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Study of Water Need for Kiru-Kiru Irrigation Area Due to Changes in Irrigation Area, Soppeng Riaja District, Barru Regency

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Abstract:- Along with the population growth rate of Barru Regency, Soppeng Riaja Sub-district, which experienced an increase in expansion, so that the lands that were previously irrigation service areas/agricultural areas changed their functions as residential land, ponds and the existence of a railroad project. This study aims to determine how much irrigation water needs due to changes in irrigation area and whether there is sufficient water availability by using irrigation areas. The evapotranspiration analysis calculation method used is the FAO Modified Penman method. For the calculation of the average rainfall analysis using a minimum half-month rainfall by means of Algebraic Average while for the analysis of water availability using the F. J Mock method. From the results of the calculation of irrigation water needs by setting different planting schedules will provide different water requirements, so the maximum irrigation water needs are obtained for each alternative. I is 2.64 L/second/ha, alternative II is 2.30 L/second/ha and alternative III is 2.46 L/second/ha. The value of the smallest maximum irrigation water requirement was obtained, namely 2.30 L/second/ha in the second period of October. Based on the water balance calculation in Kiru-kiru DI, the water deficit occurred in September period 2 and October period 1 because the water demand was greater than the mainstay discharge.

Keywords:- *Irrigation Water Needs, Mainstay Discharge, Irrigation Area.*

I. INTRODUCTION

Irrigation water in Indonesia is generally sourced from rivers, reservoirs, groundwater and tidal systems. One of the efforts to increase food production, especially rice is the availability of irrigation water in the fields according to needs. The need for irrigation water is the volume of water needed to meet the needs of evaporation, water loss, water needs for plants by taking into account the amount of water provided by nature through rain and the contribution of ground water . The amount of water needed in irrigation areas varies according to the increase in population in the area. The increase in population in an area will affect the social conditions of the community. The construction of housing and public facilities and infrastructure will continue to increase in line with the rate of population growth. This development will change the land use (*land used*) by changing the function of the existing land. Changes in land function will change the condition of the area, among others, cause changes in the need for irrigation water in the area.

Along with the population growth rate of Barru Regency, Soppeng Riaja Sub-district, which experienced changes in expansion, so that the land that was previously an irrigation service area/agricultural area changed its function as residential land, ponds, and the existence of a railroad project. In the Kiru-Kiru irrigation area with an irrigation area of 805 Ha in 2014 and in 2019 there was a change of 716.38 Ha. With irrigation water needs of 1.4 l/s/ha. In order to optimize the performance of irrigation infrastructure that has been built in the Kiru-Kiru irrigation area as well as efficient use of irrigation water according to needs, it is necessary to study irrigation water needs due to changes in irrigation area in the area.

II. THEORITICAL STUDIES

A. *Irrigation*

As a science, irrigation does not only discuss and explain methods and efforts related to taking water from various sources, storing it in a reservoir or raising its surface elevation, by channeling and distributing it to plots of land to be cultivated. , but also includes issues of river flood control and all efforts related to the maintenance and protection of rivers for agricultural purposes. According to the Irrigation Planning Standard KP-01 irrigation is a system of providing water to agricultural lands in order to meet the needs of plants so that these plants grow well[1].

B. *Land Changes*

Land use change is the transition of an old land use form and location into a new one. Land use change is an increase in land use from one side of use to another followed by a decrease in other types of land use from one time to the next, or a change in the function of a land at different times [2].In its development, the land changes will be distributed in certain places that have good potential. In addition to the distribution of change in use, land will have patterns of land use change.

C. *Hydrological Analysis*

Hydrology is a science that explains the presence and movement of water in our nature. This includes the various forms of water, which involve changes between liquid, solid and gaseous states in the atmosphere, above and below the ground surface. It also includes sea water which is the

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source and storage of water that activates life on this planet[3].

D. Water Availability

The availability of water basically consists of three forms, namely rainwater, surface water, and ground water.

The main water sources in water allocation management are surface water sources in the form of water in rivers, canals, lakes, and other reservoirs. The use of ground water is in fact very helpful in meeting the needs of raw water and irrigation water in areas where it is difficult to get surface water, but its sustainability needs to be maintained by controlled extraction below safe yield. In managing water allocation, rainwater contributes to reducing the need for irrigation water in the form of effective rain. In some areas with inadequate surface water quality, rain harvesting is carried out, where rainwater is stored as a water source for household purposes. Surface water availability can be defined in various ways. The location of the availability of water can apply at a point, for example at a location for a water reservoir, a weir where irrigation water is taken, and so on where the unit that is often used is the flow rate in cubic meters/s or liters/s. The amount of available water can also be expressed for a certain area, for example in a river area (WS), watershed (DAS), irrigation area (DI), and so on, where the unit used is the amount of water available in one unit. time, for example million cubic meters/year or millimeters/day. Analysis of water availability produces estimates of water availability in a river area, spatially and over time[4].

E. Always Debit

Reliable discharge is a reliable discharge for a certain level of reliability or reliability. For irrigation purposes, it is usual to use a reliable discharge with a reliability of 80% as specified in the Irrigation Planning Criteria[5].This means that with an 80% possibility that the discharge that occurs is greater than or equal to the discharge, or in other words the irrigation system may fail once in five years. For drinking and industrial purposes, higher reliability is required, which is around 90% to 95%. If river water is used for hydroelectric power generation, a very high reliability is required, which is between 95% and 99% .

F. Irrigation Water Need

Irrigation water needs are mostly covered from surface water. The need for irrigation water is influenced by various factors such as climatology, soil conditions, crop coefficients, cropping patterns, water supply provided, irrigation area, irrigation efficiency, reuse of drainage water for irrigation, class systems, planting schedules and others. Various field conditions related to water demand for agriculture vary with time and space as expressed in the following factors[6].

- Types and varieties of crops grown by farmers.
- Variation of crop coefficient, depending on the type and stage of growth of the plant.
- When does land preparation (class) begin.
- Planting schedule used by farmers, including water supply in connection with land preparation, seeding and fertilization.
- Types and factors of agro-climatology.

III. STUDY METHODOLOGY

A. Location of Study

This research was conducted in Soppeng Riaja District, Barru Regency, South Sulawesi Province, precisely in the Kiru-Kiru irrigation.

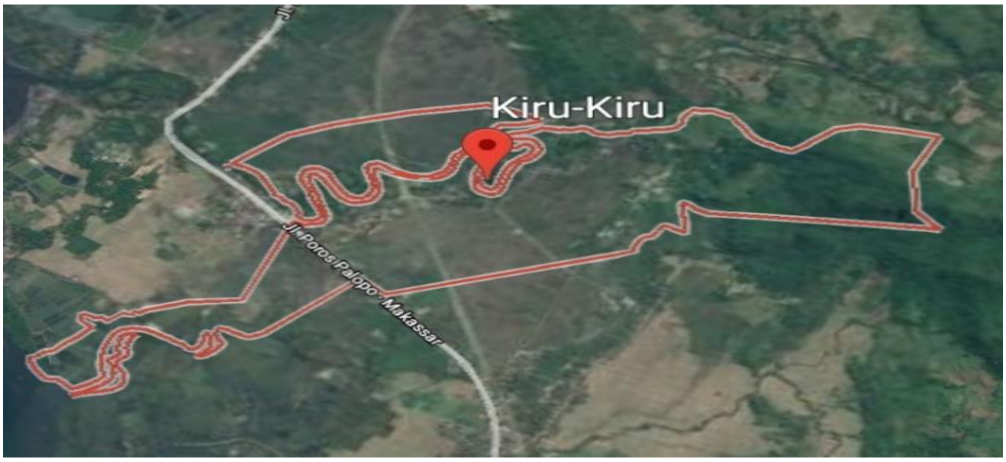

Fig 1:- Research Site Map

B. Data Colletion

Data collection in this study consisted of primary and secondary data.

Primary data in the form of data obtained directly from the field such as interviews and photo documentation from irrigation areas which are used as research objects so that they can strengthen the truth of the research results.

Secondary data was obtained from library materials relevant to this research and related institutions, namely the Center for the Pompengan Jeneberang River Basin, Ministry of Public Works and Human Settlements, which included climatological data, rainfall, irrigation network schemes, and topographic maps.

The primary data collection techniques and secondary data are carried out by:

Observation, namely data collection techniques through direct observation of the object situation.

Interviews, namely data collection techniques conducted through interviews with respondents.

Literature study, namely data collection techniques through the study of book texts.

C. Data Analysis Method

The research was carried out by analyzing secondary data and primary data obtained through data collection and field surveys. Data analysis is carried out in the following stages:

Hydroclimatological Data Analysis, data analysis of climatological elements to calculate the value of evapotranspiration (ETo) using the Modified Penman method using data from the Tabo-Tabo climatology station, Pangkep Regency.

Analysis of rainfall data using Sta. Mangkoso, Sta. Manuba, Sta Mareppang and Sta. Ralla is carried out to determine the average semi-monthly rainfall using the algebraic average method for the last 25 years which is then used to determine the effective rainfall.

Analysis of Irrigation Water Needs, Irrigation water needs are calculated for several conditions according to changes in land use, in this case it is reviewed for existing conditions (in 2014) and changing conditions in 2019.

Analysis of Water Availability, analysis of water availability is calculated using the F. J. Mock Method.

Analysis of water balance.

IV. RESULT OF RESEARCH AND DISCUSSION

Evapotranspiration Analysis

In the evapotranspiration analysis using the FAO Modified Penman method. To calculate the amount of evapotranspiration, climatological data is needed, such as: temperature, humidity, wind speed and duration of sunlight. In this study, the climatological station used was Tabo-Tabo Station, Pangkep Regency. The steps for calculating the evapotranspiration of the Kiru-kiru watershed using the Penman method can be seen in the example calculation as follows:

January
1)Calculating Incoming Radiation
Rs = (0.25 + 0.54 n/N) Ra

The Tabo-Tabo watershed is geographically 4°45'31" south latitude, so:
Latitude Position = 4 + (45/60) + (31/3600)
= 4.758

By referring to the table of extra-terrestrial radiation (Ra), then Ra is at a latitude of 4.758, which is 14.15 mm/day. So that it is obtained
Rs = (0.25 + 0.54 x 27.77/100) 14.15
Rs = 5.66 mm/day

2)Calculating Real Vapor Pressure
ed = Rh x ea
ed = 0.92 x 42.19
ed = 38.96

3)Calculating Real Vapor Pressure Function
$f(ed) = 0.34 – 0.044 (ed)^{0.5}$
$f(ed) = 0.34 – 0.044 (38.96)^{0.5}$
f(ed) = 0.34 – 0.044 (6,242)
f(ed) = 0.07

4) Calculating Exposure Time Ratio Function
f(n/N) = 0.1 + 0.9 n/N
f(n/N) = 0.1 + 0.9 x 27.77/100
f(n/N) = 0.35

5)Calculating Long Wave Net Radiation
f(T) = 16.68

6)Calculating Net Radiation
Rn = f(T) xf(ed) xf(n/N)
Rn = 16.68 x 0.07 x 0.35
Rn = 0.38

7)Calculating the Price of f(u)
f(u) = 0.27 (1 + 0.864 x U) x (1000/24 x 60 x 60)
f(u) = 0.27 (1 + 0.864 x 16.42) x (1000/24 x 60 x 60)
f(u) = 0.27 (15.187) x (0.012)
f(u) = 0.05

8)Calculating ET_0*
$ET_0* = w (0.75 x Rs-Rn) + (1-w) xf(u) x (ea – ed)$
$ET_0* = 0.79 (0.75 x 5.66 – 0.38) + (1-0.79) x 0.05 x (42.19 – 38.96)$
$ET_0* = 3.08$

9)Calculating Evapotranspiration
$ET_0 = C x ET_0*$
$ET_0 = 1.1 x 3.08$
$ET_0 = 3.39$

By referring to the steps above, the results of the calculation of evapotranspiration (mm/day) for the months of February to December are obtained which can be seen in table 1 below:

Month	Temp. (deg.C)	Humidity (%)	Wind Spd. (mm/d)	Sunshine (Second)	ea (mbar)	w	f(t)	ed	f(ed)
1	2	3	4	5	6	7	8	9	10
January	29,91	0,92	16,42	0,28	42,19	0,79	16,68	38,96	0,07
February	30,08	0,90	10,71	0,29	42,60	0,79	16,72	38,50	0,07
March	30,20	0,94	10,49	0,33	42,90	0,79	16,75	40,27	0,06
April	30,62	0,92	9,51	0,32	43,94	0,80	16,85	40,43	0,06
May	30,89	0,92	5,27	0,41	44,63	0,80	16,92	40,94	0,06
June	30,69	0,92	2,77	0,23	44,12	0,80	16,87	40,76	0,06
July	30,88	0,93	3,19	0,48	44,59	0,80	16,92	41,42	0,06
August	31,71	0,87	9,52	0,62	46,83	0,81	17,13	40,96	0,06
September	32,17	0,87	21,10	0,62	48,05	0,81	17,24	41,57	0,06
October	32,85	0,93	27,42	0,60	49,88	0,81	17,41	46,57	0,04
November	33,46	0,93	18,40	0,48	51,64	0,82	17,57	48,17	0,03
December	31,40	0,92	14,07	0,29	45,98	0,80	17,05	42,42	0,05

Month	Ra	Rs	f(n/N)	f(u)	Rn	C	Eto*	Eto (mm/day)
	11	12	13	14	15	16	17	18
January	14,15	5,66	0,35	0,05	0,38	1,10	3,08	3,39
February	14,92	6,10	0,36	0,03	0,41	1,10	3,32	3,65
March	15,46	6,63	0,40	0,03	0,41	1,10	3,64	4,00
April	15,40	6,50	0,39	0,03	0,39	0,90	3,59	3,23
May	14,98	7,05	0,47	0,02	0,46	0,90	3,87	3,48
June	14,51	5,46	0,31	0,01	0,31	0,90	3,02	2,72
July	14,71	7,47	0,53	0,01	0,51	0,90	4,08	3,67
August	15,14	8,86	0,66	0,03	0,66	0,90	4,87	4,38
September	15,30	8,96	0,66	0,06	0,64	1,10	5,01	5,51
October	15,06	8,67	0,64	0,08	0,44	1,10	4,98	5,48
November	14,39	7,32	0,53	0,05	0,32	1,10	4,26	4,68
December	13,95	5,66	0,36	0,04	0,33	1,10	3,18	3,50

Table 1. Recapitulation of Evapotranspiration Calculation Results (mm/day)

A. Rainfall Analysis

- *Average Rainfall*

In this study, the water source used came from the Kiru-Kiru River Basin. Rainfall analysis was carried out using the *Arithmetic Average* method which consisted of 4 rainfall stations, namely Mangkoso Station, Manuba Station, Mareppang Station, and Ralla Station with a period of 25 years (from 1996-2020). An example of calculating regional rainfall is as follows.
Known:
Rainfall in January Period 1 of 1996
Mangkoso Station = - mm
Manuba Station = 6 mm
Mareppang Station = 4 mm
Ralla Station = 10 mm
So,

$$\bar{p} = \frac{p_1 + p_2 + p_3 + \cdots . + p_n}{n}$$

$$\bar{p} = \frac{6 + 4 + 10}{3}$$

$$\bar{p} = \frac{20}{3}$$

$\bar{p} = 6{,}67$ mm

With the same calculation method, the rainfall value from January to December can be calculated every year.

- *Effective Rainfall*

In the calculation of the effective rainfall for rice by 70% of R80 of the time in a period while for the effective rainfall of secondary crops by 50%. The recapitulation of effective rainfall can be seen in table 2 below:

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Bulan	Period	R80	R50	Paddy		palawija	
				Re	mm/day	Re	mm/day
Jan	1	4,75	6,75	3,33	0,22	3,38	0,23
	2	3,50	5,00	2,45	0,16	2,50	0,17
Feb	1	4,50	7,50	3,15	0,21	3,75	0,25
	2	3,00	6,00	2,10	0,14	3,00	0,20
Mar	1	4,00	5,50	2,80	0,19	2,75	0,18
	2	3,75	6,75	2,63	0,18	3,38	0,23
Apr	1	3,25	4,75	2,28	0,15	2,38	0,16
	2	3,33	5,50	2,33	0,16	2,75	0,18
May	1	3,50	5,67	2,45	0,16	2,83	0,19
	2	3,33	5,25	2,33	0,16	2,63	0,18
Jun	1	3,67	4,75	2,57	0,17	2,38	0,16
	2	2,50	5,00	1,75	0,12	2,50	0,17
Jul	1	3,00	6,67	2,10	0,14	3,33	0,22
	2	2,00	5,00	1,40	0,09	2,50	0,17
Aug	1	1,00	4,00	0,70	0,05	2,00	0,13
	2	1,00	5,50	0,70	0,05	2,75	0,18
Sep	1	0,00	4,00	0,00	0,00	2,00	0,13
	2	2,75	7,33	1,93	0,13	3,67	0,24
Oct	1	4,00	5,75	2,80	0,19	2,88	0,19
	2	2,50	5,67	1,75	0,12	2,83	0,19
Nov	1	3,75	6,00	2,63	0,18	3,00	0,20
	2	4,75	6,00	3,33	0,22	3,00	0,20
Dec	1	3,75	5,00	2,63	0,18	2,50	0,17
	2	4,00	7,75	2,80	0,19	3,88	0,26

Table 2. Recapitulation of Effective Rainfall for Rice and Palawija

B. Water Need

- *Water Need for Land Preparation*

An example of calculating water needs for land preparation in January is as follows:

1)Calculating Evaporation (Eo)

$Eo = ET_0 \times 1.1$

$Eo = 3.39 \times 1.1$

$Eo = 3.73$

2)Percolation (P)

P = 2 mm/day

3)Calculating water requirements to replace water loss due to evaporation and percolation in saturated rice fields (M)

$M = Eo + P$

$M = 3.73 + 2$

M = 5.73 mm/day

4)Land Preparation Period (T)

T = 30 days

5)Calculating the water requirement for saturation plus a layer of water

S = 250 mm

6)Calculating Constants (K)

$K = M \times T / S$

$K = 5.73 \times 30 / 250$

$K = 0.69$

7)Calculating e^k

For the value of e (Nafier number) = 2.71828182846

$e^k = 2.72^{0.675}$

$e^k = 1.99$

8)Irrigation Needs for Land Preparation (IR)

$IR = M \, xe^k / (e^k - 1)$

$IR = 5.73 \times 1.99 / (1.99-1)$

IR = 11.52 mm/day

With the same calculation method, the value of water needs for land preparation can be calculated from February to December. It can be seen in table 3 below:

Month	Eto (mm/day)	Eo (mm/day)	P (mm/day)	T (day)	S (mm)	M (mm/day)	K	e	ek	Ir (mm/day)
Jan	3,39	3,73	2	30	250	5,73	0,69	2,72	1,99	11,52
Feb	3,65	4,02	2	30	250	6,02	0,72	2,72	2,06	11,70
Mar	4	4,40	2	30	250	6,40	0,77	2,72	2,16	11,94
Apr	3,23	3,55	2	30	250	5,55	0,67	2,72	1,95	11,42
Mey	3,48	3,83	2	30	250	5,83	0,70	2,72	2,01	11,58
Jun	2,72	2,99	2	30	250	4,99	0,60	2,72	1,82	11,08
Jul	3,67	4,04	2	30	250	6,04	0,72	2,72	2,06	11,71
Aug	4,38	4,82	2	30	250	6,82	0,82	2,72	2,27	12,20
Sept	5,51	6,06	2	30	250	8,06	0,97	2,72	2,63	13,00
Okt	5,48	6,03	2	30	250	8,03	0,96	2,72	2,62	12,98
Nov	4,68	5,15	2	30	250	7,15	0,86	2,72	2,36	12,41
Dec	3,5	3,85	2	30	250	5,85	0,70	2,72	2,02	11,60

Tabel 3. Recapitulation of Calculation of Water Needs for Land Preparation

- *Irrigation Water Need*

An example of calculating irrigation water requirements for land preparation is as follows:

September period 2

1)Calculating Plant Evapotranspiration (ETc)

ETc = IR Land preparation = 13.00 mm/day

2)Percolation (P)

P = 2 mm/day

3)Water Layer Replacement (WLR)

WLR = **-** mm/day

4)Effective Rainfall (Re)

Re = 0 mm/day

5)Clean water requirement in rice fields (NFR)

NFR = ETc – Re (Land Preparation)

NFR = 13.00 – 0.13

NFR = 12.88 mm/day

6)Needs Water withdrawal at the source (DR)

DR = NFR / (0.648 x 8.64)

DR = 12.88 / (0.648 x 8.64)

DR = 2.30 l/sec/ha

1/8.64 = unit conversion rate from mm/day to l/second/ha

An example of calculating irrigation water needs for other months is as follows:

October period 2

1)Calculating Plant Evapotranspiration (ETc)

ETC = Kc x ETo

= 1.1 x 5.48

= 6.03 mm/day

2)Percolation (P)

P = 2 mm/day

3)Water Layer Replacement (WLR)

WLR = **-** mm/day

4)Effective Rainfall (Re padi)

Re = 0.12 mm/day

5)Clean water requirement in rice fields (NFR)

NFR = ETc + P + WLR – Re

NFR = 6.03 + 2 + 0 – 0.12

NFR = 5.91 mm/day

6)Needs Water withdrawal at the source (DR)

DR = NFR / (0.648 x 8.64)

DR = 5.91 / (0.648 x 8.64)

DR = 1.06 l/sec/ha

1/8.64 = unit conversion rate from mm/day to l/second/ha

For the complete calculation of irrigation water requirements for rice for each period, it can be seen in table 4 below:

Month		ETo mm/day	Re		P mm/day	WLR mm/day	Plant Coef			Etc mm/day	NFR mm/day	Dr L/Sec/ha
			R80	R50			C1	C2	C Average			
Jan	1	3,39	0,22	0,23	2			0,00	0,00	0,00	1,78	0,32
	2	3,39	0,16	0,17	2				0	0,00	1,84	0,33
Feb	1	3,65	0,21	0,25	2		LP		LP	11,70	11,49	2,05
	2	3,65	0,14	0,20	2		1,10	LP	LP	11,70	11,56	2,06
Mar	1	4,00	0,19	0,18	2		1,10	1,10	1,10	4,40	4,21	0,75
	2	4,00	0,18	0,23	2	1,70	1,05	1,10	1,08	4,30	7,83	1,40
Apr	1	3,23	0,15	0,16	2	1,70	1,05	1,05	1,05	3,39	6,94	1,24
	2	3,23	0,16	0,18	2	1,70	0,95	1,05	1,00	3,23	6,77	1,21
May	1	3,48	0,16	0,19	2	1,70	0,00	0,95	0,48	1,65	5,19	0,93
	2	3,48	0,16	0,18	2			0,00	0,00	0,00	1,84	0,33
Jun	1	2,72	0,17	0,16	2				0,00	0,00	1,83	0,33
	2	2,72	0,12	0,17	2		0,5		0,50	1,36	3,19	0,57
Jul	1	3,67	0,14	0,22	2		0,59	0,5	0,55	2,00	3,78	0,67
	2	3,67	0,09	0,17	2		0,96	0,59	0,78	2,84	4,68	0,84
Aug	1	4,38	0,05	0,13	2		1,05	0,96	1,01	4,40	6,27	1,12
	2	4,38	0,05	0,18	2		1,02	1,05	1,04	4,53	6,35	1,13
Sep	1	5,51	0,00	0,13	2		0,95	1,02	0,99	5,43	7,29	1,30
	2	5,51	0,13	0,24	2		LP	0,95	LP	13,00	12,88	2,30
Oct	1	5,48	0,19	0,19	2		1,10	LP	LP	12,98	12,80	2,29
	2	5,48	0,12	0,19	2		1,10	1,10	1,10	6,03	5,91	1,06
Nov	1	4,68	0,18	0,20	2	1,70	1,05	1,10	1,08	5,03	8,56	1,53
	2	4,68	0,22	0,20	2	1,70	1,05	1,05	1,05	4,91	8,39	1,50
Dec	1	3,50	0,18	0,17	2	1,70	0,95	1,05	1,00	3,50	7,03	1,25
	2	3,50	0,19	0,26		1,70	0,00	0,95	0,48	1,66	3,18	0,57

Table 4. Recapitulation of Irrigation Water Needs (Alternative II)

C. Water Available analysis

To determine the value of water availability in the Kiru-Kiru watershed used is the result of the calculation of the water discharge in the Kiru-Kiru watershed using the F. J. Mock method. It can be seen in table 5 below:

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No.	Description	Unit	Description	Month											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I	**Meteorological Data**														
1	Monthly rain	mm/month	Data	919	558		311	76	222	373		573	180	541	1251
2	Number of Rainy Days	day	Data	18	16		10	3	6	8		12	4	14	25
3	Number of Days 1 Month	Day	Data	31	28	31	30	31	30	31	31	30	31	30	31
II	**Actual Evaporation (Ea)**														
4	Evapotranspiration (Eto)	mm/day	Data	3,39	3,65	4	3,23	3,48	2,72	3,67	4,38	5,51	5,48	4,68	3,5
5	Potential Evapotranspiration (ETo)	mm/month	3 x 4	105,09	113,15	124	96,9	107,88	81,6	113,77	135,78	165,3	169,88	140,4	108,5
6	Open Land Surface (m)	%	Data	20	20	20	20	20	20	20	20	20	20	20	20
7	(ETo/Ea) = m/20 x (18-n)	%	Count	0	2	18	8	15	12	10	18	6	14	4	-7
8	Ee = ETo x (m/20) x (18-n)/100	mm/month	Count	0,00	2,26	22,32	7,75	16,18	9,79	11,38	24,44	9,92	23,78	5,62	-7,60
9	Ea = ETo - Ee	mm/month	5 - 8	105,09	110,89	101,68	89,15	91,70	71,81	102,39	111,34	155,38	146,10	134,78	116,10
III	**Water Balance**														
10	ΔS = R - Ea	mm/month	1 - 9	813,91	447,11	-101,68	221,85	-15,70	150,19	270,61	-111,34	417,62	33,90	406,22	1134,91
11	Storm Runoff (PF = 5%)		PF x R	0,00	0,00	0,00	0,00	3,80	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	Soil Water Content (SS)	mm/month	10 - 11	0,00	0,00	-101,68	0,00	-19,50	0,00	0,00	-111,34	0,00	0,00	0,00	0,00
13	Soil Moisture Capacity	mm/month		200,00	200,00	-101,68	200,00	-19,50	200,00	200,00	-111,34	200,00	200,00	200,00	200,00
14	Excess water (WS)	mm/month	10 - 12	813,91	447,11	0,00	221,85	3,80	150,19	270,61	0,00	417,62	33,90	406,22	1134,91
IV	**Runoff and Ground Water Storage**														
15	Infiltration (I) i = 0,4	mm/month	14 x i	325,56	178,85	0,00	88,74	1,52	60,08	108,24	0,00	167,05	13,56	162,49	453,96
16	Ground water Volume (G)		0,5(1=k).I	260,45	143,08	0,00	70,99	1,22	48,06	86,59	0,00	133,64	10,85	129,99	363,17
17	L = K (Vn-1)	K = 0,6	k x ISM	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00
18	Storage Volume (Vn)		16 + 17	320,45	203,08	60,00	130,99	61,22	108,06	146,59	60,00	193,64	70,85	189,99	423,17
19	ΔVn = Vn - Vn-1	ISM= 100	18 - ISM	220,45	103,08	-40,00	30,99	-38,78	8,06	46,59	-40,00	93,64	-29,15	89,99	323,17
20	Basic Flow (BF)	mm/month	15 - 19	105,11	75,77	40,00	57,75	40,30	52,02	61,65	40,00	73,41	42,71	72,50	130,79
21	Direct Runoff (DRo)	mm/month	11+14-15	488,35	268,27	0,00	133,11	6,08	90,12	162,36	0,00	250,57	20,34	243,73	680,94
22	Total Runoff (TRo)	mm/month	20+21	593,46	344,04	40,00	190,86	46,38	142,13	224,01	40,00	323,98	63,05	316,23	811,74
2	Area (A)	km2	Data	68,	68,	68,9	68,	68,	68,	68,	68,9	68,	68,	68,	68,9

3				94	94	4	94	94	94	94	4	94	94	94	4
24	**Monthly Debit**	**m3/s**	**22 x A**	**15,28**	**9,80**	**1,03**	**5,08**	**1,19**	**3,78**	**5,77**	**1,03**	**8,62**	**1,62**	**8,41**	**20,89**

Table 5. Calculation of Water Discharge in the Kiru-kiru River Basin in 1996 (m3/s)

D. Mainstay Debit

The results of the above calculation can be defined as the mainstay discharge, that the mainstay discharge is the minimum river discharge for the predetermined probability of being fulfilled which can be used for irrigation. The probability of being fulfilled is set at 80%, or in other words the possibility that the river discharge is 20% lower, this discharge is commonly referred to as a discharge with an 80% chance or Q 80%. To determine the possibility of being fulfilled or not, the debit data are arranged in order of small to large. The records cover (n) years so the number of (m) discharge levels with a 20% probability of non-fulfillment can be calculated as m = 0.20 x n. So that the Kiru-kiru river with 25 years of discharge data will get the level number (m) = 0.20 x 25 = 5. The results of the calculation of the mainstay discharge using the Mock method As shown in table 6 below:

Year	Month											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	1,03	1,14	1,03	1,06	1,03	1,06	0,56	1,03	1,06	1,03	1,06	1,03
2	2,96	1,43	1,03	1,06	1,03	1,06	1,03	1,03	1,06	1,03	1,06	1,03
3	4,28	2,14	1,03	1,86	1,10	1,06	1,03	1,03	1,06	1,03	1,06	4,64
4	4,91	3,04	1,03	2,29	1,12	1,07	1,03	1,03	1,06	1,03	1,33	4,65
5	5,44	3,38	1,04	2,33	1,14	1,07	1,03	1,03	1,06	1,03	1,35	5,85
6	5,65	3,56	2,72	2,36	1,16	1,10	1,04	1,03	1,06	1,03	1,49	5,86
7	5,72	3,80	2,80	2,39	1,17	1,10	1,05	1,04	1,06	1,06	2,16	5,99
8	6,22	4,09	2,92	2,47	1,19	1,11	1,07	1,04	1,06	1,08	2,34	6,52
9	6,57	5,29	3,03	2,78	1,21	1,15	1,08	1,04	1,06	1,09	2,48	7,09
10	6,62	5,31	4,19	3,20	1,23	1,17	1,08	1,04	1,07	1,11	2,53	7,97
11	6,87	5,42	4,35	3,49	1,28	1,18	1,08	1,04	1,07	1,15	2,78	8,17
12	6,96	5,48	4,55	3,52	1,31	1,21	1,11	1,05	1,09	1,17	2,87	8,96
13	7,09	5,53	4,56	3,74	1,34	1,62	1,12	1,06	1,09	1,26	2,89	10,33
14	7,35	5,55	4,73	4,06	1,50	1,65	1,12	1,06	1,09	1,27	3,38	10,84
15	9,19	5,67	4,85	4,21	1,53	1,70	1,13	1,07	1,11	1,28	3,66	10,87
16	9,20	5,88	5,00	4,23	1,78	2,06	1,16	1,07	1,14	1,36	3,82	11,01
17	9,28	8,72	5,08	4,47	2,15	2,35	1,17	1,08	1,16	1,62	5,60	11,80
18	10,49	9,12	5,57	4,66	2,36	2,55	1,18	1,08	1,17	3,22	5,85	11,99
19	10,73	9,80	5,95	5,08	2,66	2,76	1,25	1,09	1,19	3,29	6,56	13,93
20	12,77	10,11	7,35	5,62	2,77	2,96	1,35	1,10	1,25	3,36	6,73	14,34
21	12,9	10,6	7,81	5,63	3,25	3,78	1,78	1,11	1,28	3,8	7,97	16,15

Year	Month											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	4	0								5		
22	13,33	10,80	8,10	6,67	3,69	3,96	2,80	1,12	2,35	4,11	8,41	16,35
23	13,41	16,61	9,60	7,00	4,44	4,55	2,89	1,17	2,99	4,18	8,52	17,92
24	15,28	16,95	11,08	8,18	5,76	5,69	5,77	2,20	7,98	4,92	9,39	20,15
25	19,43	17,50	14,68	12,80	7,95	10,40	10,67	10,20	8,62	8,27	24,35	20,89
Q80	**5,44**	**3,38**	**1,04**	**2,33**	**1,14**	**1,07**	**1,03**	**1,03**	**1,06**	**1,03**	**1,35**	**5,85**

Table 6. Mainstay Monthly Discharge of Kiru-kiru Irrigation Area (m3/second)

E. *Irrigation Area*

The size of the area that can be irrigated depends on the amount of available discharge, the demand for water intake and the cropping pattern applied. From the results of the calculation of the *water balance* between the available discharge and the intake discharge with the cropping pattern of secondary crops, the area of irrigation that can be irrigated is 716.38 Ha. Irrigation water needs in Kiru-kiru, which are calculated based on the rice-paddy-palawija cropping pattern, provide a maximum extraction requirement (DR) of 2.30 L/s/ha.

By calculating the water balance, the resulting extraction requirements for the rice-paddy-palawija cropping pattern will be compared with the mainstay discharge for each period (1/2 month). Thus the need for each month can be known. From the results of the calculation of the *water balance in* Kiru-kiru, it can be seen in table 7 below:

Period		Debit Mainstay (m^3/sec)	Irrigation Water Need		Water Balance (m^3/sec)	Description
			L/sec/Ha	m^3/sec		
Jan	1	5,44	0,32	0,23	5,22	Enough
	2	5,44	0,33	0,24	5,21	Enough
Feb	1	3,38	2,05	1,47	1,91	Enough
	2	3,38	2,06	1,48	1,90	Enough
Mar	1	1,04	0,75	0,54	0,50	Enough
	2	1,04	1,40	1,00	0,04	Enough
Apr	1	2,33	1,24	0,89	1,44	Enough
	2	2,33	1,21	0,87	1,46	Enough
May	1	1,14	0,93	0,66	0,47	Enough
	2	1,14	0,33	0,24	0,90	Enough
Jun	1	1,07	0,33	0,23	0,84	Enough
	2	1,07	0,57	0,41	0,66	Enough
Jul	1	1,03	0,67	0,48	0,55	Enough
	2	1,03	0,84	0,60	0,43	Enough
Aug	1	1,03	1,12	0,80	0,23	Enough
	2	1,03	1,13	0,81	0,22	Enough
Sep	1	1,06	1,30	0,93	0,13	Enough
	2	1,06	2,30	1,65	-0,58	Water Deficit
Oct	1	1,03	2,29	1,64	-0,61	Water Deficit
	2	1,03	1,06	0,76	0,27	Enough
Nov	1	1,35	1,53	1,09	0,25	Enough
	2	1,35	1,50	1,07	0,27	Enough
Dec	1	5,85	1,25	0,90	4,95	Enough
	2	5,85	0,57	0,41	5,44	Enough

Table 7. Water Balance of Kiru-Kiru irrigation area (m3/s)

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V. CONCLUSION

- Based on the analysis of irrigation water requirements for the rice-paddy-palawija cropping pattern, starting at the beginning of land preparation in the second period in September, it was found that the value of the maximum irrigation water requirement for each alternative I was 2.64 L/second/ha, alternative II was 2.30 L/second/ha and alternative III is 2.46 L/second/ha. The value of the smallest maximum irrigation water requirement was obtained, namely 2.30 L/second/ha in the second period of October.
- From the calculation results between irrigation water needs and water availability, it can be seen that in September period 2 to October period 1 there was a water deficit.

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