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Assessment and Optimization of Water Division Pattern in Sampean Baru Irrigation Area

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A B S T R A C T

Recently, agricultural production in the Sampean Baru Irrigation area has not shown optimal cropping production. The average percentage of planted areas in the first (November-February), second (March-June), and third (July-October) planting seasons for the upstream area was 93.67%; 98.02%, and 76.76%, and for the downstream area was 83.54%; 80.81%; and 89.36%. This research aims to optimize the water distribution system based on the calculation of water requirements for plants and the availability of channels to obtain the maximum planting area and amount of agricultural production. This optimization method uses a Dynamic Program with three scenarios. The first scenario is the dry season. The second scenario is a normal season. The third season is the wet season. This calculation is based on effective rainfall, crop water requirements, and water discharge availability. The percentage of the planted area obtained from the dry year calculation for the first, second, and third planting seasons, respectively, were 100%, 100%, and 90.36%. Based on the existing condition, the potential profit obtained for a year is IDR 170.08 billion. After optimization using Dynamic Program, potential profits in the dry year, normal year, and wet year are IDR 213.52 billion, IDR 215.92 billion, and IDR 228.50 billion, respectively.

1. Introduction

The importance of optimization in irrigation is to obtain efficient use of water resources for agriculture and sustainable agricultural development. The limitation of discharge encourages efforts to assist air distribution so that the coverage of planted services is optimal.

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The Sampean Baru Irrigation Area is located in Bondowoso Regency and Situbondo Regency, East Java Province. The Sampean Baru Irrigation Area is 8,146 Ha. There are several factors that affect unoptimal agricultural production, namely low rainfall, and water distribution. Those factors cause agricultural lands to experience drought and fallow (not planted), especially during the dry season.

Several studies have been carried out in the Sampean Baru Irrigation Area are using the Linear Programming method, which consists of an objective function and a constraint function. The objective function is the distribution of water, while the constraint function is the limited volume of water [1]. Other researchers have calculated that the use of surface water in the Sampean Basin is dominated by water demand for irrigation water [2]. Other researchers developed a tool (plug-in) that works on top of apWindowGIS named SIDI as a tool to assist the operation and management of irrigation networks and infrastructure in the Sampean Baru Irrigation Area [3].

The purpose of this study is to evaluate the water distribution system in the Sampean Baru Irrigation Area whether it has met the water needs of rice fields with existing cropping patterns or not. This research is carried out because, in downstream areas, many rice fields have not received optimal irrigation water, which causes the land to become bero (unplanted). This study also calculates the optimization of the water distribution pattern based on the cropping pattern and calculates how much area can be irrigated and how much profit is in accordance with the optimization results. By implementing the Deterministic Dynamic Program [4], [5], it is hoped that after optimization, the increase in intensity and profitability of irrigation in the Sampean Baru Irrigation Area can be calculated.

2. Area of Study and Method

2.1 Area of Study

The study area is located in Bondowoso Regency and Situbondo Regency, to be precise in the Sampean Baru irrigation area, East Java Province. The Sampean Baru Irrigation Area has an intake at the Sampean Baru Dam. The use and utilization of water in the Sampean Baru Irrigation Area is used for agricultural purposes, covering an area of ± 8,146 ha.

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Source : [6]

Figure 1. Map of the Area of Study

Distribution of water in Sampean Baru area in the rainy season and dry season still requires optimization in the distribution of water between the existing rice fields in Bondowoso Regency and in Situbondo Regency. Thus, available water can be allocated effectively and efficiently for planting to reduce or eliminate the potential for conflict [1].

2.2 Methodology

The method used in this research has several stages (Fig. 2). First, collection of agro-climatological data to calculate the potential evapotranspiration (ETo). Second, collection of crop data and rainfall data in order to determine the value of effective rainfall (R_{eff}). Third, collection of soil data. Fourth, discharge data at the intake are used to determine reliable discharge values in the dry year, normal year, and wet year. Fifth, collection of land area data and determination of cropping patterns in order to determine the area that can be planted. This stage is carried out to obtain the value of the crop. Sixth, a dynamic program is executed with the following constraint factors: land area, reliable discharge, rainfall, and potential evapotranspiration. Seventh, by changing the cropping pattern, the maximum possible values of benefit are determined. Details can be seen in Fig. 2.

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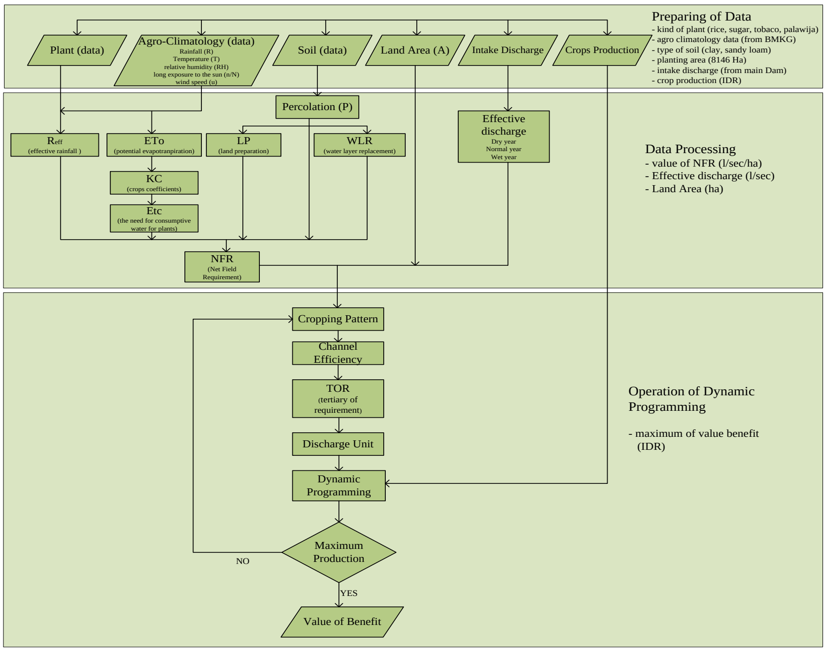

Figure 2. Optimization process flowchart

In Figure 2, the optimization step is shown in the third stage, starting with changes in cropping patterns, with changes in cropping patterns, it is determined how much discharge is needed for land needs, the number of discharge needs must not exceed the amount of available discharge for each year. It is divided into two parts, namely upstream and downstream, starting with the availability of upstream discharge, then optimizing the upstream planting pattern. The amount of discharge for the upstream part is determined and the remaining discharge is forwarded to the downstream part. The remaining discharge from the upstream part is the amount of availability downstream discharge. Optimization of the downstream cropping pattern is carried out where the amount of discharge required for the downstream part cannot exceed the availability discharge. This was repeated so as to find the optimal production value.

2.2.1 Evapotranspiration

Evaporation is a process that water turns into gas and moves from the ground surface and the water surface to the air. Evapotranspiration of crops is an important parameter in hydrological, environmental and agricultural studies [7], [8], [9], [10], [11], [12], [13]. In calculating the value of evapotranspiration, the Modified Pennman formula is utilized as follow:

$$Eto = c.(W \,.\, Rn)+(1-W).f_{(u)}.(e_a-e_d)$$

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Where:

Eto = Potential Evapotranspiration (mm/day)

c = correction factor,

W = a factor related to temperature and elevation,

Rn = short wave radiation (mm/day)

f(u) = wind function (km/day)

(ea-ed) = difference in vapor pressure (mbar)

2.2.2 Analysis of Rainfall

Regional rainfall was calculated based on rainfall data recorded at rain stations that are adjacent / within the coverage of the irrigation area. The reliable rainfall is the part of the total rainfall that is effectively available for water needs [7], [14], [15]. The arithmetic method with Equalition is calculated in order to calculate the regional rainfall.

$$\bar{R} = 1/n \sum_1^n Ri$$

Where R is regional rainfall (mm), Ri is rainfall point at station 1 (mm), n is a number of observation stations. Effective rainfall is rainfall that plants, percolation, and others can use. Rainfall for lowland rice is calculated based on 70% of rainfall probabilities of 80% (R80) with a 20% chance of failure [16], [14], [17] using Equalition as follow:

$$R_{rice} = 0.7\,(R80)$$

Where Re_{rice} is effective rainfall for lowland rice (mm / day), R80 is rainfall with probabilities of 80% (mm). Effective rainfall for plants are calculated using Equalition as follow:

$$R_{plw} = FD\,(1{,}25.\,{R_2}^{0{,}842} - 2{,}93)(10^{0{,}0095.Eto})$$

$$FD = 0{,}53 + 0{,}116D - (8{,}94.10^{-5}.\,D^2) + (2{,}32.10^{-7}.\,D^3)$$

Where, Re_{plw} is effective rainfall for palawija (mm / day), D is the availability of groundwater that is ready for use which is approximated by the depth of roots (mm), and FD (Eq. 5) is the Depth Factor of rooting (mm).

2.2.3 Water Needs for Plants

The calculation of plant water requirements for rice plants (NFR_{rice}), palawija plants (NFR_{plw}) and sugar plants (NFR_{tebu}) is based on the water balance principle which is stated in the Equalition:

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$$NFR_{rice} = LP + ET_{crop} + WLR + P - Re_{rice}$$

$$NFR_{plw} = ET_{crop} - Re_{plw}$$

$$NFR_{tebu} = ET_{crop} - Re_{tebu}$$

Where NFR_{rice} is water required in rice fields (l/sect/ha), NFR_{plw} is water required in palawija fields (l/sec/ha), NFR_{tebu} is water required in sugar fields (l/sec/ha), LP is water requirements for land preparation (mm/day), ET_{crop} is water requirements for plant consumption (mm/day), WLR is water requirements for the replacement of the water layer (mm/day), P is perkolation (mm/day), Re_{rice} is effective rainfall for rice (mm/day), Re_{plw} is effective rainfall for palawija (mm/day), Re_{tebu} is effective rainfall for sugar (mm/day). [17]

2.2.4 Water Requirement for Soil Treatment

The amount of water needed for land cultivation is approximated by a method based on a constant water rate in l/s during the land storage period [4]. The method is defined in:

$$LP = \frac{Mxe^k}{e^k - 1}$$

Where LP is water requirement for land processing (mm/s), M is water requirement for replacement of water loss due to evaporation and percolation in saturated rice fields (mm/day), M = Eo + P (mm / day), Eo is water evaporation open taken 1.1 ETo during land preparation (mm / day), P is Percolation (mm / day), K = (M x T) / S, T is Period of land preparation (days), S is Water needs for saturation are Based on soil texture, e Exponential number (2.71828).

2.2.5 Water Requirement for Soil Treatment

The need for clean irrigation water is the amount of water required for successful plant growth [4], [18], [19], [20] . Irrigation water that is needed for each tapping building and main building for each tertiary plot and secondary canal is calculated by Equalition as follow:

$$TOR_{ij} = \frac{A_{ij} \text{ X } NFR}{(n_{tersier})_{ij}}$$

$$DR = \frac{\sum_{j=1}^{m} TOR_{ij}}{n_{saluran}}$$

Where TOR_{ij} is irrigation water required in the tertiary plot i at the secondary channel j with the service area A_{ij} (l/sec), DR is main building irrigation water needs (l/sec) shown in Equalition, A_{ij} is the tertiary service area i at the secondary channel j, $(n_{tersier})_{ij}$ is an efficiency of tertiary plot i on channel j.

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ISSN (*Print*) 2579-4620

2.2.6 Irrigation Water Distribution System

The water distribution system implemented in an irrigation network depends on irrigation water availability and the need for irrigation water [21], [22]. In the operation of irrigation networks, the integration of irrigation water is expressed as K factor. The rotating/shifting system provides water in tertiary channels or main channels at certain time intervals if the available discharge is less than the K factor. If the water supply is sufficient, factor K is equal to 1, while if the water supply is less than the required one, the K factor is less than 1 [23]. In calculating the K factor, Equalition is used.

$$\text{K factor} = Q/Q_{ir}$$

K is the ratio of availability and need for irrigation water. Q is the irrigation water availability in the main building (l / sec). Q_{ir} is the required irrigation water (l/sec).

2.2.8 Dynamic Program Optimization

A dynamic program is a collection of mathematical programming techniques used for decision-making, consisting of many stages (multistage). A multistage decision-making problem is broken down into a series of sequential and interconnected problems (or sub-problems). For deterministic optimization methods, this optimization problem is characterized by a proper convexity of the domain or objective function and may involve continuous and / or discrete variables [18], [5], [24], [25], [26], [27], [28]. The completion of an optimization model generally has many alternatives. Each solution must be feasible, which means that it is still within the constraints. Optimization problems in water resources management are often non-linear. The method is solved using Deterministic Dynamic Programming [18], [4], [29], [30].

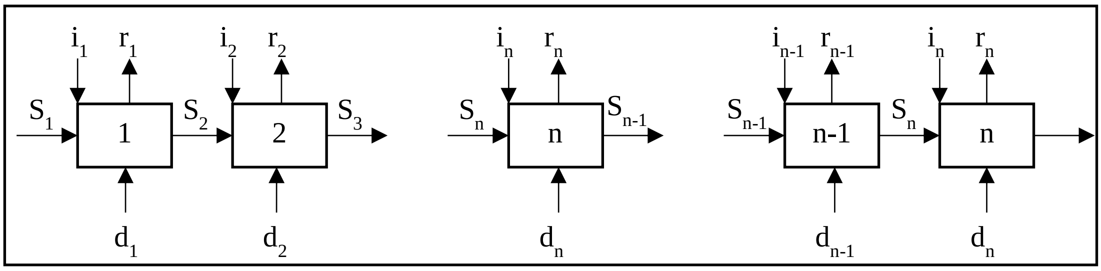

Figure 3. Serial Dynamic Problem Sequence Diagram

The elements of a dynamic program are:

1. Stage/stage (n), n is part of the land divided into upstream areas (n-1) and downstream areas (n).

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2. Decision Variable (dn), is the amount of discharge given in units of l/s for upstream land with an area of 1627 ha (dn-1) and for downstream land with an area of 6519 ha (dn).
3. Stage Variable (Sn), is the amount of water flowing in the primary channel in units of l/s, (Sn-1) is the amount of discharge from the main intake, (Sn) is the amount of discharge from the main channel minus the discharge released for the upstream land (n-1), (Sn +1) is the amount of discharge after deducting the discharge released for downstream land (n).
4. Stage Return (rn) is the result of the decision of each stage. The result of this decision is the value of agricultural production (IDR).
5. Stage Transformation or State Transition (tn). Is the water balance continuity equation.

While the operational characteristics of a dynamic program can be described in point 3, 4, and 5 [18], [4], [29].

1. The problem is solved into stages, and there are decision variables at each stage.
2. Each stage has a number of steps inside.
3. The effects of the decisions at each stage are:
   a. Generates a return based on the stage return function.
   b. Transforming the stage variable for the next stage through the transformation stage.
4. The next stage's decision does not depend on the decisions taken (in the previous stage). Completion of Dynamic Programming starts from the initial stage and moves to the final stage (forward recursive) or vice versa (backward recursive).
5. In forward recursive, the optimal policy is determined based on the optimal policy from the previous stage and the objective function for each stage.

The forward recursive equation can be written as shown in Equalition:

$$fn(S_n) = opt_{dn}\,[r_n(S_n, d_n)\,O\,f_{n-1}(S_{n-1})]$$

Where O states an algebraic operation which can be in the form of addition, subtraction, multiplication or other according to what is meant in the problem in question. For the backward recursive procedure, the equation is shown in Equalition.

$$fn(S_n) = opt_{dn}\,[r_n(S_n, d_n)\,O\,f_{n+1}(S_{n+1})]$$

3. Result and Discussion

The Sampean Baru Irrigation Area area is 8,146 Ha, which is divided into two major parts, the upstream and downstream parts. The details can be seen in Table 1.

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ISSN (*Print*) 2579-4620

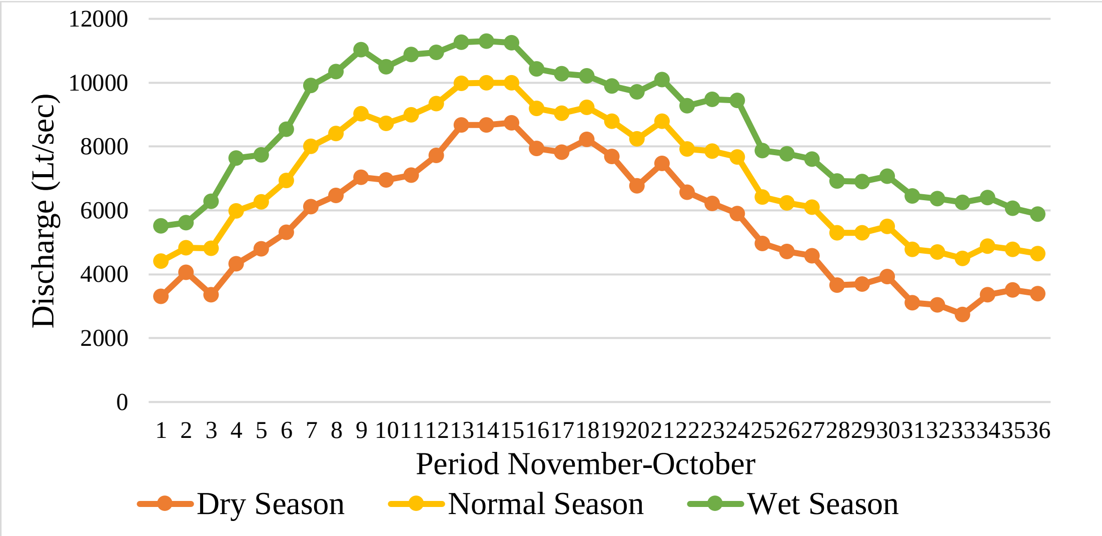
Table 1. Irrigation Area of Sampean Baru

Number	Part	Water Building	Area (Ha)	Soil
1	Upstream	B.S.B.1 s/d B.S.B.14	1,627.00	Clay
2	Downstream	B.S.B.15 s/d B.S.B.49	6,519.00	Sandy loam
Total			8,146.00	

Source: Research document (2020)

3.1 Availability of Water at Intake

Observation of water availability at the intake is carried out in each season, divided into 3 season, dry season, normal season, and wet season. The availability of water in the intake channel in Sampean Baru is presented in figure 4. The pattern of water availability at the intake for a period of 10 days in 1 year has the same pattern between dry season, normal season, and wet season. The lowest discharge was in November (week 1), and the highest was in March (week 15).



Source : UPT PSA WS Sampean Baru (2020)

Figure 4. Graphic of Intake Discharge of Sampean Baru Dam

3.2 Potential Evapotranspiration

Evaporation and transpiration are a combination of evaporation and transpiration events that occur together. The calculated potential evapotranspiration values can be seen in Table 2. The value of the evapotranspiration parameter for temperatures ranges from 27 ° C-28 ° C, for relative humidity ranges from 84% -89%, for long exposures it ranges from 56% -94%, for wind speeds it ranges from 500 km / day-800 km / day and for ETo the range is 3 mm / day-4 mm / day.

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Table 2. Potential Evapotranspiration

Description	Month											
	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Agt	Sep	Okt	Nov	Des
ETo (mm/day)	4,12	3,95	3,54	3,78	3,83	3,35	3,53	3,62	4,30	4,45	5,38	3,94

Source : Reseach document (2020)

3.3 Analysis of Rainfall

This study's Rainfall data analysis was taken based on data from rain stations located along the primary channel Sampean Baru. There are 14 observation stations in total utilized for rainfall analysis in this study. The results of the effective rainfall analysis for plants are presented in Table 3. The lowest value of effective rainfall is from July to October, and the largest is in February.

Table 3. Effective Rainfall

Effective rainfall period of 10 days (mm)											
1	2	3	1	2	3	1	2	3	1	2	3
	Jan			Feb			Mar			Apr	
19,45	11,05	21,89	15,06	7,86	15,55	5,58	6,72	1,16	3,32	2,67	0,48
	Mei			Jun			Jul			Ags	
0,28	2,59	0,37	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Sep			Okt			Nov			Des	
0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,28	1,24	5,86	10,05	9,80

Source : Reseach documentation (2020)

3.4. Water Needs For Rice Soil Preparation

Water is needed to form the soil structure and the formation of sludge and suppress weed growth. The amount of water needed for land cultivation for Sampean Baru irrigation area is shown in Table 4.

Table 4. Water Needs For Rice Soil Preparation

Description	**Month**											
	Nov	Des	Jan	Peb	Mar	Apr	Mei	Jun	Jul	Ags	Sep	Okt
LP (l/sec/day)	1,66	1,51	1,52	1,59	1,48	1,53	1,50	1,50	1,48	1,49	1,57	1,55

Source: Research document (2020)

LP is the value of water needs for soil processing in units (l/sec/ha) required before planting this value is only for rice. For example, in November, the land before planting requires a water discharge of 1.66 l/s for each hectare used to cultivate the land so that the soil structure becomes softer and smoother so that rice cultivation can be carried out.

3.5. Evaluation of Cropping Pattern

Evaluation of cropping patterns in the Sampean Baru irrigation area shows that there are many areas that are not yet planted. The details are shown in Table 5.

ISSN (*Online*) 2581-0855
ISSN (*Print*) 2579-4620

Table 5. Existing Planting Patterns

Section	Area (Ha)	discharge (l/Sec)	Planting Season	Rice (Ha)	Palawija (Ha)	Sugar (Ha)	Tobaco (Ha)	discharge used (l/dt)	Area Planted (%)
Up-stream (B.SB.1-B.SB14)	1.627,00	7.145,93	PS 1	1.294,53	229,49			914,14	93,67%
	1.627,00	8.890,90	PS2	1.394,96	199,81			1.224,60	98,02%
	1.627,00	5.260,48	PS2	298,92	950,00			725,24	76,76%
Down-stream (B.SB.15-B.SB49)	6.519,00	6.231,79	PS 1	1.147,98	2.065,43	2.232,75		3.049,41	83,54%
	6.519,00	7.666,30	PS2	1.237,04	1.798,28	2.232,75		3.950,35	80,81%
	6.519,00	4.535,24	PS2	265,08	3.269,67	2.232,75	58,00	4.081,55	89,36%

Source : UPT PSA WS Sampean Baru (2020)

Table 5 shows the existing planting pattern where for the upstream area with an area of 1627 ha, the planted land is 76.76% to 93.67%, while in the downstream area, the area of land is 6519 ha planted 80.81% to 89.36%

After optimizing the water balance in a normal year, in the first planting season and second planting season, which is the beginning of the rainy season, all the land can be planted. In the third planting season, the area that can be planted is 90.36% of the downstream area.

Table 6. Evaluation of Planting Patterns

Section	Area (Ha)	discharge (l/Sec)	Planting Season	Rice (Ha)	Palawija (Ha)	Sugar (Ha)	Tobaco (Ha)	discharge used (l/dt)	Area Planted (%)
Up- stream (B.SB.1-B.SB14)	1.627,00	7.145,93	PS 1	1.627,00				1.148,92	100,00%
	1.627,00	8.890,90	PS2	1.627,00				1.336,70	100,00%
	1.627,00	5.260,48	PS2	1.127,00	500,00			1.213,94	100,00%
Down-stream (B.SB.15-B.SB49)	6.519,00	5.997,01	PS 1	4.086,25	200,00	2.232,75		4.757,19	100,00%
	6.519,00	7.554,20	PS2	3.286,25	1.000,00	2.232,75		5.708,14	100,00%
	6.519,00	4.046,54	PS2		3.600,00	2.232,75	58,00	4.016,83	90,36%

Source: Research document (2020)

Table 6 shows the evaluation results based on the amount of discharge available in a normal year, so the evaluation of cropping patterns shows 100% intensity for the upstream part in planting season 1 to planting season 3. In comparison, in the downstream part for planting season 1 and planting season 2, the intensity is 100%. This means that all of the land is effectively planted. In contrast, for planting season 3 for the downstream part, 90.36% can be planted.

3.6. Optimization of Water Rotating System

Production analysis on the existing cropping pattern is shown in Table 7. Planting area data recorded in UPT PSAWS Sampean Baru is analyzed. The results showed potential benefits with the existing cropping pattern model of IDR 170.084 billion for one year.

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ISSN (*Print*) 2579-4620

Table 7. Analysis of Existing Production

Section	Area (Ha)	discharge (l/Sec)	Planting Season	Rice (IDR 10^6)	Palawija (IDR 10^6)	Sugar (IDR 10^6)	Tobaco (IDR 10^6)	Production (IDR 10^6)
Up- stream (B.SB.1-B.SB14)	1.627,00	7.145,93	PS 1	14.591,29	1.649,29	-	-	16.240,58
	1.627,00	8.890,90	PS2	15.723,35	1.435,97	-	-	17.159,31
	1.627,00	5.260,48	PS2	3.369,29	6.827,39	-	-	10.196,68
		-		-	-	-	-	
Down-stream (B.SB.15-B.SB49)	6.519,00	6.231,79	PS 1	12.939,45	14.843,64		-	27.783,09
	6.519,00	7.666,30	PS2	13.943,35	12.923,71		-	26.867,05
	6.519,00	4.535,24	PS2	2.987,86	23.498,20	44.934,09	417,60	71.837,75
Total Production								170.084,47

Source: Research document (2020)

Table 7 shows the results of the existing production, the area of land planted is the result of field conditions. For the upstream area with an area of 1627 hectares for planting season 1, agricultural production is IDR 16,241 billion, planting season 2 is IDR 17,159 billion, and planting season 3 is IDR 10,197. Meanwhile, the downstream agricultural production for planting season 1 is IDR 27,783 billion, planting season 2 is IDR 26,867 billion, and planting season 3 is IDR 71,837, so that the total production for the existing conditions is IDR 170.084 billion in one year.

Production analysis of cropping patterns after optimization using dynamic programs in dry years is shown in Table 8. The analysis results show a potential profit of IDR 213.522 billion for one year.

Table 8. Analysis of Dry Year Production

Section	Area (Ha)	discharge (l/Sec)	Planting Season	Rice (IDR 10^6)	Palawija (IDR 10^6)	Sugar (IDR 10^6)	Tobacco (IDR 10^6)	Production (IDR 10^6)
Up- stream (B.SB.1-B.SB14)	1.627,00	5.547,54	PS 1	18.338,80	-	-	-	18.338,80
	1.627,00	7.560,17	PS2	18.338,80	-	-	-	18.338,80
	1.627,00	3.723,80	PS2	18.338,80	-	-	-	18.338,80
Down-stream (B.SB.15-B.SB49)	6.519,00	4.398,62	PS 1	47.185,48	718,67		-	47.904,16
	6.519,00	6.223,47	PS2	28.812,87	12.433,03		-	41.245,91
	6.519,00	2.327,40	PS2	-	24.003,66	44.934,09	417,60	69.355,36
Total Production								213.521,81

Source: Research document (2020)

Table 8 shows the results of the analysis of dry year agricultural production, the area of land planted is optimized based on the availability of discharge in the dry year, from the calculation results show the agricultural production for the upstream area with an area of 1627 hectares in planting season 1 is IDR 18.339 billion in planting season 2 is IDR 18,339 billion in planting season 3 is IDR 18,339 billion, while for the downstream with an area of 6519 hectares in planting season 1 is IDR 47,904 billion in planting season 2 is IDR 41,247 billion in planting season 3 is IDR 69,355 billion, so production in a dry year is IDR 213,522 billion per year

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Production analysis of cropping patterns after optimization using dynamic programs in normal years is shown in Table 9. The results show a potential profit of IDR 215.92 billion for one year.

Table 9. Analysis of Normal Year Production

Section	Area	discharge	Planting Season	Rice	Palawija	Sugar	Tobaco	Production
	(Ha)	(l/Sec)		(IDR 10^6)	(IDR 10^6)	(IDR 10^6)	(IDR 10^6)	(IDR 10^6)
Up-stream (B.SB.1-B.SB14)	1.627,00	7.145,93	PS 1	18.338,80	-	-	-	18.338,80
	1.627,00	8.890,90	PS2	18.338,80	-	-	-	18.338,80
	1.627,00	5.260,48	PS2	12.703,03	3.593,36	-	-	16.296,39
Down-stream (B.SB.15-B.SB49)	6.519,00	5.997,01	PS 1	46.058,33	1.437,35		-	47.495,68
	6.519,00	7.554,20	PS2	37.041,10	7.186,73		-	44.227,82
	6.519,00	4.046,54	PS2	-	25.872,21	44.934,09	417,60	71.223,90
Total Production								215.921,38

Source: Research document (2020)

Table 9 shows the results of the analysis of agricultural production in the normal year, the area of land planted is optimized based on the availability of discharge in the normal year, from the calculation results show that agricultural production for the upstream area with an area of 1627 Ha in planting season 1 is IDR 18,339 billion in planting season 2 is IDR 18,339 billion in planting season 3 is IDR 16,296 billion, while the downstream area with an area of 6519 hectares agricultural production in planting season 1 is IDR 47,496 billion, in planting season 2 is IDR 44,228 billion, in planting season 3 is IDR 71,224 billion, so the optimization of production in normal years is IDR 215,921 billion per year

Production analysis of cropping patterns after optimization using a dynamic program in the wet year is shown in Table 10. The results show a potential profit of IDR 228.50 billion for one year.

Table 10. Analysis of Wet Year Production

Section	Area	discharge	Planting Season	Rice	Palawija	Sugar	Tobaco	Production
	(Ha)	(l/Sec)		(IDR 10^6)	(IDR 10^6)	(IDR 10^6)	(IDR 10^6)	(IDR 10^6)
Up- stream (B.SB.1-B.SB14)	1.627,00	8.744,33	PS 1	18.338,80	-	-	-	18.338,80
	1.627,00	10.221,63	PS2	18.338,80	-	-	-	18.338,80
	1.627,00	6.797,17	PS2	12.703,03	3.593,36	-	-	16.296,39
Down-stream (B.SB.15-B.SB49)	6.519,00	7.595,41	PS 1	48.312,64	-		-	48.312,64
	6.519,00	8.884,93	PS2	48.312,64	-		-	48.312,64
	6.519,00	5.583,22	PS2	11.271,54	22.278,85	44.934,09	417,60	78.902,08
Total Production								228.501,34

Source: Research document (2020)

Table 10 shows the results of the analysis of agricultural production in the wet year, the area of planted land is optimized based on the availability of discharge in the wet year, the results of the optimization calculations show that agricultural production for the upstream area with an area of 1627 hectares in planting season 1 is IDR 18,339 billion in planting season 2 is IDR 18,339 billion in planting season 3 is IDR 16,296 billion, while for the downstream area with an area of 6519 hectares, agricultural production in planting season 1 is IDR 48,313

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billion in planting season 2 is IDR 48,312 billion in planting season 3 is IDR 78,902 billion, so that optimization production in the wet year is IDR 228,501 billion per year

4. Conclusion and Suggestion

4.1 Conclusion

A study of the assessment and optimization of water rotating patterns in the Sampean Baru Irrigation Area has been conducted. The existing planting intensity for the upstream area (B.SB.1 - B.SB.14) was PS I (93.67%), PS II (98, 02%), and PS III (76.76%). For downstream areas (B.SB.15 - B.SB.49), the existing planting intensity was PS I (83.54%), PS II (80.81%), and PS III (89.36%). After evaluation of the water rotating analysis for the upstream area (B.SB.1 - B.SB.14), the planting intensity was obtained as follows: PS I (100.00%), PS II (100.00%), and PS III (100.00%). For the downstream area (B.SB.15 - B.SB.49), the existing planting intensity was PS I (100.00%), PS II (100.00%), and PS III (90.36%). The analysis of production results concerning the existing conditions was carried out. The potential profit a year generated is IDR 170.08 billion. After optimization with the Dynamic Program, the profit potential in one year is IDR. 213.52 billion, while for the normal year IDR 215.92 billion, and the wet year IDR. 228,50 billion.

4.2 Suggestion

A study on the optimization of irrigation water distribution in the Sampean Baru irrigation area was analyzed in this study. It is hoped that a study of the operation pattern of the distribution gate for irrigation water for each primary, quarter, and tertiary channel can be carried out so that the optimization pattern can be applied in the field.

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