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The needs and availability analysis of irrigation water of Way Wayah Irrigation Area

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Abstract. Optimization of agricultural land is an effort to mprove and increase land support capacity, in such a way become more productive farmland. The Local Government of Pringsewu Regency planned to develop irrigation network by utilizing Way Wayah river. This study aims to design irrigation area in Way Wayah and to analyse water availability of Way Wayah river and water need of the planned irrigation area. Irrigation network design includes analysis of determining the location of the weir, so that it can be estimated the area of designed paddy field, the catchment area as well as the availability of water resources. Analysis includes spatial analysis using Geographical Information System, hydrologic analysis for water availability and Penman method for irrigation water need. The results show that (1) the planned weir will be located in Giri Tunggal with catchment area of 7,238.9 ha, the area of total paddy rice fields (existing and planned paddy rice fields) is 960.46 ha; (2) The need for water are 6196.88 m^3 ha^{-1} $season^{-1}$ and 6556.96 m^3 ha^{-1} $season^{-1}$ for planting seasons 1 and 2 respectively. Water availability is sufficient during preparation and planting periods

1. Introduction
Water resources are significant in determining food production in many parts of the world [1]. As population increases the growing demand for food in the future will require adaptation of water and land management. In some regions, water resources are limited and in other regions they are abundant, which in both conditions they influence water use and availability [2, 3].

As a growing medium for paddy rice cultivations, land is one of the very important production factors. Optimization of agricultural land is an effort to increase the utilization of land resources into farmland to improve and increase land support capacity, in such a way become more productive farmland [4]. Agricultural land optimization activities are directed primarily to meet the criteria of food crop farming from technical aspects, physical and chemical improvement of the soil, as well as the improvement of the necessary agricultural infrastructure [5].

One of the efforts to improve services to water needs, especially in the agricultural sector, is to develop and build new irrigation networks, which aim to provide the availability of new water sources. There are several water sources that can be used for irrigation services, including rivers, reservoirs, springs, and groundwater [6], [7]. In an effort to improve water needs and increase production in agriculture and support regional food security programs [8], [9].

The Local Government of Pringsewu Regency seeks to conduct irrigation network development planning activities in the form of a plan for The Feasibility Study of Way Wayah Irrigation Area. From

this activity, it is expected that recommendasions can be made in accordance with the real conditions in the field related to the availability of water sources in Way Wayah.

The aims of this study are (1) to delineate Way Wayah watershed, (2) to analyse the condition of Way Wayah's water source and availability, and (3) to analyse water need and availability at the proposed new irrigation area.

2. Methods

Way Wayah Irrigation Area research site is located in North Pagelaran Sub-District and Banyumas Sub-District, Pringsewu Regency, Lampung Province (Figure 1). The river is the tributary of Way Seputih river. The method includes delineation of Way Wayah watershed [10] using imagery Digital Elevation Model data from Geospatial Information Bureau and river coordinate points.
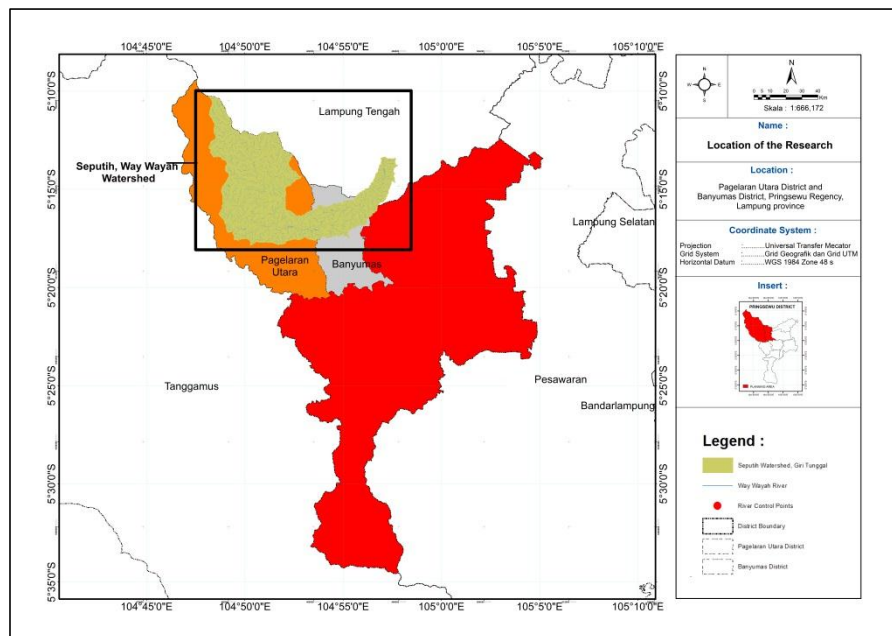

Figure 1. Location of the research

Rainfall data used in this study obtained from 5 rainfall stations including R 015 Way Kunyir station, R 018 Banyuwangi, PH 117 Way Waya-Kalirejo, and R 137 Sindang Sari. Rainfall data used in the analysis is daily rainfall data recorded from 1991 to 2019. In addition to the rainfall data, to calculate dependable discharge, it needs climatology data such as average air temperature, humidity, and wind speed which is obtained from Meteorological, Climatology and Geophysical Buraeu.

The analysis required for this research inclused evapotranspiration analysis using Modified Penman Method, water availability analysis using Moch Method and water irrigation needs.

2.1. Evapotranspiration analysis

This analysis is calculated using Modified Penman method The formula of the Modified Penman method is as follows [11]:

$$ETo = c.(w.Rn + (1-w).f(u).(ea-ed))$$

where

ETo = Evapotranspiration (mm/day)

c = Correction factor due to the state of the climate day and night

w = Weight factor depends on air temperature and place height

Rn = Net radiation equivalent to evapotranspiration (mm/day), calculated as $Rn = Rns - Rnl$

   Rns = Short wave incoming radiation, calculated as $= (1-\alpha). Rs = (1-\alpha). (0.25 + n/N). Ra$

   Ra = Extra terrestrial radiation of the sun

Rnl = Net radiation long wave = ft(t).f(ed).f(n/N)

N   = Maximum length of sun exposure

1-w   = Weight factor depending on air temperature

f(u)   = Wind speed function = 0.27. (1+u/100)

f(ed) = Steam pressure effect on long wave radiation

ea   = Saturated steam pressure depending on temperature

ed   = ea. Rh/100, Rh = Humidity

2.2. Mock Method of Water Availability Analysis

Water availability was analysed using Mock method. Water availability is represented by dependable discharge based on effective rainfall R80. Average rainfall of the watershed is calculated using Thiessen Polygon. Half monthly of potential evapotranspiration (E_{to}) was analysed using Modified Penman Method. Half mounthly of dependable discharge using Mock Method inlcudes limited/actual evapotranspiration calculation, water surplus calculation, base flow calculation, direct off and storm runoff.

2.3. Water Irigation Needs Analysis

There two kinds of irrigation water needs, i.e. water needs during land preparation and water needs for consumptive use. Water needs during land preparation is calculated using following formula [12]:

$$IR = M.\frac{e^k}{e^k - 1}$$

Description:

IR   = water needs during land preparation, mm.day^{-1}

M   = water needs to replace/compensate for water losses due to evaporation, and

   M = Eo + P, mm.day^{-1}

Eo   = open water evaporation calculated as 1.1 * ETo during land preparation, mm.day^{-1}

P   = Percolation

k   = MT/S

   T = period of land preparation, days

   S = water requirement, added with a layer of water 50 mm for saturation percolation in saturated paddy rice fields

The need for Consumptive Irrigation Water is calculated using this formula

$$NFR = ET_C + P + WLR - \text{Re}$$

with:

NFR = Nett field water requirement, mm.day^{-1}

ET_c = Plant evaporation (mm.day^{-1})

P = Percolation (mm.day^{-1})

WLR = Replacement of water layer (mm.day^{-1})

Re = Effective rainfall (mm.day^{-1})

$$IR = \frac{NFR}{e} \text{ for paddy filed}$$

$$IR = ET_C - \text{Re}/e \text{ for palawija field}$$

with

IR = Need for irrigation water (mm.day^{-1})

e = Overall irrigation efficiency

NFR = Net Field Water Requirement, the net water requirement in the field (mm.day^{-1})

The need for harvesting for plants is the amount of water discharge required by one hectare of rice fields to plant rice or secondary crops (palawija). This intake requirement is influenced by irrigation efficiency (ef). Irrigation efficiency is the ratio of the amount of water that actually reaches the tertiary plot with the amount of water leaked [13], [14]. The amount of the need for retrieval is calculated by the following formula:

$$DR = \frac{NFR}{ef \times 8,64}$$

3. Results and Discussion

The result of the delineation of Way Wayah Watershed with Control Point in Way Seputih river, and Way Wayah watershed with Control Point in Giri Tunggal can be seen in Figure 2 and Figure 3 respectively.
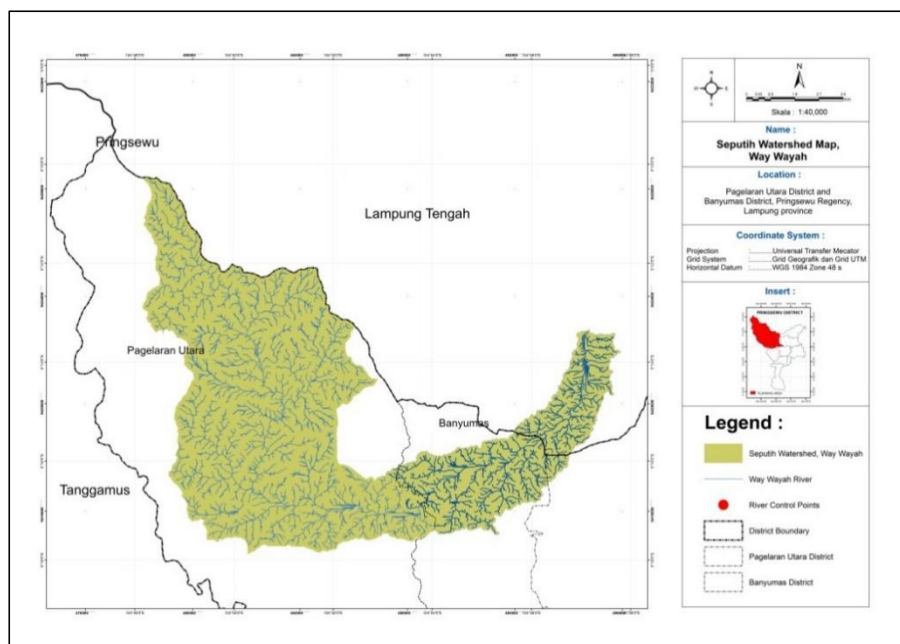

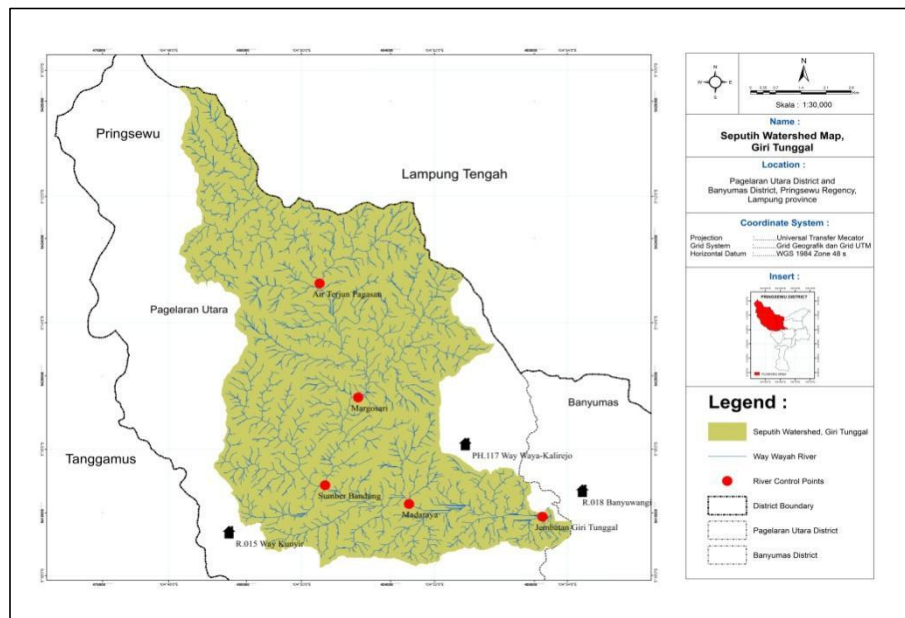**Figure 2.** Way Wayah watershed with Control Point in Way Seputih river

Figure 3. Way Wayah watershed with Control Point in Giri Tunggal

Irrigation water losses delivered by irrigation channel is highly effected by evapotranspiration. The result of evapotranspiration analysis is presented in Table 1a and 1b for the calculations of evapotranspiration from January to June and July to December respectively. The calculation was made on 15 days or half monthly basis. The result shows that the highest evapotranspiration occurs in October while the lowest one occurs in June.

Table 1a. Calculation of the amount of Evapotranspiration (January – June)

Variable	Jan		Feb		Mar		Apr		May		Jun	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
T	26.5	26.7	27.4	27.7	27.7	28.2	28.1	29.7	28.2	28.1	27.7	27.6
RH	81.0	80.4	82.1	82.5	81.3	80.8	82.4	78.4	82.8	82.2	81.3	79.9
U	38.6	39.0	38.1	37.5	33.7	29.1	30.2	29.1	30.6	34.2	30.0	33.6
n/N	1.3	1.3	1.6	1.7	1.4	1.5	1.6	2.0	1.6	1.6	1.6	1.7
ea	34.7	35.0	36.5	37.1	37.2	38.3	38.0	41.8	38.2	38.1	37.2	36.9
ed	28.1	28.2	30.0	30.6	30.2	31.0	31.3	32.8	31.6	31.3	30.2	29.5
ea - ed	6.6	6.9	6.6	6.5	7.0	7.4	6.7	9.0	6.6	6.8	7.0	7.4
f (u)	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.4	0.4	0.4	0.4
W	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
(1 - W)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ra	15.7	15.7	15.9	15.9	15.6	15.6	14.8	14.8	13.6	13.5	13.0	12.9
Rns	4.0	4.0	4.1	4.1	4.0	4.0	3.8	3.8	3.5	3.5	3.3	3.3
f (T)	16.0	16.0	16.2	16.2	16.2	16.3	16.3	16.6	16.3	16.3	16.2	16.2
f(ed)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
f(n/N)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rn1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Rn	3.8	3.8	3.9	3.9	3.8	3.8	3.6	3.7	3.3	3.3	3.2	3.2
c	1.1	1.1	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
Eto (daily)	3.8	3.9	3.9	3.9	3.5	3.6	3.0	3.2	2.8	2.8	2.7	2.7
Eto (15 days)	57.7	58.2	55.1	55.1	52.9	53.3	45.1	48.0	41.7	42.2	40.4	41.1

Table 1b. Calculation of the amount of Evapotranspiration (July – August)

Symbol	Jul		Aug		Sep		Oct		Nov		Dec	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
T	27.3	27.3	27.4	27.5	28.0	27.9	28.9	28.6	28.4	28.0	27.9	28.0
RH	79.5	79.3	80.3	80.0	80.7	79.9	78.9	78.9	78.9	79.9	81.3	82.0
U	35.6	38.1	39.2	43.6	40.0	41.1	38.8	37.6	37.6	32.9	39.5	39.7
n/N	1.7	1.9	2.0	2.0	2.0	1.7	1.9	1.8	1.7	1.5	1.5	1.7
ea	36.4	36.4	36.5	36.9	37.8	37.7	39.8	39.2	38.8	37.8	37.5	37.9
ed	28.9	28.8	29.4	29.5	30.5	30.1	31.4	30.9	30.6	30.2	30.5	31.1
ea - ed	7.5	7.5	7.2	7.4	7.3	7.6	8.4	8.3	8.2	7.6	7.0	6.8
f (u)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
W	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
(1 - W)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ra	13.2	13.2	14.1	14.1	15.0	15.0	15.7	15.7	15.7	15.7	15.6	15.6
Rns	3.4	3.4	3.7	3.7	3.9	3.9	4.1	4.1	4.1	4.0	4.0	4.0
f (T)	16.2	16.2	16.2	16.2	16.3	16.3	16.5	16.4	16.4	16.3	16.3	16.3
f(ed)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
f(n/N)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rn1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Rn	3.2	3.2	3.5	3.5	3.7	3.7	3.9	3.9	3.9	3.9	3.8	3.8
c	0.9	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Eto (daily)	2.8	2.8	3.3	3.3	3.8	3.9	4.1	4.1	4.0	4.0	3.9	3.9
Eto (15 days)	41.9	42.2	49.4	50.0	57.7	58.0	61.3	60.9	60.7	59.4	58.7	58.7

To validate the analysis of dependable discharge for water availability, the field measurement of river discharge on the Way Wayah river was conducted at two locations, which are at Madaraya Suspension Bridge (5°16'52,105" S 104°51'36,969" E) and on Giri Tunggal Bridge (5°17'4,244" S 104°53'37,404" E). The location of this survey is between Giri Tunggal – Madaraya. The field measurement was conducted on May 11, 2020. The depth of the river ranges have a depth between 0.75 – 2 meters. This measurement used a calibrated current meter tool. An illustration of the ifield discharge measurement presented in Figure 4 and 5 for discharge measurement at Madaraya Bridge and Giri Tunggal respectively.

Figure 4. Discharge measurement at Madaraya Bridge, Way Wayah River

Figure 5. Discharge measurement at Giri Tunggal Bridge, Way Wayah River

The results of discharge measurements on Way Wayah River at those two locations are 2.0878m^3s^{-1} and 2.4622m^3s^{-1} for Madaraya and Giri Tunggal respectively. Giri Tunggal is located downstream of Madaraya. Therefore it can be understand that the discharge on Giri Tunggal section is greater than that of Madaraya.

For irrigation water analysis, dependable discharge is important to determine. Dependable discharge is the river discharge that available and meet the need of irrigation water and it has probability of occurring of 80%. Dependable discharge in one year is the discharge that have probability of 80% "meet the need" of irrigation water during one year. The calculation of the dependable discharge using Mock method is presented in Table 2a and 2b for dependable discharge for January - June and dependable discharge for July – December respectively.

Dependable discharges calculated using Mock method can be validated by field measurement done in 11 May 2020. It was found that the results from those two methods are very close, that is 2.1 m^3/s and 2.4 m^3/s for the field measurement and Mock method respectively. The highest dependable discharge occurs in January while the lowest one occurs in August.

Table 2a. Dependable discharge calculation (January – June)

Description	Unit	Jan		Feb		Mar		Apr		May		Jun	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Rainfall (P)	mm/15 day	136.7	104.3	99.2	151.1	87.5	56.3	116.3	76.5	79.9	72.8	61.9	51.9
Rainy day (n)	day	9	9	8	8	9	9	9	9	8	8	6	6
Ep	mm/15 day	57.7	58.2	55.1	55.1	52.9	53.3	45.1	48.0	41.7	42.2	40.4	41.1
Et = Eto - ΔE	mm/15 day	57.7	58.2	54.0	54.0	52.9	53.3	45.1	48.0	40.9	41.3	38.0	38.6
Ds = P - Et	mm/15 day	79.0	46.1	45.2	97.1	34.6	3.0	71.2	28.6	39.0	31.5	23.9	13.2
ISMS	mm/15 day	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
SMS	mm/15 day	279.0	246.1	245.2	297.1	234.6	203.0	271.2	228.6	239.0	231.5	223.9	213.2
SW	mm/15 day	79.0	46.1	45.2	97.1	34.6	3.0	71.2	28.6	39.0	31.5	23.9	13.2
Infiltration	mm/15 day	39.5	23.1	22.6	48.5	17.3	1.5	35.6	14.3	19.5	15.7	12.0	6.6
BF	mm/15 day	27.6	37.0	23.0	26.5	43.9	14.9	6.6	32.4	15.1	18.9	15.2	11.2
DRO	mm/15 day	39.5	23.1	22.6	48.5	17.3	1.5	35.6	14.3	19.5	15.7	12.0	6.6
SRO	mm/15 day	6.8	5.2	5.0	7.6	4.4	2.8	5.8	3.8	4.0	3.6	3.1	2.6
TRO	mm/15 day	74.0	65.3	50.6	82.6	65.5	19.3	48.0	50.5	38.6	38.3	30.2	20.4
TRO	m/s	5.35E-08	5.04E-08	4.18E-08	6.83E-08	4.74E-08	1.49E-08	3.71E-08	3.90E-08	2.79E-08	2.96E-08	2.33E-08	1.57E-08
A	m^2	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07	7.24E+07
Q	m^3/s	3.9	3.6	3.0	4.9	3.4	1.1	2.7	2.8	2.0	2.1	1.7	1.1
Q	lt/s	3873.6	3649.6	3025.7	4943.0	3432.5	1075.8	2682.4	2821.1	2019.9	2140.9	1688.5	1138.1

Table 2b. Dependable discharge calculation (July – December)

Description	Unit	Jul 1st	Jul 2nd	Aug 1st	Aug 2nd	Sep 1st	Sep 2nd	Oct 1st	Oct 2nd	Nov 1st	Nov 2nd	Dec 1st	Dec 2nd
Rainfall (P)	mm/15 day	56.5	46.8	43.8	35.3	36.2	42.3	38.3	51.2	49.0	79.5	106.0	109.7
Rainy day (n)	day	6	6	6	6	5	5	7	7	9	9	9	9
Ep	mm/15 day	41.9	42.2	49.4	50.0	57.7	58.0	61.3	60.9	60.7	59.4	58.7	58.7
Et = Eto - ΔE	mm/15 day	39.4	39.7	46.5	47.0	53.1	53.4	58.9	58.4	60.7	59.4	58.7	58.7
Ds = P - Et	mm/15 day	17.0	7.1	-2.7	-11.6	-16.9	-11.1	-20.5	-7.2	-11.7	20.2	47.3	51.1
ISMS	mm/15 day	200	200	200	197.3	185.7	168.8	157.7	137.1	129.9	118.2	200	200
SMS	mm/15 day	217.0	207.1	197.3	185.7	168.8	157.7	137.1	129.9	118.2	138.4	247.3	251.1
SW	mm/15 day	17.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.2	47.3	51.1
Infiltration	mm/15 day	8.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	23.6	25.5
BF	mm/15 day	6.9	7.8	3.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	12.1	23.9
DRO	mm/15 day	8.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	23.6	25.5
SRO	mm/15 day	2.8	2.3	2.2	1.8	1.8	2.1	1.9	2.6	2.4	4.0	5.3	5.5
TRO	mm/15 day	18.2	13.7	5.2	1.8	1.8	2.1	1.9	2.6	2.4	15.6	41.1	54.9
TRO	m/s	1.3E-08	1.1E-08	3.8E-09	1.4E-09	1.4E-09	1.6E-09	1.4E-09	2.0E-09	1.9E-09	1.2E-08	3.0E-08	4.2E-08
A	m^2	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07	7.2E+07
Q	m^3/s	1.0	0.8	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.9	2.1	3.1
Q	lt/s	955.5	763.8	273.0	98.7	101.0	118.1	100.4	143.1	136.8	869.9	2149.8	3068.4

Irrigation water need for plants is the amount of water required by one hectare of paddy fields to plant paddy rice or secondary crops such as palawija. It is proposed to have three planting periods two paddy rice planting periods and one palawija planting period. The intake requirement of irrigation water need is influenced by irrigation efficiency. Irrigation efficiency is the ratio of the amount of water that actually reaches the tertiary plot with the amount of water leaked [8]. The result of the calculation of water need is presented in Table 3.

Table 3. Calculation of Water Requirements

Month	Cropping Pattern	Eto (mm)	Eo (mm)	Consumptive Use (mm)	Re rice (mm)	Re palawija (mm)	NFR	NFR'	DR (m3/15/ha)	DR (m3/season/ha)	Water Needs (m3/s)	Dependable Discharge (m3/s)	Information
Jan-01	Planting (Rice)	3.8	4.2	4.6	5.1		4.8		801.8	6196.9	0.4	3.9	Sufficient
Jan-02		3.9	4.3	4.9	3.9		6.3		1055.2		0.5	3.6	Sufficient
Feb-01		3.9	4.3	5.2	3.7		6.8		1138.5		0.5	3.0	Sufficient
Feb-02		3.9	4.3	5.1	5.6		4.8		796.3		0.4	4.9	Sufficient
Mar-01		3.5	3.9	4.6	3.3		6.6		1102.6		0.5	3.4	Sufficient
Mar-02		3.6	3.9	4.6	2.1		7.8		1302.4		0.6	1.1	Sufficient
Apr-01	Land Preparation	3.0	3.3		4.3			4.3	714.1	1698.5	0.3	2.7	Sufficient
Apr-02		3.2	3.5		2.9			5.9	984.4		0.5	2.8	Sufficient
May-01	Planting (Rice)	2.8	3.1	3.3	3.0		5.7		942.4	6557.0	0.4	2.0	Sufficient
May-02		2.8	3.1	3.6	2.7		6.2		1025.3		0.5	2.1	Sufficient
Jun-01		2.7	3.0	3.6	2.3		6.6		1095.2		0.5	1.7	Sufficient
Jun-02		2.7	3.0	3.6	1.9		6.9		1154.1		0.5	1.1	Sufficient
Jul-01		2.8	3.1	3.6	2.1		6.8		1137.8		0.5	1.0	Sufficient
Jul-02		2.8	3.1	3.7	1.7		7.2		1202.2		0.6	0.8	Sufficient
Aug-01	Land Preparation	3.3	3.6		1.6			7.2	1200.0	2456.8	0.6	0.3	Insufficient
Aug-02		3.3	3.7		1.3			7.5	1256.8		0.6	0.1	Insufficient
Sep-01	Planting (Palawija)	3.8	4.2	1.9		1.0	6.3		1043.3	6993.9	0.5	0.1	Insufficient
Sep-02		3.9	4.3	2.9		1.1	7.1		1178.7		0.5	0.1	Insufficient
Oct-01		4.1	4.5	4.1		1.0	8.4		1394.4		0.6	0.1	Insufficient
Oct-02		4.1	4.5	4.1		1.4	8.0		1331.9		0.6	0.1	Insufficient
Nov-01		4.0	4.5	3.3		1.3	7.3		1218.9		0.6	0.1	Insufficient
Nov-02		4.0	4.4	1.8		2.1	5.0		826.7		0.4	0.9	Sufficient
Dec-01	Land Preparation	3.9	4.3		4.0			5.3	889.2	1754.9	0.4	2.1	Sufficient
Dec-02		3.9	4.3		4.1			5.2	865.7		0.4	3.1	Sufficient

The need of the irrigation water is determined not only by the types of crops, but also by the activities on the paddy field such as land preparation or planting. Table 3 shows that the first period for paddy rice starts in December. Land preparation can be done well with sufficient water during the month of December, while the farmer may starts planting in January. The second period for paddy rice starts in April for land preparation continued by planting in May. The third period is used for palawija with the land preparation starts in August and plantation starts in September. Palawija needs less water than paddy rice, so that having planting period during August to November is acceptable.

The calculation of water needs compared to water availability represented by dependable water, it shows that irrigation water is sufficient for paddy rice for both periods from December to July. However, the water is insufficient during August to the first half monthly of November.

4. Conclusion

1. The Way Wayah River Basin is a sub of the Way Seputih watershed, that at the control point in Giri Tunggal has an area of 7,238.9 ha, the area of existing paddy rice fields which in North Pagelaran and Banyumas sub districts is 722.487908 ha with the highest rice field elevation of 140 m, and the raw area of rice fields in the planned Way Wayah Irrigation Area is 237.98 hectares consisting of dry land agriculture and plantations with the highest elevation of 125 m.

2. The reliable discharge on the Way Wayah river at the control point of the suggested weir location are fluctuated.

3. The results of the calculation of water requirements are as follows:
   - The need for water during the land preparation period in December was 1754.90 m^3 ha^{-1}, in April was 1698.50 m^3 ha^{-1}, and in August was 2456.83 m^3 ha^{-1}
   - The need for water during the rice planting season 1 which starts from January to March is 6196.88 m^3 ha^{-1} $season^{-1}$
   - The need for water during rice planting season 2 which starts from May to July is 6556.96 m^3 ha^{-1} $season^{-1}$

References

[1] Malek Z and Verburg P H 2018 Adaptation of land management in the Mediterranean under scenarios of irrigation water use and availability *Mitig. Adapt. Strateg. Glob. Change* **23** pp 821–837

[2] Elliott J, Deryng D, Müller C, Frieler K, Konzmann M and Gerten D 2007 Constraints and potentials of future irrigation water availability on agricultural production under climate change PNAS **8** (9) pp 3239–3244

[3] Sauer T, Uwe P H, Schneider A, Schmid E, Kindermann G and Obersteiner M 2010 Agriculture and resource availability in a changing world:The role of irrigation Water Resources Research **46** W06503, doi:10.1029/2009WR007729 pp 1-12

[4] Murniati K and Mutolib A 2020. The impact of climate change on the household food security of upland rice farmers in Sidomulyo, Lampung Province, Indonesia *Biodiversitas*. **21**, 8 p. 3487-3493.

[5] Taufik M, Rajiman R and Rahman R 2011 Analysis of Rice Paddy Productivity in East Kupang, East Nusa Tenggara *Journal of Agricultural Sciences* **8** (2) pp 105-114.

[6] Sudjarwadi 1990 *Theory and Practice of Irrigation*, Department of Engineering UGM, Yogyakarta.

[7] Rahmat A and Mutolib A 2016 Comparison of air temperature under global climate change issue in Gifu city and Ogaki city, Japan Indonesian *Journal of Science & Technology*. **1**,1 p.37-46

[8] Listiana I, Hudoyo A, Prayitno R T, Mutolib A, Yanfika H and Rahmat A 2020 Adoption Level of Environmentally Friendly Paddy Cultivated Innovation in Pringsewu District, Lampung Province, Indonesia *Journal of Physics: Conference Series*. **1467** (012025), 1-9

[9]   Directorate of Irrigation Water Management 2010 *Technical Guidelines for Empowerment of Water User Farmers Association*, DPAI Directorate General of Agricultural Infrastructure and Facilities, Ministry of Agriculture, Jakarta.

[10] Notohadiprawiro T 1992 *Rice Fields in Land Use*, Faculty of Agriculture, UPN, Yogyakarta..

[11] Triatmodjo B, 2008, *Applied Hydrology*, Beta Offset, Yogyakarta.

[12] Ministry of Public Works Directorate of Irrigation 2013 *Standard for Irrigation Planning Criteria for Building Section Planning (KP 01-09).*

[13] Grafton R Q, Williams J, Perry C J, Molle F, Ringler C, Steduto P, Udall B, Wheeler S A, Wang Y, Garrick D and Allen R G 2018 The paradox of irrigation efficiency Science **361** pp 748-750

[14] Rahmat A, Zaki M K, Effendi I, Mutolib A, Yanfika H, Listiana I 2019 Effect of global climate change on air temperature and precipitation in six cities in Gifu Prefecture, Japan *IOP Conf. J Phys: Conf Ser.* **1155**, 012070. DOI: 10.1088/1742-6596/1155/1/012070