International Journal of Scientific Engineering and Science
Volume 5, Issue 12, pp. 61-66, 2021. ISSN (Online): 2456-7361

Comparison of Cropwat 8.0 and KP-1 in Analysis of Irrigation Water Needs in Cimulu Irrigation Area

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Abstract*— The capacity of water demand in the Irrigation Area is very important, because it will determine the dimensions of all facilities and infrastructure buildings in the Irrigation Area. Water demand in an irrigation area can be determined by various methods, two of which are the Cropwat 8.0 method issued by FAO and the Ministry of Public Works method as in the Irrigation Planning Guidelines for the Irrigation Network Section or KP-01. Cimulu Irrigation Area is located in Tasikmalaya City and Tasikmalaya Regency. The Cimulu Irrigation Area (DI) covering an area of 1546.20 ha is irrigated from the Cimulu Dam in Tawangsari Village, Tawang District, Tasikmalaya City, located at 7* 19′ 14.6" South Latitude and 108* 13′ 17.4" East Longitude. The Cimulu weir is located on the Ciloseh river, which is under the management of the Citanduy River Area PSDA. Cimulu Irrigation Area (DI) which is part of the upstream Citanduy Service Unit (SUP) Balai PSDA Citanduy River Area which consists of 3 (three) Observer Working Areas, namely (1) Cimulu Observer Working Area with an area of 1008 ha of rice fields, (2) The Dalemsuba Observer Working Area with an irrigation area of 316.20 ha (3) Cihanjang Observer Working Area with an area of 222 ha of rice fields. The results of the analysis show that the highest value of irrigation water requirements for the KP-01 method occurs in the month of Dec_1 of 1.93 m3/sec, for the Cropwat 8.0 method, it occurs in the month of Sep_1 of 1.10 m3/sec. Comparison of the value of irrigation water needs in the month of Dec_1 KP-01-Cropwat 8.0 is 1.93 and 0.61 and in Sep-1 is 1.62 and 1.10. In general, the value of irrigation water requirements for the KP-01 method is greater than the Cropwat 8.0 method.*

Keywords*— Cropwat 8.0, Irrigation Water Needs, KP 01.*

I. INTRODUCTION

Water demand in an irrigation area can be determined by various methods, two of which are the Cropwat method. 8.0 and Methods as in the Irrigation Planning Guidelines for Irrigation Network Section or KP-01. The Cropwat.8.0 method issued by FAO is an application in a practical way to find the amount of water needed by plants using software. The amount of water needed for plants is also in KP 01 issued by the Ministry of Public Works, Directorate of Water Resources, Directorate of Irrigation and Swamp Irrigation Planning Standards, Criteria for Planning for the Irrigation Network Planning Section. Both methods will be compared the results of the analysis in the Cimulu Irrigation Area.

Cimulu Irrigation Area is located in Tasikmalaya City and Tasikmalaya Regency. The Cimulu Irrigation Area (DI) covering an area of 1546.20 ha is irrigated from the Cimulu Dam in Tawangsari Village, Tawang District, Tasikmalaya City, located at 7* 19′ 14.6" South Latitude and 108* 13′ 17.4" East Longitude. The Cimulu weir is located on the Ciloseh river, which is under the management of the Citanduy River Area PSDA. Cimulu Irrigation Area (DI) which is part of the upstream Citanduy Service Unit (SUP) Balai PSDA Citanduy River Area which consists of 3 (three) Observer Working Areas, namely (1) Cimulu Observer Working Area with an area of 1008 ha of rice fields, (2) The Dalemsuba Observer Working Area with an irrigated area of 316.20 ha (3) Cihanjang Observer Working Area. Drought in the Cimulu Irrigation Area in the previous study was 306 ha or 19.63% of the total irrigation area of 1546.2 ha.

II. RESEARCH METHODOLOGY

The irrigation water requirement for the purposes of comparative analysis of the Cropwat 8.0 method with the KP-01 method applied the same treatment, namely the division of the group system into 4 groups with a total area of 1546.2 ha with the same cropping pattern for each group, namely rice-paddy-palawija. The following picture is a simulation of class division and pattern, planting schedule and planting area for each group.

<table>
<tr><th rowspan="3">Group</th><th colspan="24">Month</th></tr>
<tr><th colspan="2">Nov</th><th colspan="2">Dec</th><th colspan="2">Jan</th><th colspan="2">Feb</th><th colspan="2">Mar</th><th colspan="2">Apr</th><th colspan="2">May</th><th colspan="2">Jun</th><th colspan="2">Jul</th><th colspan="2">Aug</th><th colspan="2">Sep</th><th colspan="2">Oct</th></tr>
<tr><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th><th>1</th><th>2</th></tr>
<tr><td>A</td><td colspan="8">MT-1:3162 ha</td><td colspan="8">MT-2:3162 ha</td><td colspan="8">MT-3:3162 ha</td></tr>
<tr><td>B</td><td></td><td colspan="8">MT-1:651ha</td><td colspan="8">MT-2:651ha</td><td colspan="7">MT-3:651ha</td></tr>
<tr><td>C</td><td colspan="2"></td><td colspan="8">MT-1:357 ha</td><td colspan="8">MT-1:357 ha</td><td colspan="6">MT-1:357ha</td></tr>
<tr><td>D</td><td colspan="5"></td><td colspan="8">MT-1:222 ha</td><td colspan="7">MT-2:222 ha</td><td colspan="4">MT-3:222ha</td></tr>
</table>

Fig. 1. Group Division

This research method was carried out by analyzing data from various measurement results, including analysis of rainfall data from rainfall measurements at three stations, namely Cimulu Rainfall Station, Cibeureum Rainfall Station, and Manonjaya Rainfall Station. Tasikmalaya climatological data, Cimulu weir irrigation network layout data and water availability discharge data at Cimulu weir.

Location

The research location was conducted in the Cimulu Irrigation Area in the City and District of Tasikmalaya. The Cimulu Irrigation Area with Cimulu Weir is on the Ciloseh

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River which is located in Tawangsari Village, Tawang District, Tasikmalaya City, West Java Province or geographical coordinates are located at 7o 19' 14.34" South Latitude and 108o 13' 17.55" East Longitude, with an area of about 1546 DI ,2 ha.

The following is a map of the Tasikmalaya:

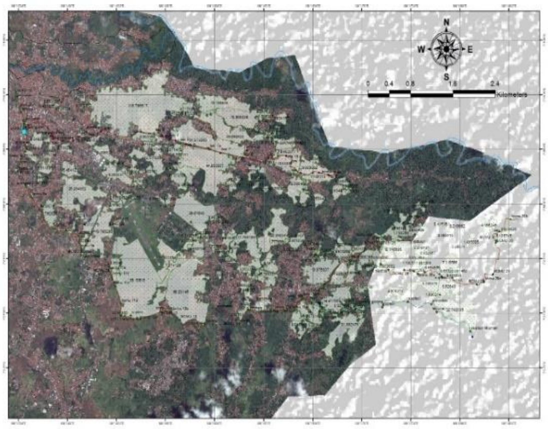

Fig. 2. Adminstration Map

Tool

The tools used in this research are Microsoft Excel, Microsoft Word, and Cropwat 8.0 software.

Data analysis

Cropwat Irrigation Water Needs Analysis 8.0

The analysis stages of using Cropwat version 8 software are as follows,

a. Run the Cropwat 8.0 software

b. Click the Climate/Eto icon

Analysis of evapotranspiration using the Penman Monteith method:

$$ET_o = \frac{0{,}408\,\Delta R_n + \gamma \frac{900}{(T+273)} U_2 (e_s - e_a)}{\Delta + \gamma (1 + 0{,}34 U_2)} \quad (1)$$

Description:

ET0 =Reference plant evapotranspiration, mm/day
Rn =Net radiation on plant surface, MJ/m2/day
G =Density of continuous heat in the soil, MJ/m2/day
T =Average daily temperature at an altitude of 2 meters,0C
U2 = Wind speed at a height of 2 meters, m/s
Ice = Saturated vapor pressure, kPa
ea = Actual vapor pressure, kPa
Δ = Vapor pressure slope, kPa/0C
γ = Psychometric constant, kPa/0C

c. Input climatological data in the form of:

- Input country data, the country where the climatological data are obtained.
- Input data station, recording climatology station.
- Input altitude data, the height of the recording station.
- Input latitude data, latitude (North/South).
- Input longitude data, latitude (East/West).
- Input maximum and minimum temperature data (°C/°F/°K).
- Input relative humidity data (%, mm/Hg, kpa, mbar).
- Input wind speed data (km/day, km/hour, m/s, mile/day, mile/hour).
- Input sun exposure data (hours or %)
- ETo automatically accumulates and the results are immediately listed.

d. Click the Rain icon.

- Input rainfall data
- Total rain data for each month from January to December.
- Select and fill in the calculation method,
- Fixed Percentage (70% for rice calculation; 50% for secondary crops)
- Automatically the effective rainfall accumulates and the effective rain results for paddy and secondary crops are immediately listed.

e. Click the crop icon

- Input crop data by taking from the FAO – Rice and FAO-Palawija data base according to the plan for the type of crop to be planned, then edit the initial planting date according to the planned planting schedule.
- Next click the soil icon
- Input soil data by, for example, taking from the FAO-Medium database according to the soil data in the irrigated area.

f. Click the CWR icon to view the results of the analysis of irrigation water needs.

Schematically, it can be seen in Figure 3 below

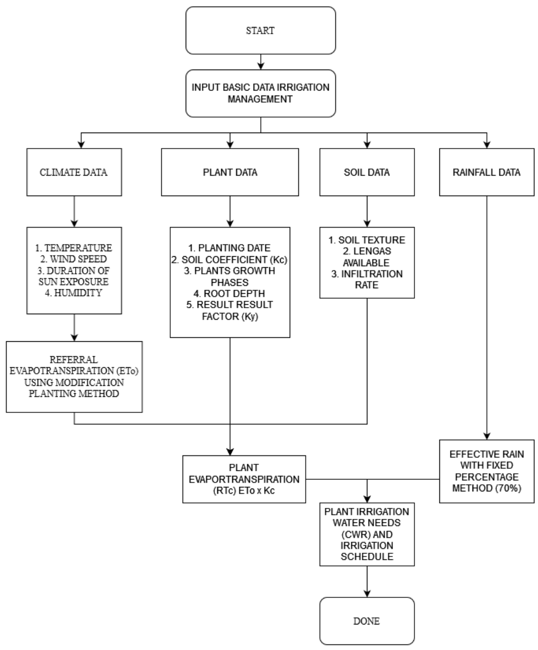

Fig. 3. Flowchart Water Demand Analysis Cropwat 8.0

Analysis of Irrigation Water Needs KP-01

Data analysis is divided into several stages, including:

1. Climatological Analysis

International Journal of Scientific Engineering and Science
Volume 5, Issue 12, pp. 61-66, 2021.
ISSN (Online): 2456-7361

The evapotranspiration value of the Ciloseh River Irrigation Area uses the Modified Penman method because the data obtained are in accordance with this method.

Analysis of potential evapotranspiration (ETo) using the Modified Penman method are:

$$ETo = c(W.Rn + (1-W).f(u).(ea-ed)) \quad (2)$$

Description :
Eto = Reference evapotranspiration (mm/day)
c = coefficient of albedo or coefficient of reflection
W = Factors that affect sunlight
C = Adjustment factor for weather conditions due to day and night
Rns = Solar radiation (mm/day), where:
Rn1 = net longwave radiation (mm/hr)
Ra = Extraterrestrial radiation or member . value
f(T) = temperature function
n/N = Solar radiation ratio in 1 day (%)
f(n/N) = Sun irradiation ratio function in 1 day
f(u) = Relative wind function
ea = Saturated vapor pressure (mbar)
ed = real vapor pressure (mbar)
RH = Relative humidity
f(ed) = real vapor pressure function

2. Rainfall Analysis

Analysis of the average rainfall using the algebraic average method with the following formula:

$$R = \frac{1}{n}(R_1 + R_2 + R_3 + ... + R_n) \quad (3)$$

Description :
R = regional rainfall (mm)
N = number of observation points (posts)
R1+ R2+⋯+Rn = rainfall at each observation point (mm)

Effective rain is the portion of the total rain that can be utilized by plants, after some is lost due to interception, runoff and percolation. The effective rainfall for rice is 70% of the half-monthly rainfall that is exceeded by 80%. The effective rainfall for secondary crops is 50% of the semi-monthly rainfall which has exceeded 80%. The 80% rain exceeded formula is as follows:

$$R_{80} = \frac{m}{n+1} \quad (4)$$

Description :
M = R_80 x (n+1)
R_80 = 80% rainfall exceeded
N = Number of data
M = Preferred rainfall rank

Analysis of irrigation water needs

Land preparation

Analysis of water demand during land preparation, used the method developed by Van De Goor and Zjistra, as follows:

$$IR = \frac{Me^k}{e^k - 1} \quad (5)$$

Description :
IR= Irrigation water requirement at rice field level (mm/day)
M= Water requirement to replace water loss due to evaporation and percolation in saturated rice fields

$$M = Eo + P \quad (6)$$

with :
Eo = Evaporation of open water taken 1.1 Eto during land preparation (mm/day)
P = Percolation (mm/day)

$$K = \frac{M \times T}{S} \quad (7)$$

Description :
T = Land preparation period (days)
S = Water requirement, for saturation added with a layer of water 50 mm

a. Consumptive use

Consumptive use is the amount of water used by plants for the photosynthesis process of these plants.

b. Percolation and seepage

Percolation is the downward movement of water from the unsaturated zone, which is compressed between the soil surface to the ground water surface (saturated zone).

c. Water layer replacement

Replacement of the water layer is done after fertilization. The water layer is replaced as needed. If no such schedule exists, perform 2 replacements, each 50 mm (or 3.3 mm/day for 1/2 month) for a month and two months after transplantation.

Schematically, it can be seen in Figure 4 below,

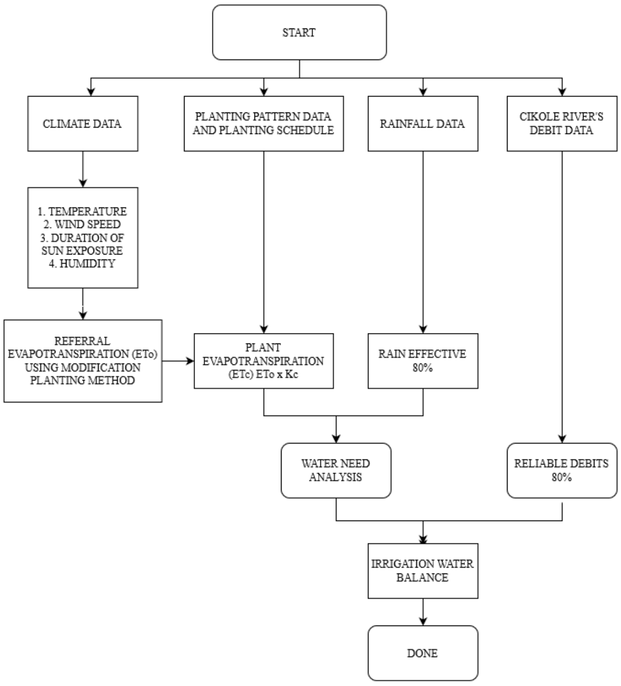

Fig. 4. Flowchart Irrigation Water Demand Analysis KP-01

III. RESULT AND DISCUSSIONS

A. Results

1. Evapotranspiration

Evapotranspiration for analysis of irrigation water needs with the Cropwat 8.0 method used the Pennman-Monteith method, for the KP-01 method the Modified Pennman method was used. The results of the evapotranspiration analysis can be seen in the following table and figure.

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TABLE 1. Comparison of Evapotranspiration Values of Cropwat 8.0 and KP-01

Month	Evapotranspiration (Eto)	
	Cropwat 8.0 (mm/day)	KP-01 (mm/day)
January	3.22	4.13
February	3.67	4.63
March	3.25	3.51
April	3.16	3.33
May	3.06	3.53
June	2.74	3.30
July	3.02	3.39
Augtus	3.36	4.15
September	4.13	5.16
October	4.17	5.57
November	3.05	5.04
December	2.79	4.33

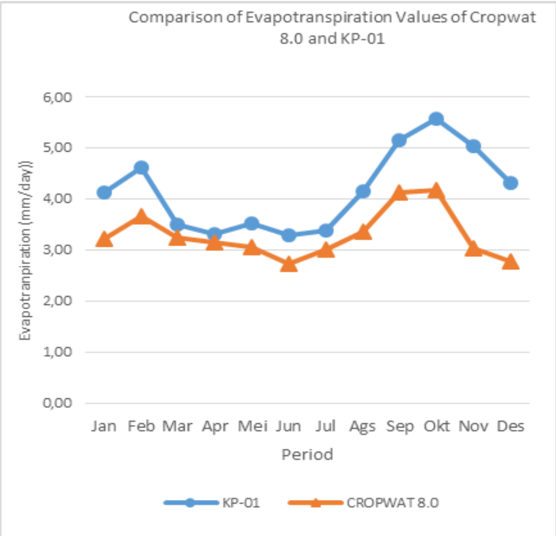

Fig. 5. Comparative Graph of Effective Rainfall of Cropwat 8.0 and KP-01

2. *Effective Rain*

Effective rainfall The Cropwat 8.0 method uses reliable rain (FAO) with an 80% chance of passing which describes dry year conditions. Effective rainfall method KP-01 is determined by 80% chance of missed rain (R80) and rain coefficient for rice plants. The results of the analysis of effective rainfall can be seen in the following table and figure.

TABLE 2. Comparison of Effective Rainfall of Cropwat 8.0 and KP-01

Month		Effective Rain	
		Cropwat 8.0 (mm/day)	KP-01 (mm/day)
Jan	I	4.62	1.76
	II		5.00
Feb	I	9.29	5.38
	II		5.70
March	I	9.62	5.61
	II		5.15
April	I	6.08	5.79
	II		2.76
May	I	3.16	2.09
	II		1.68
June	I	1.63	0.91
	II		0.39
July	I	0.52	0.10
	II		0.03
Augt	I	0.00	0.00
	II		0.00
Sept	I	0.01	0.00
	II		0.02
Oct	I	3.58	0.06
	II		1.51
Nov	I	6.41	3.01
	II		5.81
Dec	I	6.95	4.41
	II		4.53

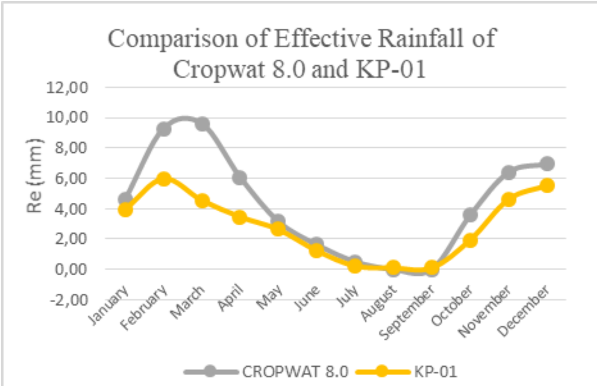

Fig. 6. Comparative Graph of Effective Rainfall of Cropwat 8.0 and KP-01

3. *Irrigation Water Needs*

The need for irrigation water at the time of land cultivation is usually the maximum water requirement. The division of groups will reduce the maximum value of water needs. Water needs were analyzed using the existing cropping pattern, namely rice-paddy-palawija with the type of secondary crop being corn. The results of the analysis of irrigation water requirements for the two methods can be seen in the following table and figure.

TABLE 3. Comparison of Irrigation Water Needs of Cropwat 8.0 and KP-01

Month		Planting Time	Irrigation Water Needs (m3/s)	
			Cropwat 8.0	KP-01
Nov	I	I	0.45	0.63
	II		2.27	1.96
Dec	I		1.92	2.57
	II		1.56	1.86
Jan	I		1.55	1.82
	II		1.15	1.19
Feb	I		0.80	0.86
	II		1.00	0.42
March	I		1.21	0.41
	II		2.96	1.19
April	I	II	1.32	1.44
	II		2.56	1.56
May	I		0.62	0.87
	II		0.99	1.56
June	I		0.66	1.60
	II		0.86	0.88
July	I		0.63	0.29
	II		0.71	0.69
Aug	I		0.74	1.34
	II		0.63	1.62
Sept	I	III	0.65	1.97
	II		0.66	2.03
Oct	I		0.50	1.84
	II		0.15	0.99
Nov	I		0.10	0.31
	II		0.10	0.10
Dec	I		0.05	0.07
	II		0.00	0.00

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International Journal of Scientific Engineering and Science

Volume 5, Issue 12, pp. 61-66, 2021. ISSN (Online): 2456-7361

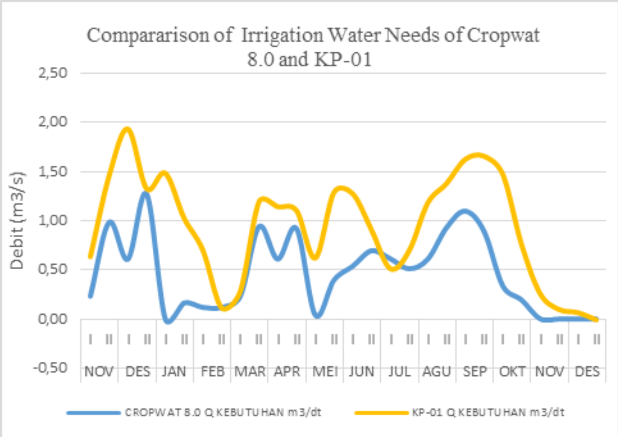

Fig. 7. Comparative Graph of Irrigation Water Needs of Cropwat 8.0 and KP-01

4. *Water Balance*

The value of irrigation water needs will affect the water balance in the Irrigation Area of the research location. Each different input will produce a different equilibrium output. The water balance for the input pattern and planting schedule as described in the scenario will produce a water balance as shown in the table and figure as follows.

TABLE. 4. Comparison of Water Demand and Availability of Cropwat 8.0 and KP-01

Month		Cropwat 8.0		KP-01		Qavaibility
		Q Needs (m3/s)	More (m3/s)	Q Needs (m3/s)	More (m3/s)	
Nov	I	0.23	1.30	0,63	1.12	1.76
	II	0.98	-0,65	1.46	0,16	1.61
Dec	I	0.61	0.89	1.93	-0,13	1.80
	II	1.27	-0,72	1.33	0,38	1.70
Jan	I	0.00	1.19	1.48	0.45	1.93
	II	0.16	1.88	1.03	2.07	3.09
Feb	I	0.12	2.68	0.88	2.83	3.53
	II	0.12	1.45	0,29	2,45	2,56
March	I	0.23	1.65	0,41	2,64	2.92
	II	0.94	-0,15	1,19	1.62	2.81
April	I	0.61	1.38	1.14	1.56	2,71
	II	0.92	0,12	1,32	1.57	2,68
May	I	0.04	1.28	0,88	1,28	1.90
	II	0.40	0.72	1,57	0,43	1.72
June	I	0.54	1.06	1,27	0,44	1.72
	II	0.69	0.97	0,54	0.92	1.83
July	I	0.61	0.65	0,29	0,76	1.27
	II	0.51	0.72	0,69	0,73	1.43
Aug	I	0.61	0.12	1,18	-0,33	0.85
	II	0.93	0.14	1,30	-0,61	0.77
Sept	I	1.10	0.00	1,62	-0,97	0.65
	II	0.89	0.32	1,66	-0,68	0.98
Oct	I	0.34	0.09	1.47	-0,88	0.59
	II	0.20	0.57	0.80	-0,04	0.72
Nov	I	0.00	1.65	0.32	1,50	1.76
	II	0.00	1.52	0.18	1,52	1.61
Dec	I	0.00	1.75	0.07	1,74	1.80
	II	0.00	0.00	0.00	1,71	1.70

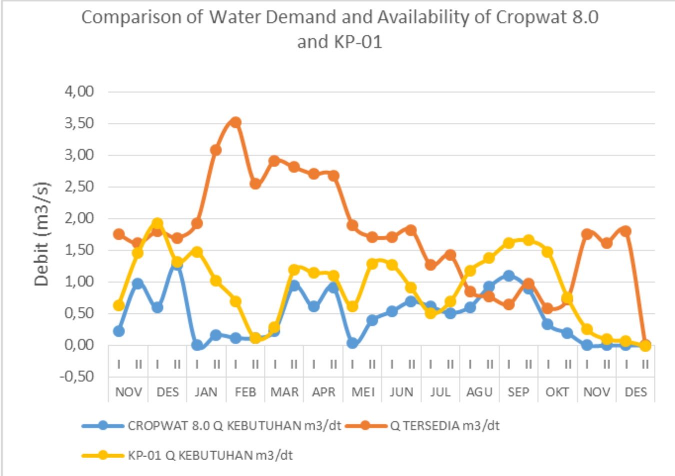

Fig. 8. Comparative Graph of Water Demand and Availability of Cropwat 8.0 and KP-01

B. *Discussion*

1. *Evapotranspiration*

The evapotranspiration pattern is almost similar to the highest evapotranspiration value in October. The evapotranspiration value of the Modified Penman Method occurred in October of 5.57 mm/day and the Penman Monteith method of 4.17 mm/day. The evapotranspiration value of the Modified Penman Method tends to be higher than the Penman Monteith method.

2. *Effective Rain*

The graphic pattern of effective rain is almost the same as the maximum effective rainfall in February and the minimum in September. The value of effective rainfall produced by the Cropwat 8.0 method tends to be greater than the KP-01 method.

3. *Irrigation Water Needs*

The irrigation water requirement of the KP-01 method is generally greater than the Cropwat 8.0 method because the parameters for the analysis are also larger. The maximum irrigation water requirement for the KP-01 method occurred in the December-I period of 1.93 m3/sec, while the Cropwat 8.0 method occurred in the December-II period of 1.27 m^3/sec.

4. *Water Balance*

Analysis of water availability is calculated using the Weibull formula in determining the 80% reliable discharge, the maximum availability value in February-I is 3.53 m3/s, and the minimum availability discharge is 0.59 m3/s in October-I.

The comparison of the two methods when using a simulated scenario shows that the average water availability can meet the water needs of the Cimulu DI. The k factor analysis of Cropwat 8.0 shows a line that tends to be stable, namely the k value is always above 0.65, which means that water needs are always met. The results of the analysis of the KP-01 method, the value of k decreased to k < 0.5 in August-II to October-I. The following figure shows a graph of the value of the k factor.

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Volume 5, Issue 12, pp. 61-66, 2021. ISSN (Online): 2456-7361

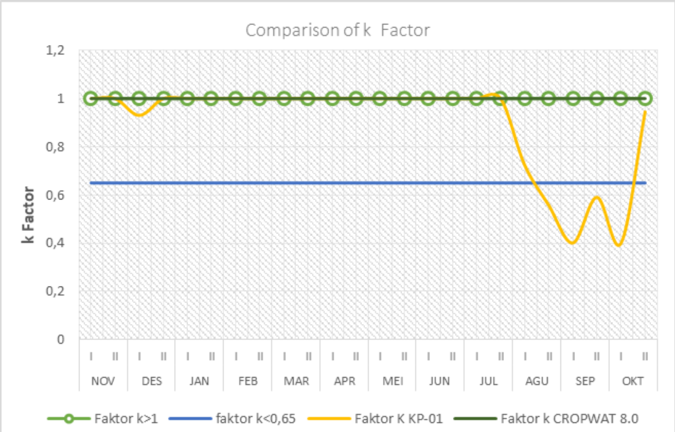

Fig. 9. Graph of Comparison k factor

IV. Conclusions and Suggestions

A. Conclusion

1. Availability of irrigation water for the Cimulu Irrigation Area by calculating the reliable discharge, the minimum availability discharge is 0.59 m3/s and the maximum available discharge is 3.53 m3/sec, respectively, in October-I and February-I
2. The maximum irrigation water requirement from the analysis of the Cropwat 8.0 method occurred in December-II of 1.27 m3/sec and the results of the analysis of the KP-01 method occurred in December-I of 1.93 m3/sec,
3. The need for irrigation water from the analysis of KP-01 tends to be greater than the Cropwat 8.0 method. This condition is reasonable because the results of the analysis of the parameters of the two methods tend to have a pattern that makes the KP-01 method greater than the Cropwat 8.0 method.

B. Suggestion

1. The group scenario with the cropping pattern and schedule made can be applied to the Cimulu Irrigation Area.
2. The socialization of the scenario requires socialization and coordination with the local community to find out the socio-cultural aspects and habits of the community when the rotation and group system is applied.

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