	0,450	2,121	0,471	-0,108
5	96,9	0,455	-0,450	0,067	1,647	0,607	-0,153
6	94,8	0,545	-0,479	0,040	1,620	0,617	-0,072
7	84,0	0,636	-0,625	-0,098	1,497	0,668	-0,032
8	81,5	0,727	-0,659	-0,130	1,471	0,680	0,047
9	78,2	0,818	-0,703	-0,173	1,438	0,695	0,123
10	71,8	0,909	-0,790	-0,255	1,380	0,725	0,184
Σ	1302,3					ΔP_{Max}	0,184
n	10						
$\overline{Xi}$	130,2						

1) Column [1] data serial number
2) Column [2] the annual maximum daily rainfall data are arranged from the largest to the smallest
3) Column [3] Calculating the probability of each data with the Weilbull formula (Sri Harto, 1993: 179):

$$P = \frac{m}{n+1} \text{ x } 100\%$$
$$P = \frac{1}{10+1} \text{ x } 100\%$$
$$P = 0,09$$

4) Column [4] Find the value of F(t) with the formula:

$$F(t) = \frac{Xi - \overline{Xi}}{Sd}$$
$$F(t) = \frac{305,7 - 130,2}{74,54}$$
$$F(t) = 2,371$$

5) Column [5] Find the Yt value using the formula

$$Yt = (F(t) \text{ x } Sn) + Yn$$
$$Yt = (2.371 \text{ x } 0.9497) + 0.4952$$
$$Yt = 2,747$$

6) Column [6] looks for the value of T with the following formula function:

$$T = \frac{-\left[\text{Exp}\left(\text{Exp}(Y_t)\right)^{-1}\right]}{1-\left[\exp\left(\exp(Y_t)^{-1}\right)\right]}$$
$$T = \frac{-\left[\text{Exp}\left(\text{Exp}(2,747)\right)^{-1}\right]}{1-\left[\exp\left(\exp(2,747)^{-1}\right)\right]}$$
$$T = 16,106$$

7) Column [7] looks for the value of P'(Xi) with the formula"

$$P'(Xi) = \frac{1}{T}$$
$$P'(Xi) = \frac{1}{16,106}$$
$$P'(Xi) = 0,062$$

8) Column [8] finds the value of Δ P with the formula:

$$\Delta P = P\,(Xi) - P'\,(Xi)$$
$$\Delta P = 0,091 - 0,062$$
$$\Delta P = 0,029$$

obtained ΔPmax value = 0.184. Because the amount of data (n) = 10 and the degree of sloping (α) = 5%, from table 2.4 the value of ΔPcritical = 0.409.

Because ΔPmax < ΔPcritical
0.184 < 0.409

Then the analysis of rain data with the gumbel probability distribution is acceptable.

✓ Frequency Distribution Test of Type III Log Person Smirnov Kolmogorof Method

NO	Xi	Log Xi	P (Xi)	G	Pr	P' (Xi)	P (Xi) - P'(Xi)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
1	305,7	2,485	0,09	2,0332	4,094	0,041	0,050
2	192,5	2,284	0,18	1,0612	14,731	0,147	0,035
3	170,2	2,231	0,27	0,8024	18,295	0,183	0,090
4	126,7	2,103	0,36	0,1821	38,437	0,384	-0,021
5	96,9	1,986	0,45	-0,3814	56,735	0,567	-0,113
6	94,8	1,977	0,55	-0,4274	61,256	0,613	-0,067
7	84,0	1,924	0,64	-0,6816	72,544	0,725	-0,089
8	81,5	1,911	0,73	-0,7451	75,364	0,754	-0,026
9	78,2	1,893	0,82	-0,8320	79,221	0,792	0,026
10	71,8	1,856	0,91	-1,0114	90,487	0,905	0,004
Σ		20,651				DP_{max}	0,090
n		10					
$\overline{\text{Log Xi}}$		2,065					

1) Column [1] data serial number
2) Column [2] the annual maximum daily rainfall data are arranged from the largest to the smallest
3) Column [3] looks for the log value of the average rainfall (Xi)

$$\text{Log(Xi)} = \text{Log}(305,7)$$
$$= 2.485$$

Zenobius Ara, Lily Montarcih Limantara, and Widandi Soetopo, "Study of Water Use Optimization with a Linear Program at Raknamo Dam, East Nusa Tenggara Province," *International Research Journal of Advanced Engineering and Science*, Volume 8, Issue 1, pp. 122-132, 2023.

4) Calculate the empirical probability by entering the data serial number from the smallest data to the largest data with the equation:

$$P = \frac{m}{n+1} \times 100\%$$
$$P = \frac{1}{10+1} \times 100\%$$
$$P = 0{,}09$$

5) Column [5] looks for the value of G with the equation

$$G = \frac{\text{Log(Xi)} - \overline{\text{Log(Xi)}}}{\text{Sd}}$$
$$G = \frac{2{,}485 - 2{,}065}{0{,}21}$$
$$G = 2{,}0332$$

6) Column [6] looks for the value of Pr through the Pearson Type III Distribution table, with a sloping coefficient value (Cs) = 1.06, then based on table (Table of Pearson Type III Log Pearson Characteristics Factors for Positive Cs), by interpolation we get The characteristic factor value of the Pearson log distribution type III is in the table below.

Y(Year)	1,0101	1,0526	1,1111	1,25	2	5	10	25	50	100	200
Cs P(%)	99	95	90	80	50	20	10	4	2	1	0,5
1,1	-1,518	-1,28	-1,107	-0,848	-0,18	0,745	1,341	2,066	2,585	3,087	3,575
1,06	-1,544	-1,294	-1,115	-0,850	-0,174	0,750	1,341	2,057	2,569	3,062	3,543
1	-1,588	-1,317	-1,128	-0,852	-0,164	0,758	1,34	2,043	2,542	3,022	3,489

Based on the G and Cs values, the Pr value in column 6 (Table) can be determined by the interpolation formula, namely:

$$Pr = Y1 + \frac{(Xn - X1)}{(X2 - X1)} \times (Y2 - Y1)$$
$$Pr = 2 + \frac{(2{,}0332 - 2{,}569)}{(2{,}057 - 2{,}569)} \times (4 - 2)$$
$$Pr = 4{,}094$$

7) Column [7] finds the value of P'(Xi) with the formula:

$$P'(Xi) = \frac{Pr}{100}$$
$$P'(Xi) = \frac{4{,}094}{100}$$
$$P'(Xi) = 0{,}041$$

8) Column [8] finds the value of ΔP with the formula:

$$\Delta P = P(Xi) - P'(Xi)$$
$$\Delta P = 0.091 - 0.041$$
$$\Delta P = 0.05$$

From table, the value of ΔP_{max} = 0.09 is obtained. Because the amount of data (n) = 10 and the degree of sloping (α) = 5%, then from table the $_{critical\ \Delta P\ value}$ = 0.409.

Because $\Delta P_{max} < \Delta P$ is $_{critical}$

$$0.097 < 0.409$$

Then the analysis of rain data with the gumbel probability distribution is acceptable.

✓ Test the Normal Log Distribution of the Smirnov Kolmogorof Method

NO	Xi	Log Xi	P(xi)	f(t)	Area under the Normal Curve	P'(xi)	P (Xi) - P'(Xi)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
1	305,7	2,485	0,091	2,033	0,9767	0,023	0,068
2	192,5	2,284	0,182	1,061	0,8688	0,131	0,051
3	170,2	2,231	0,273	0,802	0,8441	0,156	0,117
4	126,7	2,103	0,364	0,182	0,5666	0,433	-0,070
5	96,9	1,986	0,455	-0,381	0,3304	0,670	-0,215
6	95	1,977	0,545	-0,427	0,3163	0,684	-0,138
7	84,0	1,924	0,636	-0,682	0,2273	0,773	-0.136
8	81.5	1,911	0.727	-0.745	0.2093	0.791	-0.063
9	78.2	1,893	0.818	-0.832	0.1854	0.815	0.004
10	71.8	1,856	0.909	-1.011	0.1055	0.894	0.015
Σ	20, 651					DP max	0, 117
n	10						
$\overline{\text{Log Xi}}$	2.0 6 5						

1) Column [1] data serial number
2) Column [2] the annual maximum daily rainfall data are arranged from the largest to the smallest
3) Column [3] looks for the log value of the average rainfall (Xi)

Log(Xi) = Log(305,7)
= 2.485

4) Calculate the empirical probability by entering the data serial number from the smallest data to the largest data with the equation:

$$P = \frac{m}{n+1} \times 100\%$$
$$P = \frac{1}{10+1} \times 100\%$$
$$P = 0{,}09$$

5) Column [5] looks for the value of f(t) with the equation:

$$f(t) = \frac{\text{Log(Xi)} - \overline{\text{Log(Xi)}}}{\text{Sd}}$$
$$f(t) = \frac{2{,}485 - 2{,}065}{0{,}21}$$
$$f(t) = 2{,}033$$

6) Column [6] uses the f(t) value to find the area under the normal curve using the interpolation method based on table below.

Table of Area under the Smirnov Kolmogorov Test Normal Curve for a=0.05:

t	a=0.05	t	a=0,05	t	a=0,05	t	a=0,05
-3,4	0,0003	-1,4	0,0735	0,5	0,7088	2,5	0,9946
-3,3	0,0004	-1,3	0,0885	0,6	0,7422	2,6	0,996
-3,2	0,0006	-1,2	0,1056	0,7	0,7734	2,7	0,997
-3,1	0,0008	-1,1	0,1251	0,8	0,8023	2,8	0,9978
-3	0,0011	-1	0,1469	0,9	0,8289	2,9	0,9984
-2,9	0,0016	-0,9	0,1711	1	0,8591	3	0,9989
-2,8	0,0022	-0,8	0,1977	1,1	0,8749	3,1	0,9992
-2,7	0,003	-0,7	0,2266	1,2	0,8944	3,2	0,9994
-2,6	0,004	-0,6	0,2578	1,3	0,9115	3,3	0,9996
-2,5	0,0054	-0,5	0,2912	1,4	0,9265	3,4	0,9997
-2,4	0,0071	-0,4	0,3264	1,5	0,9394		
-2,3	0,0094	-0,3	0,3632	1,6	0.9505		
-2,2	0.0122	-0,2	0.4013	1,7	0.959		
-2,1	0.0158	-0.1	0.4404	1,8	0.9678		
-1,4	0.0735	0.5	0.7088	2,5	0.9946		

7) Column [7] finds the value of P'(Xi) with the formula:

P'(Xi) = 1 - Area under the Normal Curve
P'(Xi) = 1 – 0.9767
P'(Xi) = 0.023

8) Column [8] finds the value of Δ P with the formula:

$$\Delta P = P(Xi) - P'(Xi)$$
$$\Delta P = 0.091 - 0.023$$
$$\Delta P = 0.068$$

From table, the value of ΔPmax = 0.117 is obtained. Because the amount of data (n) = 10 and the degree of sloping (α) = 5%, from table 2.4 the value of ΔPcritical = 0.409.

Because $\Delta P_{max} < \Delta P$ is $_{critical}$

$$0.117 < 0.409$$

Then the analysis of rain data with the gumbel probability distribution is acceptable.

Chi Square Test (X2)

1) Rain data is sorted from the largest data to the smallest data or vice versa.

NO	Xi
[1]	[2]
1	305,7
2	192.5
3	170.2
4	126.7
5	96.9
6	94.8
7	84.0
8	81.5
9	78.2
10	71.8

2) Group k classes, each class has at least 4 observational data. With n = 10, then:

$$k = 1 + 3.22 \log n$$
$$k = 1 + 3.22 \log 10$$
$$k = 4.22$$
$$k = 4$$

3) Calculating the class limit with the probability distribution.

$$\frac{100\%}{k} = \frac{100\%}{4} = 25\%$$

Then the distribution intervals are 25%, 50% and 75%

2. *Effective Rainfall*

Stages:

1. Daily rainfall data is arranged from smallest to largest
2. The mainstay of rainfall is searched with a failure ratio of 20% and a probability of 80% is searched for in order using the formula, namely:

$$R_{80} = \frac{n}{5} + 1$$
$$= \frac{10}{5} + 1$$
$$= 3$$

So, the mainstay rainfall is in the 3rd order of the data. Below is a summary table of the 3rd order reliable rainfall.

The mainstay rainfall probability table

No.	Year	Month	Total CH
1	2012	January	280
2	2019	February	181.3
3	2019	March	197.8
4	2018	April	27
5	2018	May	1,6
6	2017	June	0
7	2021	July	0.3
8	2014	August	0
9	2015	September	0
10	2012	October	2
11	2020	November	61.9
12	2017	December	205,8

1) Calculation of effective rainfall (Re) of rice plants for January.

With a reliable rainfall of R80 = 80 mm and an observation period of 15 days

2) Calculation of effective rainfall (Re) of crops for January

With a reliable rainfall of R80 = 80 mm and an observation period of 15 days

3. *Mainstay Debt*

The calculation of the mainstay debit is carried out using the Basic Year method, which is taking one debit pattern from a certain year. The probability of its occurrence is calculated by the Weibull equation (Subarkah, 1980: 111):

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

With:

P = Probability (%)

M = serial number of debit data

n = amount of discharge data.

The data to be used in calculating the mainstay discharge according to FJ Mock are:

1) Rainfall data
2) Evapotranspiration
3) Water balance (water balance)
4) Climatological data
5) Rain Catch Data (Catchment Area)

4. *Irrigation Water Needs*

The need for irrigation water is the need for water for plants plus the loss of water in transit. So the water requirement for irrigation is greater than the water requirement for plants. The amount of water needed for plant growth is influenced by the amount of effective rain (Re), replacement of stagnant water (W), soil percolation (P) and evapotranspiration (ETo).

The following is the calculation of water requirements for rice plants, namely:

1) Evapotranspiration (ETo)

The evapotranspiration value used is based on an analysis of the evapotranspiration value

2) Open evaporation (Eo)

Eo = 1.1 x ETo

With:

Eo = open evaporation (mm/day)

Eto = evapotranspiration (mm/day)

Then Eo for January is:

Eo = 1.1 x ETo

Eo = 1.1 x 3.828

Eo = 4.21 mm/day

3) Percolation (P)

The P value is seen based on the slope of the land

4) Water loss due to evaporation and percolation (M)

M = Eo + P

With:

M = water loss due to evaporation and percolation (mm/day)

Eo = open evaporation (mm/day)

P = percolation (mm/day)

So:

M = Eo + P

M = 4.21 + 1
M = 5.21

5) Effective rain (Re)
The Re value is taken based on the daily effective rain value.

6) Rainfall of crops (Re padi)
Repadi = Re x FH
With:
Repadi = effective rainfall of rice plants (mm/day)
Re = effective rainfall (mm/day)
FH = rain factor
So:
Repadi = Re x FH
Repadi = 6.53 x 0.18
= 1.18 mm/day

7) Plant evapotranspiration (Etc)
Etc = Eto x Kt
With:
Etc = plant evapotranspiration (mm/day)
Eto = reference evapotranspiration (mm/day)
Kt = crop coefficient
So:
Etc = 3.83 x 1.2
= 4.59 mm/day

8) Land processing (Lp)
The Lp value is taken based on the results of the interpolation of the irrigation water requirements during preparation.

9) The need for replacing stagnant water (W)
The need to replace stagnant water = Etc1 – Re3 + P + W
With:
Etc1 = 1st plant evapotranspiration (mm/day)
Re3 = 3rd effective rainfall (mm/day)
P = percolation
W = replacement (mm/day)
So:
Substitute for standing water = 4.59 – 3.59 + 1 + 3.33
= 5.33 mm/day

5. *Water Balance*

The water balance is obtained by comparing the availability of water and the demand for water. If there is a surplus, it means that the need for water is less than the availability of water, and vice versa, if there is a deficit, it means that the need for water is greater than the availability of water. If there is a shortage of debits, then there are four options to consider as follows:
1) The area of the irrigation area is adjusted or reduced
2) The area of the irrigation area remains the same but there is additional discharge from weirs or other reservoirs.
3) Make modifications to the planting pattern.

6. *Optimization Models*

- *Harvest Productivity*

The results of the calculation of the yield productivity are in the form of net income for each plant which will be used as the objective function in the calculation of the profits to be obtained.

No.	Plant Type	Net income (/ha)	Land area (Ha)	Total income (Rp.)
1	Paddy MT 1	25,000,000	752,257	18,806,425,000
2	Corn MT 1	17,500,000	570,742	9,987,985,000
3	Paddy MT 2	25,000,000	350,065	8,751,625,000
4	Corn MT 2	17,500,000	972,934	17,026,345,000
5	Paddy MT 3	25,000,000	350,065	8,751,625,000
6	Corn MT 3	17,500,000	972,934	17,026,345,000
Amount				80,350,350,000

Total existing farm income = planted area x net rice income / ha. The productivity of farming results in the existing condition of the Raknamo irrigation area is 5 tons/ha (rice), 5 tons/ha (corn), with the price of grain in the area of rice Rp. 5000/kg and corn Rp. 3500/kg.

So:
MT I net income = (5 x 1,000 x IDR 5,000) + (5 x 1,000 x 3,500)
= IDR 25,000,000/ha paddy + IDR 17,500,000/ha corn
= IDR 42,500,000/ha
So the net income based on MT I planting area is:
= (Rp. 25,000,000 x 752,257) + (Rp. 17,500,000 x 570,742)
= Rp. 18,806,425,000 + Rp. 9,987,985,000
= Rp. 28,794,410,000
MT II net income = (5 x 1,000 x IDR 5,000) + (5 x 1,000 x 3,500)
= IDR 25,000,000/ha paddy + IDR 17,500,000/ha corn
= IDR 42,500,000/ha
So the net income based on MT II planting area is:
= (Rp. 25,000,000 x 350,065) + (Rp. 17,500,000 x 972,934)
= Rp. 8,751,625,000 + Rp. 17,026,345,000
= Rp. 25,777,970,000
MT III net income = (5 x 1,000 x IDR 5,000) + (5 x 1,000 x 3,500)
= IDR 25,000,000/ha paddy + IDR 17,500,000/ha corn
= IDR 42,500,000/ha
So the net income based on MT III planting area is:
= (Rp. 25,000,000 x 350,065) + (Rp. 17,500,000 x 972,934)
= Rp. 8,751,625,000 + Rp. 17,026,345,000
= Rp. 25,777,970,000
Total income = Rp. 80,350,350,000 (before optimization)

- *Optimizing Yields With Linear Programming*

To obtain effective results, with the aim of approaching the existing conditions in the field, this analysis is carried out by taking the limits according to the calculations that have been done before. The restrictions that will be used are as follows:
1) The availability of water is limited according to the calculation of the volume of water availability in the Raknamo Dam.
2) The need for water for irrigation should not be greater than the availability of water that is relied on at the Raknamo Dam with a value of 1,202.54 m3/planting season.

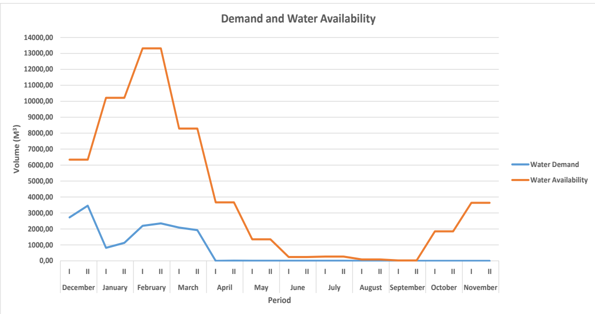
7. Dam Operations

In this study, optimizing the service of downstream water needs requires a guideline for dam operations. Which means optimization maximizes release for downstream needs in accordance with the conditions of the reservoir. If the reservoir storage decreases, the percentage of release as needed will also decrease and vice versa.

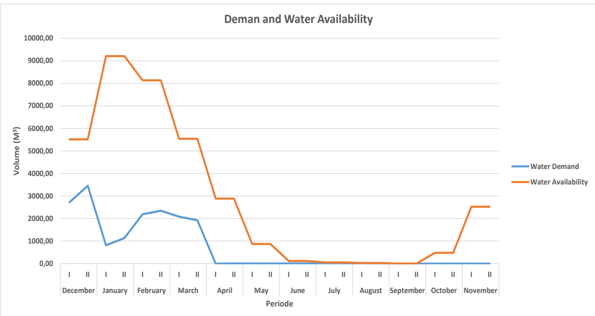
No.	Dam storage limit (%)	Release from Storage (%)
1	0 - 10	10
2	10-20	20
3	20-30	30
4	30 - 40	40
5	40-50	50
6	50 - 60	60
7	60 - 70	70
8	70 - 80	80
9	80 - 90	90
10	90 - 100	100

Based on the release limit table above, the total failure and success of the reservoir/period is obtained:

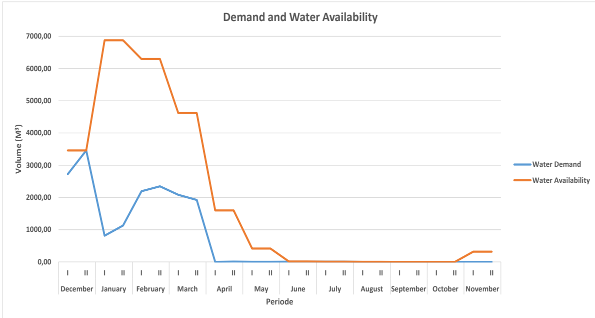
No.	Flagship debit (20%)	Flagship debit (40%)	Flagship debit (60%)	Flagship debit (80%)	Flagship debit (100%)	Information
1	15	15	15	15	15	Success
2	9	9	9	9	9	Fail
3	6 3 %	63 %	63 %	63 %	63 %	Obstacle Level



Graph of reservoir water fluctuations in wet years



Graph of reservoir water fluctuations in normal years



Graph of reservoir water fluctuations in dry years

V. CONCLUSION

1. The water debit for filling the Raknamo Dam reservoir and the water demand debit that will be needed to meet the irrigation water needs for agricultural land in each period can be seen in the table below.

No	Month	Period	Volume	
			Water Needs	Mainstay Debt
			(Outflow)	(Inflow)
			m³	m³
one	December	I	2722.78	6342.59
		II	3456.93	6342.59
2	January	I	814.33	10215.56
		II	1130.29	10215.56
3	February	I	2191.76	13313.84
		II	2344.97	13313.84
4	Maret	I	2083.16	8291.53
		II	1922,19	8291,53
5	April	I	0.00	3662,53
		II	8.44	3662,53
6	May	I	3,12	1347,44
		II	3.69	1347,44
7	June	I	6,23	241,77
		II	6.81	241,77
8	July	I	6.68	266,22
		II	6,22	266,22
9	Agustus	I	0,00	86,08
		II	0,00	86,08
10	September	I	0,00	24,80
		II	0,00	24,80
11	Oktober	I	0,00	1848,99
		II	0,00	1848,99
12	November	I	0,00	3637,55
		II	0,00	3637.55

2. Based on the large volume of available water and water demand, with the optimization results it is known that the maximum area of land that must be planted. From the optimization results, the most optimal cropping pattern was obtained, namely the rice-plants cropping pattern in the first planting season in December I-March II with a rice planting area of 556.4 ha and a palawija planting area of 535.71 ha, a grain-planting pattern in the planting II in April I – July II with a palawija planting area of 2.94 ha, in August I – November II no paddy or secondary crops were planted. Profits based on optimization results are Rp. 23,336,445,000.

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