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OPTIMIZATION OF IRRIGATION CROPPING PATTERN (CASE STUDY ON KARANG ANYAR IRRIGATION AREA, MALANG REGENCY, INDONESIA)

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ABSTRACT: The irrigation area of Karang Anyar has the problem related to the cropping pattern and planting area which is not in accordance with the availability of the irrigation water. Therefore, this study intends to optimize the planting area and cropping intensity for obtaining the maximum benefit of the farming results. The methodology started from the analysis of irrigation water requirement for the 5 alternatives cropping patterns as the input on the linear mathematical modeling by using the solver from the Microsoft Excel. The 5 alternatives of cropping patterns are analyzed based on the discharge with the probability of 80% (Q_{80}), 50% (Q_{50}), and 25% (Q_{25}). Based on the low discharge condition (Q_{80}) and the normal discharge condition (Q_{50}), the 5th alternative is the best with the cropping pattern is paddy, cane-second crop, cane-paddy, cane), the cropping intensity is 190.46% and 231.14%, and the benefit is Rp. 10,895,973,582.- and Rp. 13,539,099,637.-. However, analysis by the sufficient discharge condition (Q_{25}) indicates that the 3rd alternative is the best with the cropping pattern is paddy, second crop, cane-paddy, second crop, cane-second crop, cane), the cropping intensity is 262.99%, and the benefit is Rp. 15,951,071,409.-

Keywords: : irrigation, optimize, cropping pattern, linear program

1.INTRODUCTION

The agricultural sector is a key driver in the world-wide economic and social development that plays a substantial role in achieving, among other, economic diversification, food security, and human welfare. The adjustment of planting schedule and crop variety are among the selected planned adaptation actions in the agricultural sector [1]. The vulnerability of the agricultural sector due to climate changes has driven many countries to set up the programs and policies heading towards maximizing the utilization of its limited resources, especially the irrigation water supply and arable land to produce high-value crops like fruits and vegetables. However, to provide the crop water requirements is one of the most important crop production factors that following its decrease, the crop yield will be reduced as well [2]. Although the farmers intend to use the maximum water for irrigating the crop, this is only available in the case of no limitation of water resources. Under such conditions, it is required that the water use efficiency has to be optimized in the field [3]. When the crop water requirement is not met, the crop encounters the water stress; as a result, the crop yield is reduced. The crop water stress and the yield reduction was varied for the different crops [4].

The rapid population growth in Indonesia is a challenge that has to be faced. Therefore, the various developments in the food production are necessary to be increased. The irrigation area of Karang Anyar has a problem in water allocation which has not been enough for irrigating mainly in the dry season. One of the approaches is to carry out the optimization study of cropping pattern for determining the optimal cropping pattern and planting area to obtain the maximum net benefit. Various modelling approaches have been applied to optimize the cropping pattern worldwide including the linear and nonlinear optimization models [5]-[8]; deterministic linear programming and chance-constrained linear programming models [9], the interactive fuzzy multi-objective optimization approach [10], the goal program approach [9], the multi-objective fractional goal programming approach [12], and the genetic algorithm model [13].

This study intends to know the optimal cropping pattern based on the planting area and maximum net benefit. To support the aim of the study, some analysis will be carried out such as the condition of available water balance, the irrigation water requirement, the cropping intensity, and the maximum net benefit. The Linear Programming is used for solving this problem.

2. MATERIALS AND METHODS

The irrigation area of Karang Anyar is located in the Poncokusumo district-Malang regency-East Java Province-Indonesia. This irrigation area obtains the water from Kali Amprong and the area is 436 ha. The irrigation scheme is presented as in the Fig. 1.

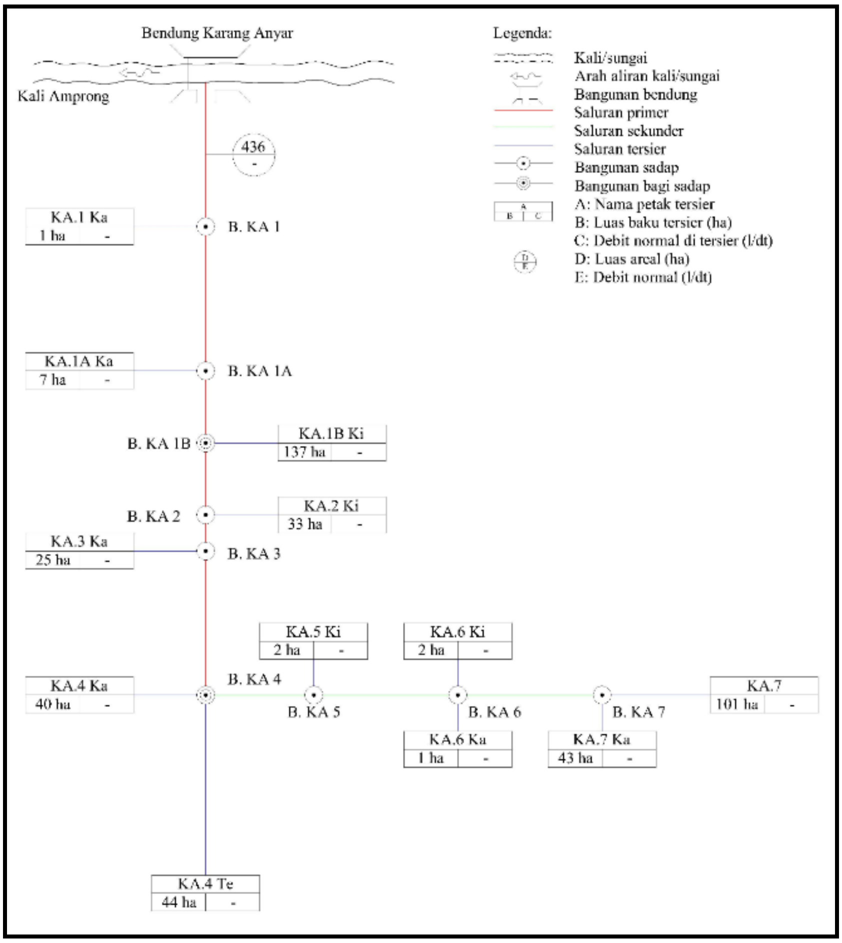

Fig. 1 Irrigation network scheme of Karang Anyar irrigation area
Source: General work institution of Malang regency water resources

The steps of study analysis are as follow: 1) To carry out the hydrological analysis which consists of the potential evapotranspiration analysis by using the Modified Penman method, the consistency test of rainfall data by using the double mass curve method, the area rainfall analysis by using the arithmetic mean method, the dependable rainfall analysis by using the basic year method, the effective rainfall analysis, and the dependable discharge analysis by using the Weibull method in the low (Q_{80}), normal (Q_{50}), and moderate (Q_{25}) discharge condition; 2) To analyze the parameter of irrigation water requirement which consists of percolation, water need for preparation by using the Van de Goor and Zijlstra method, water layer change for paddy, cropping coefficient, and efficiency of irrigation; 3) To analyze the cropping water requirement (consumptive use) by making the cropping pattern due to the influenced factors of irrigation, cropping schedule, and the scenario of cropping pattern; 4) To determine the linear mathematical model which consists of the constraints (planting area, cropping water requirement, and dependable discharge) and the objective function (optimal planting area and maximum net benefit); and 5) The optimization analysis of cropping pattern is analyzed by using the Linear Programming with the solver facility on the Microsoft excel.

3. RESULTS AND DISCUSSION

3.1 Existing irrigation water requirement

The existing cropping pattern in the Karang Anyar irrigation area is paddy-second crop and cane. The planting area for each crop is presented as in Table 1.

Table 1. Existing planting area of each crop in the Karang Anyar irrigation area

Type of crop	Area (ha)		
	Rainy season	Dry season-1	Dry season-2
Paddy	329.00	230.00	82.00
second crop	87.00	150.00	177.00
Cane	20.00	20.00	20.00
Percentage (%)	100.00	91.74	63.99

Source: General work institution of Malang regency water resources

The cropping water requirement (consumptive use) or generally is mentioned as Netto Farm Requirement (NFR) is determined by as follow [14] land preparation (LP), 2) consumptive use (ETc), 3) percolation (P), 4) water layer change (WLR), 5) effective rainfall (Re), 6) efficiency of irrigation (ef), and 7) cropping pattern. However, the irrigation water requirement (mm/day) can be formulated as follow: $NFR = ETc + P + LP + WLR - Re_{paddy}$; the net water requirement for second crop and cane (mm/day): $NFR = ETc + P - Re_{spond\ crop\ and\ cane}$; the net water requirement in intake (m^3/s): $DR = (NFR_{total} \times \text{planting area}) / ef$. Based on the analysis result of irrigation water requirement and then it is compared with the irrigation water availability, it can be known that there is happened water imbalance on the dry season-I and II.

3.2 Scenario of irrigation water requirement

This study intends to carry out 5 scenario of cropping pattern with the cropping schedule due to the existing condition (Dec-March, April – July, and August – Nov). Table 2 presents the optimization scenario of cropping pattern.

Table 2. The scenario of cropping pattern

The scenario of the crop. pattern	Cropping season		
	Rainy season	Dry season-I	Dry season-II
Alt-1	paddy	paddy	paddy
	second cr.	second cr.	second cr.
	cane	cane	cane
Alt-2	paddy	paddy	paddy
	-	-	-
	cane	cane	cane
Alt-3	paddy	paddy	-
	second cr.	second cr.	second cr.
	cane	cane	cane
Alt-4	paddy	paddy	-
	second cr.	-	second cr.
	cane	cane	cane
Alt-5	paddy	-	paddy
	-	second cr.	second cr.
	cane	cane	cane

The analysis of water requirement is carried out until the calculation of net water requirement (NPR) which has been divided by the efficiency of irrigation. Then, it converses into the volume of cropping water requirement per-unit area. The result is presented as in Table 3. The water requirement on the existing cropping pattern indicates that the minimum volume is 0 m^3/ha (rainy season) and the maximum volume is 123.90 m^3/ha (dry season).

Table 3. The volume of cropping water requirement per-unit area for the existing cropping pattern/ alternative-1

Month	Period	Cropping season	Irrigation water requirement					
			l/s/ha			m^3ha		
			paddy	sec.crop	cane	paddy	sec.crop	cane
	I		0.92	0.00	0.00	79.75	0.00	0.00
Dec	II		0.81	0.00	0.00	69.70	0.00	0.00
	III		0.96	0.27	0.41	83.22	23.43	35.70
	I		0.78	0.60	0.57	67.67	51.80	49.28
Jan	II		0.76	0.70	0.48	65.42	60.67	41.51
	III	Rainy season	0.76	0.77	0.42	65.92	66.88	36.08
	I		0.16	0.67	0.01	13.61	57.57	0.58
Feb	II		0.64	0.61	0.51	55.05	52.75	44.19
	III		0.37	0.50	0.62	32.36	43.29	53.73
	I		0.18	0.31	0.33	15.72	26.96	28.50
Mar	II		0.58	0.02	0.32	50.12	1.55	27.66
	III		1.47	0.00	0.70	126.65	0.00	60.09
	I		1.52	0.00	0.59	131.43	0.00	50.76
Apr	II		0.90	0.09	0.41	77.52	7.53	35.14
	III		0.96	0.36	0.78	83.06	31.18	67.64
	I		0.94	0.71	0.90	81.35	61.40	77.39
May	II		0.94	0.80	0.82	81.19	68.82	71.28

	III	Dry season-I	1.14	0.86	0.92	98.12	74.02	79.81
	I		1.19	0.93	0.99	103.00	80.37	85.18
Jun	II		1.09	0.89	0.99	94.55	76.51	85.73
	III		0.84	0.80	0.99	72.34	68.92	85.73
	I		0.98	0.64	1.02	84.50	55.03	88.35
Jul	II		1.39	0.36	1.02	120.17	30.76	88.35
	III		1.84	0.10	1.02	158.93	8.96	88.35
	I		2.09	0.12	1.20	180.22	10.65	103.35
Aug	II		1.75	0.40	1.20	150.93	34.58	103.35
	III		1.41	0.71	1.20	121.66	61.12	103.35
	I		1.52	1.09	1.43	131.19	94.15	123.90
Sep	II		1.59	1.22	1.43	137.77	105.59	123.90
	III	Dry season-II	1.67	1.31	1.43	144.34	113.60	123.90
	I		1.62	1.31	1.16	139.58	113.31	99.98
Oct	II		1.50	1.24	1.16	129.60	106.99	99.98
	III		1.10	1.09	1.13	94.96	94.58	97.20
	I		0.89	0.49	0.65	76.66	42.31	56.34
Nov	II		1.01	0.13	0.41	87.26	11.25	35.00
	II		1.36	0.00	0.31	117.84	0.00	26.94

3.3 Optimization analysis by using Linear Programming

Linear Programming is used for solving the cases which all of the variables in the constraint and objective function have the linear relation [15]. The mathematical modelling in this optimization analysis is as follow:

The objective function: to optimize the planting area (X_{mn}) and the benefit of every season (Z_m):

$Z_1 = A.X_{1p} + B.X_{1j} + C.X_{1t}$; $Z_2 = A.X_{2p} + B.X_{2j} + C.X_{2t}$; $Z_3 = A.X_{3p} + B.X_{3j} + C.X_{3t}$

The constraints are as follow:

The planting area of paddy in Karang Anyar irrigation area is 436 ha (X_{total})

$X_{1p} + X_{1j} + X_{1t} \leq X_{total}$; $X_{2p} + X_{2j} + X_{2t} \leq X_{total}$; $X_{3p} + X_{3j} + X_{3t} \leq X_{total}$

Maximum planting area of cane in Karang Anyar irrigation area is 20 ha (X_{cane})

$X_{1t} \leq X_{cane}$; $X_{2t} \leq X_{cane}$; $X_{3t} \leq X_{cane}$

The volume of the crop water requirement per-unit area for every alternative is V_{mn} and the volume of irrigation water availability in the low, normal, and moderate discharge condition is V_{mq}

Low discharge condition ($Q_{80\%}$)

$V_{1p}.X_{1p}+V_{1j}.X_{1j}+V_{1t}.X_{1t} \leq V_{1r}$; $V_{2p}.X_{2p}+V_{2j}.X_{2j}+V_{2t}.X_{2t} \leq V_{2r}$; $V_{3p}.X_{3p}+V_{3j}.X_{3j}+V_{3t}.X_{3t} \leq V_{3r}$

Normal discharge condition ($Q_{50\%}$)

$V_{1p}.X_{1p}+V_{1j}.X_{1j}+V_{1t}.X_{1t} \leq V_{1n}$; $V_{2p}.X_{2p}+V_{2j}.X_{2j}+V_{2t}.X_{2t} \leq V_{2n}$; $V_{3p}.X_{3p}+V_{3j}.X_{3j}+V_{3t}.X_{3t} \leq V_{3n}$

Moderate discharge condition ($Q_{25\%}$)

$V_{1p}.X_{1p}+V_{1j}.X_{1j}+V_{1t}.X_{1t} \leq V_{1n}$; $V_{2p}.X_{2p}+V_{2j}.X_{2j}+V_{2t}.X_{2t} \leq V_{2n}$; $V_{3p}.X_{3p}+V_{3j}.X_{3j}+V_{3t}.X_{3t} \leq V_{3n}$

Where: m = cropping season; n = type of crop; p, j, t = paddy, second crop, cane; q = condition of dependable discharge; r, n, c = low, normal, moderate; Z_m = objective function in every cropping season (maximum net benefit) (Rp); A, B, C = net benefit every cropping season of paddy (A), second crop (B), and cane (C) (Rp/ha); X_{mn} = decision variable such as planting area of every cropping season and every type of crop (ha); V_{mn} = volume of 10 daily crop water requirement per-unit area of every cropping season and every type of crop (m^3/ha); V_{mq} = volume of irrigation water availability of every cropping season (m^3)

The objective function and constraints above are as the example for three cropping seasons with the cropping pattern for the consecutive three seasons is paddy, second crop, and cane per-cropping season. The objective function and constraints have to be adjusted for the other scenario of cropping pattern

The optimization result produces the total volume of irrigation water requirement, planting area, and the maximum net benefit due to the constraint of irrigation water availability in the low (Q_{80}), normal (Q_{50}), and moderate (Q_{25}) discharge condition. Based on the result, it can be analyzed the cropping intensity and it can be compared with the existing condition. Table 4 presents the percentage of irrigation water usage during one year each for the low (Q_{80}), normal (Q_{50}), and moderate (Q_{25}) discharge condition. The mean of water usage is about 63.74% for Q_{80}; 58.51% for Q_{50}; and 59% for Q_{25} due to the water availability.

Table 4. Irrigation water usage percentage during one year on the low (Q_{80}), normal (Q_{50}), moderate (Q_{25}) discharge condition

The scenario of the crop. pattern	Water requirement (m^3)	Water availability (m^3)	Percentage (%)
Alt-1	625,529.61		71.53
Alt-2	484,258.80	Q_{80}	55.38
Alt-3	573,872.52	874,454.40	65.63
Alt-4	553,355.01		65.28
Alt-5	532,326.98		60.88
Alt-1	983,141.91		65.52
Alt-2	799,429.20	Q_{50}	55.20
Alt-3	863,819.20	1,202,523.84	58.56
Alt-4	814,729.61		56.34
Alt-5	814,049.55		56.91
Alt-1	983,141.91		67.84
Alt-2	799,429.20	Q_{25}	55.16

Alt-3	863,819.20	1,449,213.12	59.61
Alt-4	814,729.61		56.22
Alt-5	814,049.55		56.17

Table 5, 6, and 7 present the optimal planting area and cropping intensity due to the irrigation water availability on the low (Q_{80}), normal (Q_{50}), and moderate (Q_{25}) discharge condition. On the low discharge condition (Q80): the maximum cropping intensity is on the existing condition that is 255.73%, however, the minimum one is on the alternative-2 that is 113.98%. On the normal discharge condition (Q_{50}): the maximum cropping pattern is on the existing condition that is 255.73%, however, the minimum one is on alternative-2 that is 143.00% On the moderate discharge condition (Q_{25}): the maximum cropping pattern is on the alternative-3 that is 262.99%, however, the minimum one is on alternative-2 that is 163.01%

Table 5. Optimal planting area and cropping intensity on the low discharge condition (Q_{80})

Scenario of crop, pattern	Cropping pattern	Crop, area (ha)	Crop.intensity (%)	Total of the crop. Intensity (%)
Existing	Rainy season	436.00	100.00	
	Dry season-1	400.00	91.74	255.73
	Dry season-2	279.00	63.99	
Alt-1	Rainy season	436.00	100.00	
	Dry season-1	294.96	67.65	187.39
	Dry season-2	86.07	19.74	
Alt-2	Rainy season	243.81	55.92	
	Dry season-1	167.08	38,32	113.98
	Dry season-2	86.07	19.74	
Alt-3	Rainy season	436.00	100.00	
	Dry season-1	273.19	62.66	188.36
	Dry season-2	112.06	25.70	
Alt-4	Rainy season	436.00	100.00	
	Dry season-1	236.77	54.31	180.01
	Dry season-2	112.06	25.70	
Alt-5	Rainy season	410.12	94/06	
	Dry season-1	334.21	76.65	190.46
	Dry season-2	86.07	19.74	

Table 6. Optimal planting area and cropping intensity on the normal discharge condition (Q_{50})

Scenario of Crop.pattern	Cropping Pattern	Cropping Area (ha)	Crop. intensity (%)	Total of Crop. Intensity (%)
Existing	Rainy season	436.00	100.00	
	Dry season-1	400.00	91.74	255.73
	Dry season-2	279.00	63.99	
Alt-1	Rainy season	436.00	100.00	
	Dry season-1	387.16	88.80	221.33
	Dry season-2	141.86	32.54	
Alt-2	Rainy season	297.71	68.28	
	Dry season-1	183.94	42.19	143.00
	Dry season-2	141.86	32.54	
Alt-3	Rainy season	436.00	100.00	
	Dry season-1	350.25	80.33	219.35
	Dry season-2	170.11	39.02	
Alt-4	Rainy season	436.00	100.00	
	Dry season-1	302.87	69.47	208.48
	Dry season-2	170.11	39.02	
Alt-5	Rainy season	436.00	100.00	
	Dry season-1	429.89	98.60	231.44
	Dry season-2	141.86	32.54	

Table 8, 9, and 10 present the net benefit of the optimization result in each on the low (Q_{80}), normal (Q_{50}), and moderate (Q_{25}) discharge condition. On the low discharge condition (Q_{80}): the maximum benefit is on the existing condition that is Rp. 15,728,034,400.-. On the normal discharge condition (Q_{50}): the maximum benefit is on the existing condition that is Rp. 15,728,034,400.-. On the moderate discharge condition (Q_{25}): the maximum benefit is on the existing condition that is Rp. 15,728,034,400.-

Table 7. Optimal planting area and cropping intensity on the moderate discharge condition (Q_{50})

Scenario of Crop.pattern	Cropping pattern	Cropping Area (ha)	Cropping Intensity (%)	Total of Crop. Intensity (%)
Existing	Rainy season	436.00	100.00	
	Dry season-1	400.00	91.74	255.73
	Dry season-2	279.00	63.00	
Alt-1	Rainy season	436.00	100.00	
	Dry season-1	436.00	100.00	257.56
	Dry season-2	250.98	57.56	
Alt-2	Rainy season	342.18	78.48	
	Dry season-1	226.67	51.99	163.01
	Dry season-2	141.86	32.54	
Alt-3	Rainy season	436.00	100.00	
	Dry season-1	418.54	96.00	262.99
	Dry season-2	292.11	67.00	
Alt-4	Rainy season	436.00	100.00	
	Dry season-1	331.42	76.01	243.01
	Dry season-2	292.11	67.00	
Alt-5	Rainy season	436.00	100.00	
	Dry season-1	436.00	100.00	257.56
	Dry season-2	250.98	57.56	

Table 8. Recapitulation of the net benefit of the optimization result on the low discharge condition (Q_{80})

Scenario of Cropping pattern	Cropping pattern	Benefit per-crop.pattern (Rp)	Total of benefit (Rp)
Existing	Rainy season	6,713,883,600.-	
	Dry season-1	5,621,532,000.-	15,728,034,400.-
	Dry season-2	3,392,618,800.-	
Alt-1	Rainy season	5,892,546,844.-	
	Dry season-1	3,982,701,514.-	11,432,136,668.-
	Dry season-2	1,556,888,310.-	
Alt-2	Rainy season	4,187,854,305.-	
	Dry season-1	2,908,094,809.-	8,652,837,424.-
	Dry season-2	1,556,888,310.-	
Alt-3	Rainy season	5,892,546,844.-	
	Dry season-1	4,393,405,651.-	11,557,536,387.-
	Dry season-2	1,271,583,892.-	
Alt-4	Rainy season	5,892,546,844.-	
	Dry season-1	4.070,429,417.-	11,234,560.152.-
	Dry season-2	1,271,583,892.-	
Alt-5	Rainy season	6,529,265,568.-	
	Dry season-1	2,809,819,204.-	10,895,973,582.-
	Dry season-2	1,556,888,310.-	

Table 9. Recapitulation of the net benefit of the optimization result on the normal discharge condition (Q_{50})

Scenario of Cropping pattern	Cropping pattern	Benefit per-cropping pattern (Rp)	Total of benefit (Rp)
Existing	Rainy season	6,713,883,600.-	
	Dry season-1	5,621,532,000.-	15,728,034,400.-
	Dry season-2	3,392,618,800.-	
Alt-1	Rainy season	6,313,352,578.-	
	Dry season-1	4.896,975,185.-	13,697,731,526.-
	Dry season-2	2,487,403,763.-	
Alt-2	Rainy season	5,086,676,901.-	
	Dry season-1	3,189,174,338.-	10,763,255,001.-
	Dry season-2	2,487,403,763.-	
Alt-3	Rainy season	6,313,352,578.-	
	Dry season-1	5,593,132,648.-	13,692,933,443.-
	Dry season-2	1,786,448,218.-	
Alt-4	Rainy season	6,313,352,578.-	
	Dry season-1	5,172,845,742.-	13,272,646,538.-
	Dry season-2	1,786,448,218.-	
Alt-5	Rainy season	7,393,214,400.-	
	Dry season-1	3,658,481,475.-	13,539,099,637.-

	Dry season-2	2,187,403,763.-	

Table 10. Recapitulation of the net benefit of the optimization result on the moderate discharge condition (Q_{25})

Scenario of Cropping pattern	Cropping pattern	Benefit per-cropping pattern (Rp)	Total of benefit (Rp)
Existing	Rainy season	6,713,883,600.-	
	Dry season-1	5,621,532,000.-	15,728,034,100.-
	Dry season-2	3,392,618,800.-	
Alt-1	Rainy season	6,660,650,475.-	
	Dry season-1	5,661,033,513.-	16,210,830,822.-
	Dry season-2	3,889,146,833.-	
Alt-2	Rainy season	5,828,489,980.-	
	Dry season-1	3,901,846,949.-	13,197.134,504.-
	Dry season-2	3,466,797,575.-	
Alt-3	Rainy season	6,660,660,475.-	
	Dry season-1	6,421,806,769.-	15,951,071,409.-
	Dry season-2	2,868,611.165	
Alt-4	Rainy season	6,660,650,475.-	
	Dry season-1	5,649,063,321.-	15,178,327,961.-
	Dry season-2	2,868,614.165	
Alt-5	Rainy season	7,393,214,400.-	
	Dry season-1	4,144,920,000.-	15,427,281,233.-
	Dry season-2	3,889,146,833.-	

Selection of the best cropping pattern is based on the biggest percentage increasing or the smallest percentage decreasing of the cropping intensity. Based on the analysis as above, it can be known that the alternative-5 of cropping pattern can be applied to the law (Q_{80}) and moderate (Q_{50}) discharge condition. However, the cropping intensity on the condition is decreasing from the existing condition that is each for 25.53% and 9.62%. In addition, the alternative-3 of cropping pattern can be applied on the moderate (Q_{25}) discharge condition. Based on the recapitulation of crop intensity, the alternative-3 of cropping pattern is increasing in the amount of 2.85% from the existing condition.

Generally, it can be concluded that the alternative-5 cropping pattern can be applied on the low (Q_{80}) and normal (Q_{50}) discharge condition, however, the alternative-3 of cropping pattern can be applied on the moderate (Q_{25}) discharge condition. The percentage of water allocation for each crop in all discharge condition is similar, it is due to the standard of unit price for each crop production [11][15].

4. CONCLUSION

Based on the analysis as above, it can be concluded as follow: the water balance on the existing condition (cropping season (2015/2016) in the Karang Antyar irrigation area indicates that the irrigation water availability is a deficit to cover the irrigation water requirement on the dry season-I and II. It is caused by the composition of planting area which is applied has not still been suitable for the irrigation water availability.

Based on the biggest percentage increasing or the smallest percentage decreasing from the existing condition of cropping intensity, it is produced the optimal result due to the irrigation water availability as follow:

- Low (Q_{80}) discharge condition: alt-5 (paddy, cane-second crop, cane-second crop, cane), the cropping intensity is 190.46%, and the benefit is Rp. 10,895,973,582,-
- Normal (Q_{50}) discharge condition: alt-5 (paddy, cane-second crop, cane-second crop, cane), the cropping intensity is 231.14%, and the benefit is Rp. 13,539,099,637,-
- Moderate (Q_{25}) discharge condition: alt-3 (paddy, second crop, cane-paddy, second crop, cane-second crop, cane), the cropping intensity is 262.99%, and the benefit is Rp. 15,951,071,409,-

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