Jurnal Teknik Sipil: Vol 23, No. 1, February 2024, 825-838
Department of Civil Engineering, University of Tanjungpura.
ISSN: 1412-3576 (Print), 2621-8429 (Online), Indonesia

Constructions of UNTAN
Jurnal Teknik Sipil
Journal homepage: https://jurnal.untan.ac.id/index.php/jtsuntan

Evaluation of Ngabean Secondary Canal Irrigation Network, Ngawi District Part of Saluran Induk Madiun Irrigation Area

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ABSTRACT

The SIM Irrigation Area has an area of 10,860 Ha and a primary canal length of 27,022 m, which passes through the Regencies of Madiun, Magetan, Ngawi, and Madiun City. One of the secondary canals in the D.I SIM is the Ngabean Secondary Canal, located in Ngawi Regency. This canal receives the main water supply from Jati Dam, 25% of the primary dam discharge and water withdrawal from the Ngabean Dam intake of 0.45 m3/ha. However, this value only meets the water needs of some of the irrigation areas. Due to the limited supply from the Jati Bendung, the government is working on rehabilitation work at the Jati Bendung. Apart from that, the Ngabean Secondary Canal also experienced a reduction in the irrigation area from 1840 ha to 1818 ha, to be precise in the NG3 Ki tertiary plot, which had an initial area of 120 ha to 98 ha. Therefore, an evaluation of the Ngabean Secondary Canal is needed to determine the value of water demand, water availability before and after rehabilitation and land reduction, and increasing agricultural profits.

From the results of the analysis that has been carried out, it was concluded that the highest dependent flow at Ngabean Dam was 5.00 m3/s, and the lowest was 0.01 m3/s. Meanwhile, in conditions before rehabilitation, the highest dependent flow of Jati Dam was 1.01 m3/s, and the lowest was 0.00 m3/s with water withdrawal at the intake of 25%, able to fulfill the planting pattern of paddy (15%)-crops (75%)-crops (50%) generated a production profit of IDR 8.794.123.880,00. Meanwhile, after rehabilitation, the highest was 5.93 m3/s, and the lowest was 3.21 m3/s with an intake of 32%, able to fulfill the planting pattern of paddy (100%)-paddy (100%)-paddy (100%), resulting in a production profit of IDR 83, 564,115,480.00 with the highest irrigation water requirement value of 3.10 m3/sec. Apart from that, the existing canal dimensions still meet the requirements after land reduction, so no changes to the canal dimensions are required.

ARTICLE INFO

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Citation:

Nusantara, Danayanti Azmi Dewi; Hartiningsih, Poppy Fajar Putri. (2024). **Evaluation of Ngabean Secondary Canal Irrigation Network, Ngawi District Part of Saluran Induk Madiun Irrigation Area.** Jurnal Teknik Sipil (JTS) Vol. 24, 1. p.825-838. https://doi.org/10.26418/jts.v24i1.75862

Submitted: 26 Januar 2024
Accepted: 22 April 2024
Revised: 10 April 2024
Published: 22 April 2024

Publisher's Note: JTS stays neutral about jurisdictional claims in published maps and institutional affiliations

1. Introduction

Rapid population growth can cause problems, one of which is the increasing need for food, which requires an effort to increase agricultural yields further. Therefore, irrigation networks and good irrigation buildings are needed. (Astutik & Suhardi, 2021)

Ngabean Secondary Canal, Ngawi Regency, receives the main water supply from Jati Dam at 25% of the dam's mainstay discharge. However, this value does not cover the water needs of the entire irrigation area. From the topographic measurements and inventory results that have been carried out, it is known that some of the areas of tertiary plots and supporting buildings have changed. Ngabean Secondary Canal, with an irrigation area of 1840 ha, and the raw paddy field area became 1818 ha. This is due to the area's development, so some rice fields have changed functions for residential and educational areas. (PUPR SDA, 2019)

Similar research has been conducted in the same irrigation area with different research locations. Previous research focused on fulfilling irrigation water needs and agricultural profits but did not calculate the dimensions of irrigation canals (Nusantara & Fawati, 2023). Based on the problems mentioned, it is necessary to evaluate the Ngabean Secondary Canal by considering the fulfillment of water needs, agricultural profits, and the feasibility of canal dimensions. This research is expected to provide recommendations to improve the effectiveness of irrigation networks.

2. Materials and Methods

This research uses the F.J. Mock Method to determine the availability of water discharge and the Penman Method to determine the amount of evapotranspiration used in calculating water requirements in each cropping pattern. The value of water availability and water demand will be presented as a water balance. The framework of this research is shown in Figure 1.

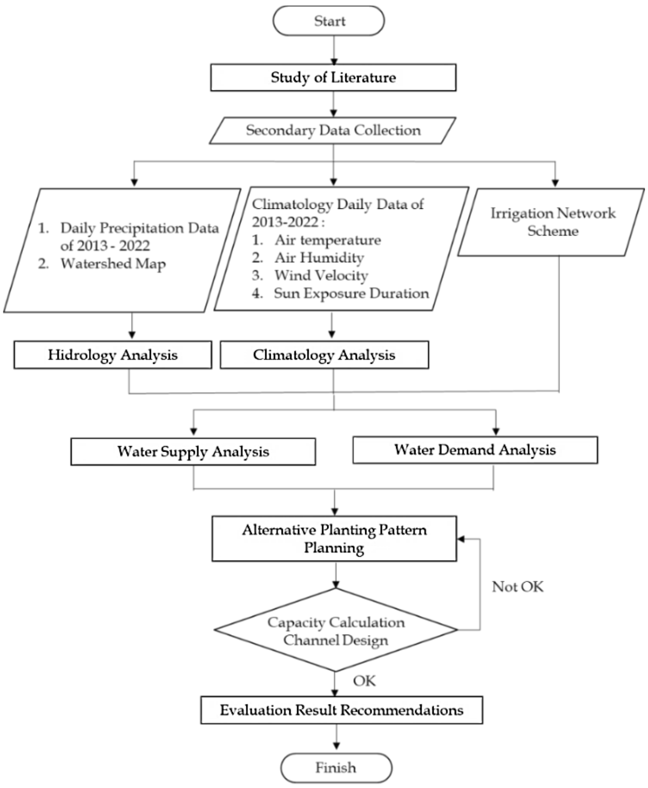


Figure 1. Research Flowchart

2.1. Research Location

This research was conducted in Ngabean Secondary Canal, SIM Irrigation Area, Ngawi Regency, East Java. The research location can be seen in Figure 2.

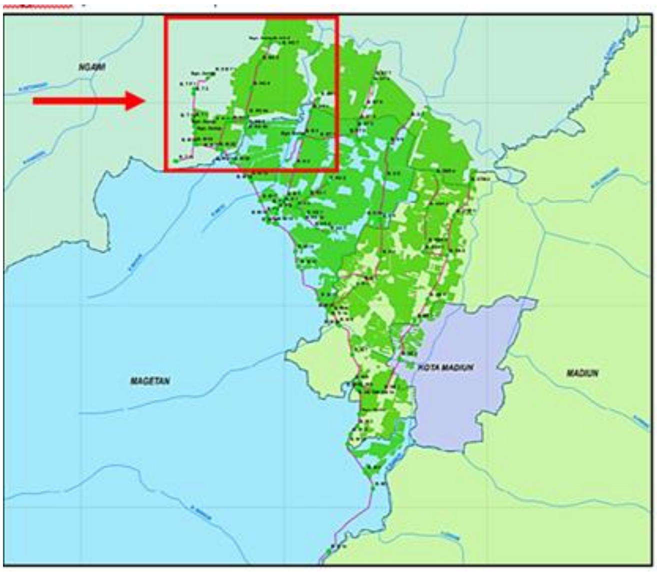


Figure 2. Research Location

2.2. Data

Some of the data needed in this study include daily rainfall data from 2013 - 2022 Guyung Rain Station from DPU SDA East Java, climatological data (air temperature data, air humidity, sun exposure duration, and wind speed) from BMKG Sawahan, and D.I. SIM data (watershed area data, irrigation network schemes, and previous reports) from PUPR SDA Bengawan Solo.

2.3. Analysis Method

The methods used in this research are as follows:

a. Study of Literature
At the literature study stage, it is carried out by collecting references that are relevant to the research theories. In addition, the literature study also aims to obtain information about similar studies or those related to research in order to deepen knowledge about the problems.

b. Data Collection
Data collection is carried out to obtain the information needed in order to achieve the research objectives. Supporting data used is obtained from agencies concerned with the topic taken. In this case, the agencies are DPU SDA East Java, BMKG Sawahan, and PUPR SDA Bengawan Solo.

c. Data Analysis
Data analysis is carried out by analyzing hydrology and climatology which will be the basis for calculating the availability and demand for irrigation water. After that, alternative cropping pattern planning is carried out, making water balance, and canal capacity adjustment in the irrigation area under review.

d. Conclusions
Conclusions are drawn on the basis of the data that has been obtained and analyzed in such a way as to produce a solution to the problem formulated.

3. Result and Discussion

a. Hydrology Analysis

In the hydrological analysis, the effective precipitation value was calculated. The daily precipitation data used was obtained from Guyung Rain Station located in Geneng District, Ngawi Regency for the last 10 years (2013 - 2022). Effective rainfall can be calculated by sorting the monthly rainfall data for 10 years starting from the largest to the smallest value, calculating the R80 rainfall with the following formula:

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

Based on the results of the calculations, it is found that the R_{80} value is located in the third row of the rainfall sequence from the smallest value. The effective rainfall value can be seen in table 1.

Table 1. Results of Effective Precipitation

Effective Precipitation																	
Jan			Feb			Mar			Apr			May			Jun		
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
25	77	49	57	37	45	38	72	22	74	42	40	0	0	3	0	0	0
Jul			Aug			Sep			Oct			Nov			Dec		
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
0	0	0	0	0	0	0	0	0	0	0	0	4	0	47	20	43	26

b. Climatology Analysis

Daily climatological data including temperature (°C), air humidity (%), sun exposure duration (hours), wind velocity (m/s) were taken from BMKG Sawahan for the last 10 years. The data is then calculated for the average value per month to be analyzed using the Penman Method. The following is an example of evapotranspiration calculation in January:

$ETo = C (W \times Rn + (1-W) \times f(u) \times (ea - ed))$

$= 1,10 (0,73 \times 4,08 + (1 – 0,73) \times 0,28 \times 3,25)$

$= 3,54$ mm/day

The calculation for the next month is calculated using the same formula. The results of the calculation of monthly evapotranspiration values are in table 2.

Table 2. Results of Evapotranspiration

Evapotranspiration											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3,54	3,59	3,39	3,27	3,21	3,00	3,25	4,12	5,01	5,05	4,33	3,67

c. Water Availability Analysis

The value of water availability is determined using the FJ Mock Method which is calculated for each monthly period for the last ten years (2013-2022). The calculation in January period one of 2013 is as follows:

$Q = \frac{\text{DR x A x 1000}}{\text{H x 24 x 3600}} = \frac{147{,}94 \text{ x } 67{,}83 \text{ x } 1000}{10 \times 24 \times 3600}$

$= 11{,}615 \text{ m}^3/\text{s}$

After recapitulating the discharge using FJ Mock, sort the data from the largest value to the smallest value. The mainstay discharge (Q_{80}) value can be calculated with the following formula:

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

The results of these calculations show that the Q80 value is located in the third row of discharge order from the smallest or lowest value, as shown in Table 3.

Table 3. Result of Dependable Discharge Q_{80} Ngabean Dam

Q_{80} Ngabean Dam											
Jan			**Feb**			**Mar**			**Apr**		
I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
1,99	4,57	2,74	5,00	2,72	4,54	2,98	3,79	1,65	4,17	3,05	2,93
Mei			**Jun**			**Jul**			**Agu**		
I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
2,09	1,13	0,53	0,29	0,15	0,08	0,04	0,02	0,01	0,01	0,01	0,01
Sep			**Okt**			**Nov**			**Des**		
I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
0,01	0,01	0,01	0,01	0,01	0,01	0,05	0,04	1,41	1,89	1,65	1,95

d. Water Needs Analysis

Calculating water needs in crops that are scheduled appropriately according to the planting period will optimize crop yields. The division of planting season months based on rainfall data is as follows:

Rainy season (RS) = November – February

Dry season I (DS I) = March – June

Dry season II (DS II) = July - October

Based on the seasonal division, crop water requirements are calculated with the beginning of planting in the November I, November II, and November III periods to obtain the average value of NFR. The calculation of water requirements for rice and secondary crops with the beginning of planting in November I is as follows:

Calculation of paddy NFR in November Period 3

NFR padi = Etc + P – Re + WLR = 9,96 + 2,50 – 3,29 + 0,00 = 9,17 mm/day = 1,06 l/s/ha

Calculation of crops NFR in November Period 3

NFR palawija = Etc – Re pal = 2,371– 0,00 = 2,31 mm/day = 0,27 l/s/ha

The calculation for the next period is done using the same formula. The obtained NFR values are then recapitulated, and the largest value is sought for each season. The recapitulation results are in Table 4.

Table 4. Result of Need Field Requirement

Plantinting Start	**Need Field Requirement**		
	Rainy Season	**Dry Season I**	**Dry Season II**
November I	1,22	1,18	1,10
November II	1,18	1,11	1,11
November III	1,11	1,17	1,11
Average	1,17	1,16	1,11

e. Sectioning and Discharge

The section separation uses the irrigation network map of the Ngabean Secondary Canal. The total area of the Ngabean Secondary Canal has changed from 1840 ha to 1818 ha, precisely in the NG3 Ki tertiary plot, which had an initial area of 120 ha to 98 ha. The division of irrigation sections in the Ngabean Secondary Canal is in Table 5.

Table 5. Sectioning on Ngabean Secondary Canal

Irrigation Structure	Tertiary	Before Land Reduction				After Land Reduction			
	Plots	Area	Sec. A	Sec. B	Sec. C	Area	Sec. A	Sec. B	Sec. C
B.NG1	NG1 Ki	79	79			79	79		
B.NG2	NG2 Ki1	118	118			118	118		
	NG2 Ki2	82	82			82	82		
B.NG3	NG3 Ki	120		120		98		98	
	NG3 Ka1	121		121		121		121	
	NG3 Ka2	120		120		120		120	
B.NG3b	NG3b Ka	50		50		50		50	
B.NG4	NG4 Ka1	121		121		121		121	
	NG4 Ka2	87		87		87		87	
	NG4 Ka3	118		118		118		118	
B.NG5	NG5 Ki	101			101	101			101
	NG5 Ka	199			199	199			199
B.NG6	NG6 Ki	121			121	121			121
B.NG7	NG7 Ki	101			101	101			101
	NG7 Te	103			103	103			103
	NG7 Ka	199			199	199			199
Total		**1840**	**279**	**737**	**824**	**1818**	**279**	**715**	**824**

The discharge value is determined by the area irrigated, the NFR value, and the irrigation efficiency. The NFR used is the maximum average value of 1,17 lt/s/ha. The calculation of discharge in tertiary plots and secondary canal segments is as follows:

1. Before Land Reduction
   Tertiary Plot (NG3 Ki)
   A = 120 ha
   $Q = \frac{A \times NFR}{EI} = \frac{120 \times 1,17}{0,80}$ = 175,84 lt/s
   Secondary Canal Segment (R.NG1)
   A = 1840
   $Q = \frac{A \times NFR}{EI} = \frac{1840 \times 1,17}{0,80 \times 0,90}$ = 2995,73 lt/s

2. After Land Reduction
   Tertiary Plot (NG3 Ki)
   A = 98 ha
   $Q = \frac{A \times NFR}{EI} = \frac{98 \times 1,17}{0,80} = 143,60$ lt/s
   Secondary Canal Segment (R.NG1)
   A = 1818
   $Q = \frac{A \times NFR}{EI} = \frac{1818 \times 1,17}{0,80 \times 0,90} = 2959,91$ lt/s

The results of the calculation of discharge in the Ngabean Secondary Canal in the condition before and after rehabilitation are in Table 6. Based on the calculations in the table, it can be seen that land reduction can affect the value of canal discharge.

Table 6. Discharge on Ngabean Secondary Canal

Irrigation Structure	Tertiary Plots	Discharge (lt/s)		Canal	Discharge (lt/s)	
		Before	After	Section	Before	After
B.NG1	NG1 Ki	115,76	115,76	R.NG1	2995,73	2959,91
B.NG2	NG2 Ki1	172,91	172,91			
	NG2 Ki2	120,15	120,15	R.NG2	2867,11	2831,29
B.NG3	NG3 Ki	175,84	143,60			
	NG3 Ka1	177,30	177,30			
	NG3 Ka2	175,84	175,84	R.NG3	2541,48	2505,67
B.NG3b	NG3b Ka	73,27	73,27	R.NG3b	81,41	81,41
B.NG4	NG4 Ka1	177,30	177,30			
	NG4 Ka2	127,48	127,48			
	NG4 Ka3	172,91	172,91	R.NG4	1872,33	1872,33
B.NG5	NG5 Ki	148,00	148,00			
	NG5 Ka	291,60	291,60	R.NG5	1341,57	1341,57
B.NG6	NG6 Ki	177,30	177,30	R.NG6	853,13	853,13
B.NG7	NG7 Ki	148,00	148,00			
	NG7 Te	150,93	150,93			
	NG7 Ka	291,60	291,60	R.NG7	656,13	656,13

f. Water Balance

The Ngabean secondary canal receives supply from two dams: the main dam (Jati Dam) and the supplementary dam (Ngabean Dam). Based on data from PUPR SDA in 2019, Table 7 shows the main dam supply value and the intake value of the supersession dam in each secondary canal before and after rehabilitation.

Table 7. Supply and Intake Discharge from Jati Dam

Month	Period	Before Rehabilitation			After Rehabilitation		
		Q_{80} Jati Dam	Supply (25%)	Retrieval at Intake	Q_{80} Jati Dam	Supply (32%)	Retrieval at Intake
Jan	I	48,63	0,87	0,45	52,70	4,39	0,45
	II	46,76	1,01	0,45	50,83	5,93	0,45
	III	69,59	1,01	0,45	73,65	5,93	0,45
Feb	I	73,41	1,01	0,45	77,47	5,93	0,45
	II	82,34	1,01	0,45	86,41	5,93	0,45
	III	69,53	1,01	0,45	73,60	5,93	0,45
Mar	I	75,07	1,01	0,45	79,14	5,93	0,45
	II	79,63	0,89	0,45	83,70	5,60	0,45
	III	89,88	0,70	0,45	93,95	5,10	0,45
Apr	I	79,08	0,26	0,45	83,15	3,90	0,45
	II	50,54	0,04	0,45	54,61	3,29	0,45
	III	27,23	0,01	0,45	31,30	3,21	0,45
Mei	I	23,75	0,50	0,45	27,82	4,53	0,45
	II	17,78	0,84	0,45	21,84	5,48	0,45
	III	14,10	1,01	0,45	18,47	5,93	0,45
Jun	I	12,78	1,01	0,45	16,85	5,93	0,45
	II	11,80	1,01	0,45	15,86	5,93	0,45
	III	11,30	1,01	0,45	15,37	5,93	0,45
Jul	I	11,06	1,01	0,45	15,12	5,93	0,45
	II	10,93	1,01	0,45	15,00	5,93	0,45
	III	10,77	0,97	0,45	14,84	5,89	0,45
Agu	I	10,51	0,89	0,45	14,58	5,81	0,45
	II	10,26	0,81	0,45	14,33	5,72	0,45
	III	10,05	0,73	0,45	14,12	5,65	0,45
Sep	I	9,79	0,64	0,45	13,86	5,56	0,45
	II	9,56	0,56	0,45	13,63	5,48	0,45
	III	9,41	0,50	0,45	13,48	5,42	0,45

Month	Period	Before Rehabilitation			After Rehabilitation		
		Q_{80} Jati Dam	Supply (25%)	Retrieval at Intake	Q_{80} Jati Dam	Supply (32%)	Retrieval at Intake
Okt	I	9,42	0,51	0,45	13,48	5,43	0,45
	II	9,45	0,52	0,45	13,52	5,44	0,45
	III	9,80	0,64	0,45	13,87	5,56	0,45
Nov	I	57,37	0,78	0,45	61,44	5,32	0,45
	II	33,47	0,47	0,45	37,54	4,53	0,45
	III	22,29	0,00	0,45	26,36	3,29	0,45
Des	I	22,78	0,04	0,45	26,84	3,39	0,45
	II	45,31	0,21	0,45	49,38	3,85	0,45
	III	59,96	0,54	0,45	64,03	4,71	0,45

Based on the data and calculations obtained, three alternative cropping patterns are planned to compare the water balance before and after rehabilitation. The calculation of water balance in the condition before rehabilitation is applied: paddy (15%) - crops (75%) - crops (50%) can be seen in Figure 3.

Figure 3. Water Balance Before Rehabilitation

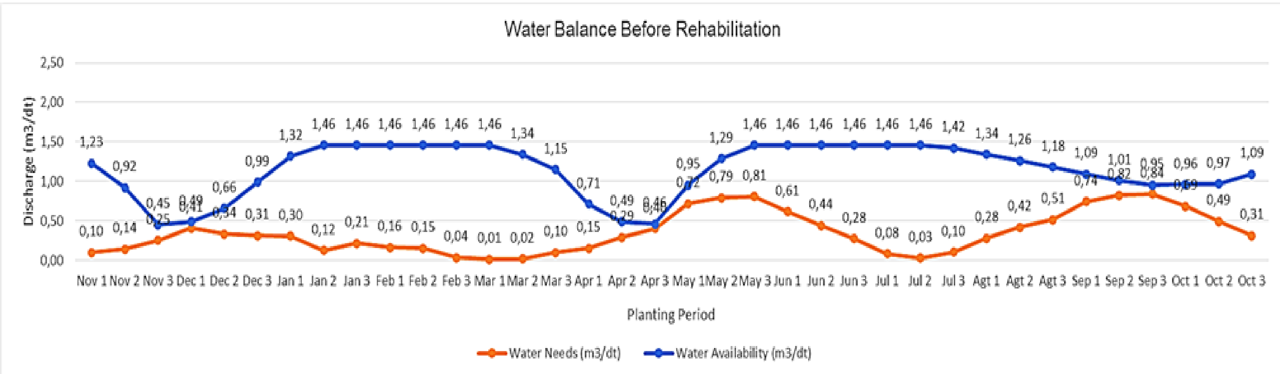


Figure 4 shows the water balance alternative I in conditions after rehabilitation: paddy (100%)—crops (100%)—crops (100%).

Figure 4. Water Balance Alternative I

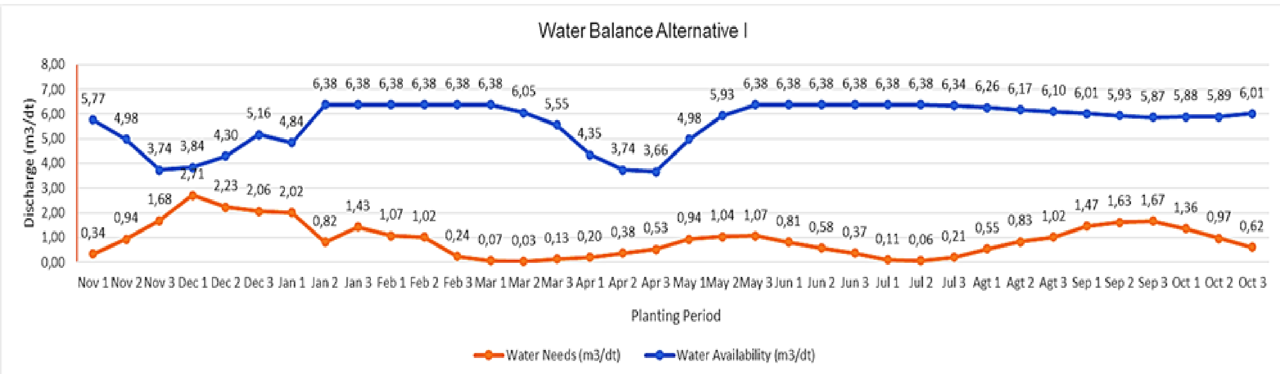


Figure 5 shows the water balance of alternative II in conditions after rehabilitation: paddy (100%)—paddy (100%)—crops (100%).

Figure 5. Water Balance Alternative II

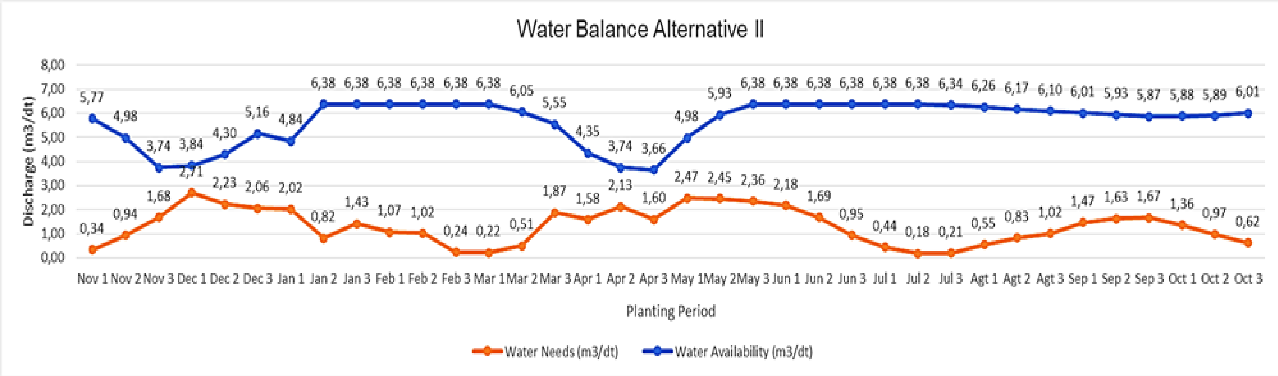
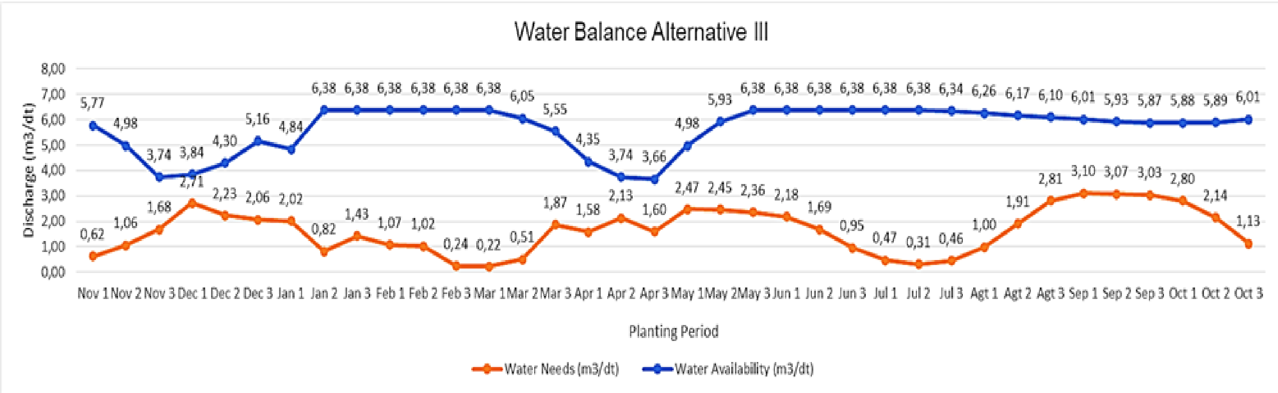


Figure 6 shows the water balance alternative III in conditions after rehabilitation: paddy (100%)—paddy (100%)—paddy (100%).

Figure 6. Water Balance Alternative III



In calculating the water balance that has been done, these three alternatives can be used because the water balance is surplus and can meet the overall water needs of irrigated land. Agricultural profits will then be calculated to determine alternative cropping patterns with the most significant productivity gains of the three alternatives.

g. Agricultural Profit Analysis

Agricultural analysis is carried out to determine the highest profit value. The assumptions of plant production value, plant price value, and processing costs are taken based on the Economic Analysis Report on D.I SIM by PUPR SDA in 2019 as follows:

Paddy Production/Ha = 2,83 Ton

Paddy Price (Rp)/Ton = Rp.5.414.000,00

Crops Production/Ha = 0,8 Ton

Crops Price (Rp)/Ton = Rp.2.500.000,00

Calculation of agricultural productivity profits in condition before rehabilitation with paddy (15%) - crops (75%) - crops (50%) planting pattern as follows:

= ((274 Ha x 2,83 Ton x Rp5.414.000,00) + (1379 Ha x 0,80 Ton x Rp2.500.000,00) + (919 Ha x 0,80 Ton x Rp2.500.000,00))

= Rp8.794.123.880,00

Calculation of agricultural productivity profits in conditions after rehabilitation with alternative planting pattern I paddy (100%) - crops (100%) - crops (100%)as follows:

= ((1818 Ha x 2,83 Ton x Rp5.414.000,00) + (1818 Ha x 0,80 Ton x Rp2.500.000,00) + (1818 Ha x 0,80 Ton x Rp2.500.000,00))

= Rp35.126.705.160,00

Calculation of agricultural productivity profits in conditions after rehabilitation with alternative planting pattern II paddy (100%) - paddy (100%) - crops (100%) as follows:

= ((1818 Ha x 2,83 Ton x Rp5.414.000,00) + (1818 Ha x 2,83 Ton x Rp5.414.000,00) + (1818 Ha x 0,80 Ton x Rp2.500.000,00))

= Rp59.345.410.320,00

Calculation of agricultural productivity profits in conditions after rehabilitation with alternative planting pattern III paddy (100%) - paddy (100%) - paddy (100%) as follows:

= ((1818 Ha x 2,83 Ton x Rp5.414.000,00) + (1818 Ha x 2,83 Ton x Rp5.414.000,00) + (1818 Ha x 2,83 Ton x Rp5.414.000,00))

= Rp83.564.115.480,00

Based on the calculation of agricultural profit analysis on each alternative cropping pattern after rehabilitation, it is known that the paddy (100%) - paddy (100%) - paddy (100%) cropping pattern produces the most significant production profit reaching Rp83,564,115,480.00 compared to before rehabilitation with the Paddy (15%)-Palawija (75%)-Palawija (50%) cropping pattern of Rp8,794,123,880.00. So, it can be concluded that agricultural profits increased 10 times.

h. Canal Dimension

With the discharge calculation in Table 6, the canal is planned with a trapezoidal cross-section, and a 45° angle of inclination of the talus using concrete is planned based on the existing canal data. An example of R.NG1 canal dimension calculation before land reduction is shown below:

1) Discharge plan (Q) = 2,996 m^3/s
2) Roughness coefficient (k) = 70
3) Manning's roughness coefficient (n) = $\frac{1}{k}$ = 0,014
4) Canal bottom width (b) = 4,0 m
5) Water level (h) = 1,0 m
6) Safeguard height (w) = 0,30 m
7) Canal depth (H) = w + h = 0,30 + 1,0 = 1,30 m
8) Slope of Talud (m) = 1
9) Wet cross sectional area (A) = h (b + (m x h)) = 1,0 (4,0 + (1 x 1,0)) = 5,00 m^2
10) Wet perimeter (P) = $b + 2h\sqrt{1+m^2}$ = 4,0 + (2 x 1,0 x $\sqrt{1+1^2}$) = 6,83 m
11) Hydraulic Radius (R) = $\frac{A}{P} = \frac{5,00}{6,83}$ = 0,73 m
12) Canal Slope (s) = 0,00011
13) Standard Velocity (V) = $\frac{1}{n} R^{2/3} s^{1/2} = k R^{2/3} s^{1/2}$
    = 70 x $0,73^{2/3}$ x $0,00011^{1/2}$ = 0,60 m/s
14) Canal Discharge (Q) = V x A = 0,60 x 5,00 = 2,982 m^3/s
15) Qmaks = Q + (5% x Q) = 2,982 + (5% x 2,982) = 3,131 m^3/s
16) Qmin = Q - (5% x Q) = 2,982 - (5% x 2,982) = 2,833 m^3/s

Control:

Qmin < Q < Qmaks

2,833 < 2,996 < 3,131 [OK]

The example of calculating the dimensions of the secondary canal R.NG1 after land reduction is as shown below:

1) Discharge plan (Q) = 2,960 m^3/s
2) Roughness coefficient (k) = 70
3) Manning's roughness coefficient (n) = $\frac{1}{k}$ = 0,014
4) Canal bottom width (b) = 4,0 m
5) Water level (h) = 1,0 m
6) Safeguard height (w) = 0,30 m

7) Canal depth (H) = w + h = 0,30 + 1,0 = 1,30 m
8) Slope of Talud (m) = 1
9) Wet cross sectional area (A) = h (b + (m x h)) = 1,0 (4,0 + (1 x 1,0)) = 5,00 m^2
10) Wet perimeter (P) = $b + 2h\sqrt{1+m^2}$ = 4,0 + (2 x 1,0 x $\sqrt{1+1^2}$) = 6,83 m
11) Hydraulic Radius (R) = $\frac{A}{P} = \frac{5,00}{6,83}$ = 0,73 m
12) Canal Slope (s) = 0,00011
13) Standard Velocity (V) = $\frac{1}{n} R^{2/3} s^{1/2} = k R^{2/3} s^{1/2}$
= 70 x $0,73^{2/3}$ x $0,00011^{1/2}$ = 0,60 m/s
14) Canal Discharge (Q) = V x A = 0,60 x 5,00 = 2,982 m^3/s
15) Qmaks = Q + (5% x Q) = 2,982 + (5% x 2,982) = 3,131 m^3/s
16) Qmin = Q - (5% x Q) = 2,982 - (5% x 2,982) = 2,833 m^3/s

Qmin < Q < Qmaks

2,833 < 2,960 < 3,131 [OK]

Based on the calculation of the dimensions, it is known that the existing dimensions are still qualified after the reduction of land. The recapitulation of the calculation of the dimensions of the Ngabean Secondary Canal is in Table 8 and Table 9.

Table 8. Recapitulation of Canal Dimensions Before Land Reduction

Canal	Q	k	b	h	m	A	P	R	s	V	Q	Desc
	m^3/s	($m^{1/3}$ /s)	m	m		m^2	m	m		m/s	m^3/s	
BM. 22 - B. NG2	2,996	70	4,0	1,0	1	5,00	6,83	0,73	0,00011	0,60	2,982	OK
B. NG 1 - B.NG 3	2,867	70	3,5	0,8	1	3,44	5,76	0,60	0,00028	0,83	2,857	OK
B. NG 2 - B.NG 4	2,541	70	3,0	0,8	1	3,04	5,26	0,58	0,00030	0,84	2,556	OK
B. NG 3 - B.NG 5	1,872	70	3,0	0,8	1	3,04	5,26	0,58	0,00016	0,61	1,867	OK
B. NG 4 - B.NG 6	1,342	70	3,0	0,8	1	3,04	5,26	0,58	0,00008	0,43	1,320	OK
B. NG 5 - B.NG 7	0,853	70	2,5	0,8	1	2,64	4,76	0,55	0,00005	0,33	0,882	OK
B. NG 6 - B.NG 8	0,656	70	2,0	0,7	1	1,89	3,98	0,47	0,00007	0,36	0,674	OK

Table 9. Recapitulation of Canal Dimensions After Land Reduction

Canal	Q	k	b	h	m	A	P	R	s	V	Q	Desc
	m^3/s	($m^{1/3}$ /s)	m	m		m^2	m	m		m/s	m^3/s	
BM. 22 - B. NG2	2,960	70	4,0	1,0	1	5,00	6,83	0,73	0,00011	0,60	2,982	OK
B. NG 1 - B.NG 3	2,831	70	3,5	0,8	1	3,44	5,76	0,60	0,00028	0,83	2,857	OK
B. NG 2 - B.NG 4	2,506	70	3,0	0,8	1	3,04	5,26	0,58	0,00030	0,84	2,556	OK
B. NG 3 - B.NG 5	1,872	70	3,0	0,8	1	3,04	5,26	0,58	0,00016	0,61	1,867	OK
B. NG 4 - B.NG 6	1,342	70	3,0	0,8	1	3,04	5,26	0,58	0,00008	0,43	1,320	OK
B. NG 5 - B.NG 7	0,853	70	2,5	0,8	1	2,64	4,76	0,55	0,00005	0,33	0,882	OK
B. NG 6 - B.NG 8	0,656	70	2,0	0,7	1	1,89	3,98	0,47	0,00007	0,36	0,674	OK

4. Conclusion

Based on the results of the analysis and calculations that have been carried out, the following conclusions can be drawn:

a. Ngabean Secondary Canal gets water supply from the main dam (Jati Dam) and the supplementary dam (Ngabean Dam). The mainstay discharge of Jati Dam in the condition before rehabilitation was the highest at 1.01 m^3/s and the lowest at 0.00 m^3/s. While in the condition after rehabilitation the highest was 5.93 m^3/s and the lowest was 3.00 m^3/s. While in the condition after rehabilitation the highest was 5.93m^3/s and the lowest was 3.21 m^3/s. Meanwhile, the highest mainstay discharge at Ngabean Dam was 5.00 m^3/s and the lowest was 0.01 m^3/s.

b. The maximum irrigation water requirement for each alternative cropping pattern are as follows:
Paddy (100%) – Crops (100%) – Crops (100%) = 2,71 m^3/s
Paddy (100%) – Paddy (100%) – Crops (100%) = 2,71 m^3/s
Paddy (100%) – Paddy (100%) – Paddy (100%) = 3,10 m^3/s

c. Based on the analysis of agricultural profits, in conditions before rehabilitation and land reduction with a planting pattern of Paddy (15%) - Crops (75%) - Crops (50%), the resulting agricultural profit amounted to Rp8,794,123,880.00. Meanwhile, the cropping pattern with the largest production profit after land rehabilitation and reduction is Paddy (100%) - Paddy (100%) - Paddy (100%) which results in agricultural profits reaching Rp83,564,115,480.00. Thus, agricultural profits increased 10 times compared to conditions before rehabilitation and land reduction.

d. Based on the calculation of the dimensions of the Ngabean Secondary Canal, it is known that the existing dimensions still qualify after the reduction of land so that no changes in canal dimensions are needed.

5. Acknowledgement

The author would like to thank all parties who have contributed to this research, especially the data source institutions, which are DPU SDA East Java, BMKG Sawahan, and PUPR SDA Bengawan Solo. Hopefully this research can be useful as a reference for further research in the field of irrigation.

6. Author's Note

The author claims that this journal article is not plagiarized from other journals. This content is original.

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