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Optimization of Water Utilization Through the Application of Hydropande Technology to Meet Clean Water and Agricultural Needs in Timuhun Village, Banjarangkan District, Klungkung Regency

I Komang Ery Kusnada, I Ketut Sudiarta*, I Gusti Agung Putu Eryani, Yohanes Parlindungan Situmeang, Dewa Nyoman Sudita, Nengah Muliarta
Master of Agricultural Science Study Program, Postgraduate Faculty, Warmadewa University, Denpasar, Bali, Indonesia.
*Corresponding author: ksudiarta64@gmail.com

Abstract
Timuhun Village, located in Banjarangkan District, Klungkung Regency, covers an area of 375 hectares with a population of 3,334 in 2021. Approximately 86.67% of the total land is utilized for agriculture, including rice fields, gardens, and dry fields, with a total agricultural area of 325 hectares. This village plays a significant role in food production, especially rice, supported by the irrigation system from Subak Timuhun, which utilizes the Manik Tirta Spring. However, challenges in water management arise due to the higher elevation of agricultural land compared to water sources, leading to difficulties in meeting the demands for clean water and irrigation. The Appropriate Technology of Hidropande is introduced as a solution to lift water from lower sources. This study aims to develop an integrated water management model by analyzing the residual water volume from the Manik Tirta Spring, determining the irrigation requirements for the paddy-cassava-paddy cropping pattern, and planning optimal water management strategies. Utilizing CROPWAT 8.0 software, this research estimates the water needs of crops based on various climatic and soil parameters. The results indicate that the highest irrigation water requirement reaches 41 mm/decade in December, while the lowest demand of 6.8 mm/decade occurs during the maturation phase of the plants. With calculations showing surplus residual water of 1.97 liters/second, the potential discharge from the Manik Tirta Spring can be maximized to support irrigation and meet clean water needs, alongside plans for developing a more efficient Hidropande pump. This study provides valuable insights into sustainable water management in Timuhun Village.

Keywords: *Cropwat; Hydropande technology; irrigation water; agricultural water*

1. Introduction

Village Timuhun, Banjarangkan District, Klungkung Regency, has an area of 375 hectares with a population of 3,334 people in 2021 [1]. Of the total land area, 325 hectares (86.67%) are used for agriculture, while the remainder is allocated as yards covering 24.65 hectares (6.57%) and other land uses covering 25.35 hectares (6.76%). Agricultural land in the village consists of 147 hectares of rice fields, 129 hectares of orchards, and 49 hectares of dryland. Approximately 629 people or 18.79% of the village population work as farmers [2].

Village Timuhun is located in a fertile lowland area at an altitude of 510-550 meters above sea level. With 147 hectares of rice fields, this village plays an important role as a food producer, especially rice and other food crops in the Klungkung Regency. The rice fields in this village are part of the Subak Timuhun irrigation system, which receives water from the Pasedahan Toya Bubuh, sourced from the Manik Tirta Spring. There is also surface water potential that can meet the water needs of the population, both for clean water and agriculture, as the village is surrounded by two large rivers, namely Tukad Bubuh and Tukad Jinah. However, the water potential of these rivers has not been optimally utilized due to their lower elevation compared to agricultural land and settlements, causing serious problems in water availability for drinking water and agriculture.

Appropriate Hydro-Panel Technology is a creative innovation in efforts to meet community water needs. This technology applies a mechanism designed to utilize the potential energy of liquids, to lift water from a lower to a higher place, so that it can be used for clean water supply, irrigation, and livestock. However, the application of Hydro-Panel Technology in Desa Timuhun has not fully met the problem of accessible water availability for the population. Currently, the water source utilized is the Manik Tirta Spring, which is managed by the Village Water Supply Company for clean water needs, while water for agricultural irrigation comes only from the remaining water usage.

Irrigation water is the amount of water required to support plant growth on cultivated land. According to [3], efficiency in utilizing water as a vital resource must be maximized. Irrigation water requirements are calculated by considering reference evapotranspiration (ET0), cropping patterns, and planting schedules [4]. Water requirements for plants are defined as the amount of water needed for normal plant growth, representing a combination of various factors including evapotranspiration [5].

Cropping patterns in tropical regions, including Indonesia, are determined based on water availability and the physical and chemical conditions of the soil. According to [6], the main constraint for the growing season in rainfed rice fields is water availability. The determination of cropping patterns will differ for areas with water deficits and those with access to irrigation, and is influenced by many factors, including rainfall and social, economic, and cultural conditions [7, 8].

Simulation of residual water or water discharged from a reservoir with a rice-palawija-rice cropping pattern will use climate data, temperature, rainfall, and soil type as input data in the CROPWAT software. The Cropwats simulation process is terminated and is said to meet the water requirements in one planting period based on the availability of water entering the subak irrigation canal with an area of 1 plot of land from the land area in the Subak Timuhun Irrigation Area. The CROPWAT Application System According to [9], the use of Cropwat 8.0 software can help determine the estimated water application adjusted to the water needs of plants by inputting weather elements, soil, and plant characteristics. The computer program developed by the Food and Agriculture Organization (FAO) provides an opportunity to estimate irrigation schedules by adjusting to field water availability conditions. The estimated value obtained is more accurate and closer to field facts and minimizes human error compared to other methods in estimating crop evapotranspiration (ETc) [10].

This study aims to develop an integrated water management model through the application of Hydro-Panel Technology, with specific objectives to: 1) Analyze the volume of residual water from the Manik Tirta Spring for agriculture; 2) Analyze agricultural water requirements for land in the Subak Timuhun Irrigation Area with a rice-palawija-rice cropping pattern; 3) Plan a water management model for the Manik Tirta Spring to meet clean water and agricultural needs; 4) Optimize the utilization of water resources through Hydro-Panel Technology for clean water and agricultural needs.

2. Materials and Methods

2.1. Research Design

This study employs a research design using a survey method and a naturalistic/qualitative method in a continuum. The data sources used are primary and secondary data. Primary data includes data on the Manik Tirta spring related to water discharge, residual water that can be utilized by the community, land use data, population data, and climate and rainfall data. Secondary data that can be obtained from the description includes information that can be found in external sources, such as literature, government reports, and statistical data as well as monographic data of Timuhun village.

According to [11], survey research is a critical observation to obtain clear and good information on a particular issue and in a specific area. Survey research aims to achieve generalization, and some also aim to make predictions.

This study is also designed with a mixed method type of explanatory sequential. According to [12], the mixed method is a research approach that connects quantitative and qualitative research methods. [13] states that the mixed method is a method focused on collecting, analyzing, and mixing quantitative and qualitative data in one or a series of studies. The main premise is that the use of quantitative and qualitative approaches, in combination, provides a better understanding of 1 research problem than 2 individual approaches.

Explanatory sequential mixed method, according to [12], is one type of mixed method where the researcher first conducts quantitative research, analyzes the results, and then builds on the results to explain them in more detail with qualitative 3 research. Quantitatively, this study applies methods to investigate the relationship between variables in the analysis of agricultural/irrigation water needs. Qualitatively, it is applied in the process of developing a model to explore and understand what is experienced by research subjects (scuba diving stakeholders), for example, perceptions, views, actions, expectations, and experiences holistically.

2.2. Research Location

The Beji Manik Tirta Spring is located in Timuhun Village, Banjarangkan District, Klungkung Regency. The Beji Manik Tirta Spring is a perennial spring that releases water continuously with a stable discharge during both the rainy and dry seasons. The environmental conditions at the Beji Manik Tirta Spring are filled with lush natural vegetation and a sacred area. There is a river in the area. This spring is used by the villagers of Timuhun as daily raw water. The villagers of Timuhun walk down about 240 meters to take water from this spring. The Beji Manik Tirta Spring in Timuhun has great potential to meet the raw water needs of the villagers of Timuhun. With the potential of the Beji Manik Tirta Spring, the raw water needs in 2025 and 2030 will be planned, and the construction of a reservoir will be planned to meet water needs for the next 10 years in Timuhun Village. The preservation of this spring also needs to be considered for its sustainability, therefore it will be analyzed through SWOT analysis to find the right recommendations for sustainable management and conservation of the Beji Manik Tirta Spring in Timuhun.

2.3. Research Time

The research was conducted from May 2023 to July 2023. The research was carried out by measuring the discharge of water that was wasted because it was unused or unutilized by the population. The measurement was carried out by calculating the water discharge per unit of liters per second.

2.4. Analysis of Population Projection

The analysis of the population projection to determine the population in the next 10 years in 2032 uses the linear regression method. This method is used based on the average annual growth of the population of Timuhun Village for the previous 5 years from 2018 to 2022, the data of which was obtained directly from the Timuhun Village office. For the data table and calculations, see the table below.

Table 1. Population Projection

No.	Years	Total population
1	2018	3367
2	2019	3367
3	2020	3364
4	2021	3463
5	2022	3450

Source: Timuhun Village Office

The equation used in calculating the correlation test is:

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$$r = \frac{n(\Sigma XY) - (\Sigma X)(\Sigma Y)}{\sqrt{[(n(\Sigma X2) - (\Sigma X)2] x [(n)(\Sigma Y2) - (\Sigma Y)2]}}$$

$$= \frac{5(51295) - (15)(17011)}{\sqrt{[(5(55) - (225)] x [(5)(57884743) - (289374121)]}}$$

r = 0,832

The formula used in calculating the population projection is: $y = a + bx$
Which one:

$$a = \frac{(\Sigma y)(\Sigma x2) - (\Sigma x)(\Sigma yx)}{n(\Sigma x2) - (\Sigma x)2}$$

$$= \frac{(10711)(55) - (15)(51295)}{5(55) - 225}$$

a = 3324

$$b = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x2) - (\Sigma x)2}$$

$$= \frac{5(51295) - (15)(17011)}{5(55) - 225}$$

b = 26
So,
$y = a + bx$
y2023 = 3324 + 26 x 6
y2023 = 3481 people

The calculation of the next 10 years using the linear regression method, is continued with the table below. The results of the population project calculation for the next 10 years will be used in the calculation of water needs and reservoir capacity where the population used in the calculation of reservoir capacity is in 2032 with a population of 3717 people.

Table 2. Population Projection for the Next 10 Years

No.	Tahun	Total population
1	2023	3481
2	2024	3507
3	2025	3534
4	2026	3560
5	2027	3586
6	2028	3612
7	2029	3638
8	2030	3665
9	2031	3691
10	2032	3717

Source: Analysis Results

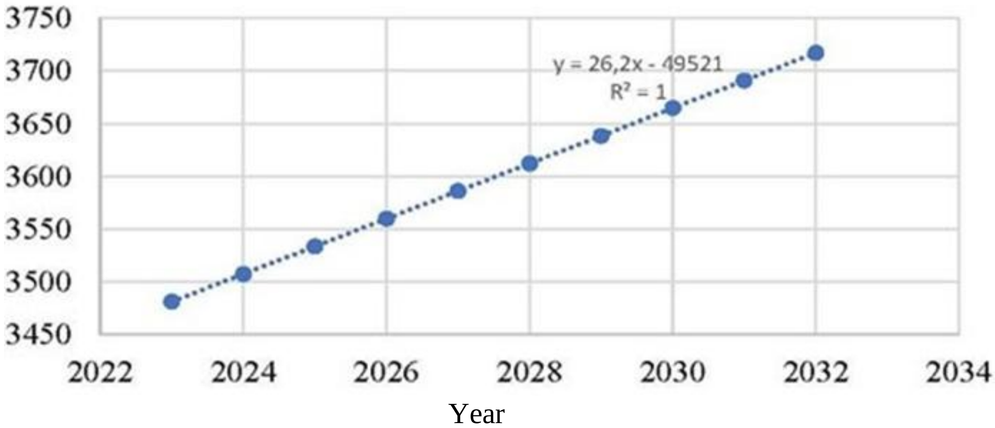

Figure 1. Population Growth Projection Graph
Source: Analysis Results

2.5. Total Water Requirements Analysis

Water demand analysis is used to determine the total water demand required in the next 10 years in Timuhun Village and to plan water storage or reservoirs. Water demand is calculated from domestic and non-domestic water demand, water loss/leakage, total water demand, maximum daily water demand, and peak hour water demand. The parameters set as the basis for calculating water demand can be seen in Table 3 below.

Table 3. Water Needs of the Population

No	Parameter	Value	Description
1	Domestic Water Needs	60 liters/person/day	Water needs in villages with a population of <20,000, taken as 60, are greater than the standard because water use increases every year.
2	Non-Domestic Water Needs	20%	20% of domestic needs
3	Water Loss	20%	Water loss in the village
4	Daily Factor	1.1	Daily factor maximum village water

Source: Directorate General of Human Settlements, Ministry of Public Works, 2000

Calculation of water requirements based on the parameters above have been determined, then the calculation of water requirements is as follows:

a. Domestic Water Needs

Q_D = Total population x 60 liters/person/day
Q_D 2023 = 3481 x 60 liters/person/day
Q_D 2023 = 208872 liters/person/day
Q_D 2023 = $\frac{208872}{24 \times 3600}$
Q_D 2023 = 2,418 liters/second

b. Non-Domestic Water Needs

Q_{nD} = Q_D x Sn
Q_{nD} 2023 = 2,418 liters/second x 20%
Q_{nD} 2023 = 0,484 liters/second

c. Water Loss

Q_{HL} = (Q_D + Q_{nD}) x Kt%
Q_{HL} 2023 = (2,418 +0,484) x 20%
Q_{HL} 2023 = 0,435 liters/second

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d. Total Water Requirements

$QT = QD + QnD + QHL$

$QT = 2,418 + 0,484 + 0,435$

$QT = 3,481$ liters/second

e. Maximum Daily Water Requirements

$Q_{HM} = 1,1 \times QT$

$Q_{HM} = 1,1 \times 3,418$

$Q_{HM} = 3,829$ liters/second

f. Peak Hour Water Needs

$QJP = 1,5 \times QT$

$QJP = 1,5 \times 3,418$

$QJP = 5,222$ liters/second

The calculation of total water requirements for the next 10 years is continued in Table 4 below.

Table 4. Total Water Requirements

Year	Population Domestic	Domestic Water Needs (Q_D)	Non-Domestic Water Needs (Q_{nD})	Water Loss (Q_{HL})	Total Water Needs (Q_T)	Maximum Daily Water Needs (Q_{HM})	Peak Hour Water Needs (Q_{JP})
		liters/second	liters/second	liters/second	liters/second	liters/second	liters/second
2023	3481	2,418	0,484	0,580	3,481	3,829	5,222
2024	3507	2,436	0,487	0,585	3,507	3,858	5,261
2025	3534	2,454	0,491	0,589	3,534	3,887	5,300
2026	3560	2,472	0,494	0,593	3,560	3,916	5,340
2027	3586	2,490	0,498	0,598	3,586	3,945	5,379
2028	3612	2,508	0,502	0,602	3,612	3,973	5,418
2029	3638	2,527	0,505	0,606	3,638	4,002	5,458
2030	3665	2,545	0,509	0,611	3,665	4,031	5,497
2031	3691	2,563	0,513	0,615	3,691	4,060	5,536
2032	3717	2,581	0,516	0,620	3,717	4,089	5,576

Source: Analysis Results

From the calculation of water needs with a 10-year population projection in the 10th year with a total water requirement of 3,717 liters/second, the results will be used in calculating the reservoir capacity to determine the dimensions that will be used to accommodate water from the Beji Manik Tirta Timuhun spring to meet water needs in Timuhun Village. This research was conducted in Timuhun Village, Banjarangkan District, Klungkung Regency. The research was conducted for one month, namely from mid-May to mid-June 2023.

2.6. Research Equipment

The tools used in this study are as follows:

1. Stationery, used to record data/research results.
2. Camera used to document the situation and conditions in the field.
3. Global Positioning System (GPS), is used to record geographic location data (latitude and longitude coordinates) of the research object.
4. Computer, used to process data.
5. CROPWAT 8.0 software, was used to process data from the study.

2.7. Research Variables

Variable is a concept that has a variation in value. According to [15], a variable is an attribute characteristic or value of a person, object, or activity that has a certain variation that is determined by the researcher to be studied and concluded. While [16] states that variables or variables are values that can change, which describe an indicator that reflects a perception or concept that can be measured. The variables involved in this study are as follows:

a. Residual Water Variables for Agriculture

The residual water variables from Manik Tirta Spring for agriculture consist of the following indicators:

1) Volume of water discharge from Manik Tirta Spring.
2) Volume of water to meet clean water needs.
3) Volume of water lost in the production and distribution process.

b. Agricultural Water Needs Variables

Calculation of agricultural/irrigation water needs using CROPWAT 8.0 software. The variables used for the operation of CROPWAT 8.0 software include:

1) Climatology variables, with indicators including location, climatology station, altitude, latitude, longitude, maximum and minimum temperature, rainfall,
2) Plant variables, with indicators including types of plants and initial planting schedule.
3) Soil variables, with indicators including soil type, plant root depth, and soil solum depth.

c. Model Development Variables

The formulation of the Manik Tirta Spring water management model to optimally meet the needs of clean water and agricultural water in Subak Timuhun through the application of Hydropande Appropriate Technology begins with determining the most influential key variables and determining the optimization of water utilization.

2.8. Research Procedures

A study will apply a certain procedure as part of the research format, to provide clear direction to achieve the research targets and objectives in question.

2.8.1. Data source

This study uses data from primary and secondary sources. The types of data used consist of quantitative data and qualitative data.

1. Primary data is data obtained directly from the research object, using observation, measurement, and interview. Observation or observation to obtain data on the situation/condition of the research object. Measurements are carried out to obtain quantitative data related to the volume of water sources and allocation of water sources. Interviews are to obtain qualitative data on the perceptions, problems, and expectations of local stakeholders in meeting water needs.
2. Secondary data is data obtained through other parties not directly obtained from researchers from their research subjects. This secondary data is obtained through literature related to the research in the form of journals, magazines newspapers, and books related to the research.

2.8.2. Data collection technique

a. Primary Data Collection Techniques

The primary data collected and data collection techniques in this study are as follows:

1) Data on the general environmental conditions of Timuhun Village, including:
   a) Data on the general environmental conditions of Timunun Village in the form of the location of water sources and agricultural land.
   b) This data was collected using observation techniques or methods where data recording was assisted by a Global Positioning System (GPS).
2) Data on residual water for agriculture were collected using field measurements, including:
   a) Volume of water discharge from Manik Tirta Spring.
   b) Volume of water lifted into the reservoir.
   c) Volume of water distributed to meet the clean water needs of residents.
   d) Volume of water lost in the production and distribution process.

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3) Data on community perceptions, problems, and expectations regarding water management. This data was collected using structured interview techniques with local stakeholders, including village officials, Bendesa/Prajuru Desa Adat, Community Leaders, Subak Administrators, and farmers.

b. Secondary Collection Techniques
Secondary data is collected utilizing institutional surveys and searching books, journals, data/information, and other publications via the Internet.

3. Results and Discussion

Data analysis in this study used non-parametric descriptive statistical methods, including exploratory descriptive analysis. Descriptive analysis includes: (1) data portrait analysis (frequency and presentation), namely the calculation of the frequency of a value in a variable. Values are presented as absolute numbers or percentages of the whole; (2) analysis of the central tendency of data, namely the calculation of the arithmetic mean value of all values of the measured variable; and (3) analysis of value variation, to see the spread of values in the overall distribution of a variable's values from its middle value. This analysis is to see how much the values of a variable differ from its value. Measurement of value variation is done by looking at the range of data or standard deviation.

a. Analysis of Residual Water Data for Agriculture
The residual water data for agriculture analyzed includes:
1) Total remaining water
Total residual water is the remaining water from the Manik Tirta Spring water source after being used to meet clean water needs. The formula is as follows:
AST = Qma – Ve – Vd – Vh
Where: AST: Total residual water; Qma: spring water discharge; Ve: volume of water lifted (in the reservoir); Vd: volume of water distributed for domestic needs (clean water); Vh: volume of water lost (leaked) in distribution.
2) Effective residual water
Effective residual water is the residual water from the reservoir (volume of water lifted using TPG Hidropande) after being used to meet clean water needs. The formula is as follows:
ASE = Ve – Vd – Vh
Where: AS: Effective residual water; Ve: volume of water lifted (in the reservoir); Vd: volume of water distributed for domestic needs (clean water); Vh: volume of water lost (leaked) in distribution.

Calculation of water utilization and residual water:

The availability of flowing water originating from the Manik Tirta spring in Timuhun village is 10 liters/second. Water is lifted to be channeled to and stored in several water reservoirs/buildings with the help of appropriate hydropande pump technology. Two pump units will be used, each pump unit has a water lifting capacity of 1 liter/second. So the water discharge entering the reservoir is 2 liters/second. The amount of water capacity in one minute is the amount of water discharge per second entering the reservoir multiplied by 60 to (2 x 60 = 120 liters/minute) so that in 1 hour the water discharge flowing into the reservoir is 120 x 60 = 7200 liters per hour. So in 1 day the water discharge flowing into the reservoir is 172,800 liters/day (maximum discharge). Assuming the water requirement for one person in one day is 60 liters, then 172,800/60 = 2880 people. The community takes drinking water/gallon (20 liters)/day, on average people take water approximately 100 people per day = 100 x 20 liters = 2000 liters /day. The remaining overflowing water is not utilized 172,800 liters - 2000 liters = 170,800 liters per day.

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b. Analysis of Agricultural Water Requirements

Calculation of water requirement optimization with the concept of Irrigation Planning Standard (KP-01) using CROPWAT software version 8.0. CROPWAT software version 8.0 CROPWAT is a decision support system developed by the FAO Land and Water Development Division based on the Penman-Monteith method, to plan and manage irrigation [17].

CROPWAT software was developed by FAO in 1990. Input data includes meteorological, soil, and crop data [18]. Definition of CROPWAT and its functions CROPWAT is a Windows-based program used to calculate crop water requirements and irrigation requirements based on soil, climate, and crop data. CROPWAT can be used to calculate potential evapotranspiration, actual evapotranspiration, irrigation water requirements for one type of plant or several types of plants in one area, and to plan irrigation water provision. From several studies, it was found that the Penmann-Monteith model provides accurate estimates so FAO recommends its use for estimating standard evapotranspiration rates in estimating water requirements for plants [17].

The data required to operate CROPWAT is monthly climatology data (maximum-minimum or average temperature, sunshine, humidity, wind speed, and rainfall). Crop data is available in the program in a limited way and can be added or modified according to local conditions. The main function of CROPWAT [18] is:

1) To calculate evapotranspiration reference.
2) To calculate crop water requirement.
3) To calculate irrigation water requirement.
4) To prepare irrigation schedule.
5) To create a water availability pattern.
6) To evaluate rainfall.
7) To evaluate irrigation practice efficiency.

The analysis stage for using CROPWAT software version 8.0 [19] is:

1) Run the CROPWAT 8.0 software
2) Click the climate/ETo icon
3) Input climatology data in the form of: 1) Input country data, the country where the climatology data comes from; 2) Input station data, the recording climatology station; 3) Input altitude data, the height of the recording station; 4) Input latitude data, the location of the latitude (North/South); 5) Input longitude data, the location of the latitude (East/West); 6) Input maximum and minimum temperature data (oC/oF/oK); 7) Input relative humidity data (%, mm/Hg, kpa, mbar); 8) Input wind speed data (km/day, km/hour, m/sec, mile/day, mile/hour); 9) Input sunlight duration data (hours or %); 10) ETo is automatically calculated and the results are displayed directly.
4) Then click the Rain icon.
5) Input rainfall data: 1) Total rainfall data for each month from January to December; 2) Select and fill in the calculation method, option-(1) Fixed Percentage (70% for rice calculation), (4) USDA soil conservation service (for secondary crop calculation); 3) Automatically accumulated effective rainfall and the results are displayed directly.
6) Next, click the Crop icon.
7) Input plant data (taken from the FAO – Rice and FAO- Maize databases), then edit the initial planting date.
8) Next, click the soil icon.
9) Input soil data (taken from the FAO – Medium database).
10) Next, click the CWR icon to see the results of the irrigation water requirement analysis in mm3/second units.

c. Plant Water Requirements

Plant water requirements are the amount of water needed by plants to grow optimally or the amount of water used to meet the plant evapotranspiration process. Plant evapotranspiration is a reflection of the amount of water needed by plants. Plant evapotranspiration is influenced by the density of the ground surface cover by the canopy, soil moisture content, and root distribution.

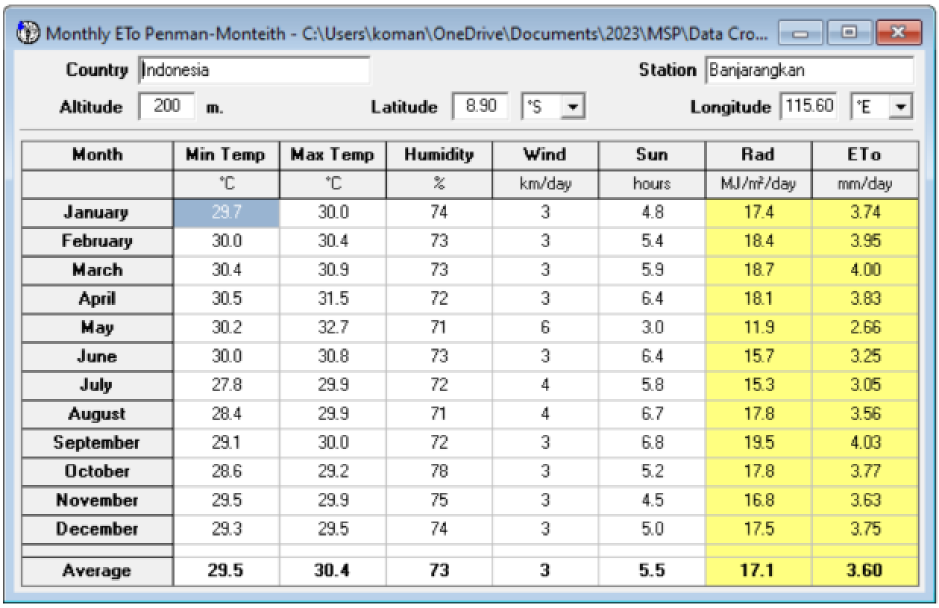
Plant evapotranspiration is obtained from the product of potential evapotranspiration and the plant coefficient (kc). The plant coefficient varies depending on the type of plant, plant variety, and growth phase.

According to [20], irrigation water requirements are influenced by various factors such as climatology, soil conditions, plant coefficients, planting patterns, water supply provided, irrigation area, irrigation efficiency, reuse of drainage water for irrigation, planting schedules, and others. Irrigation water requirements are carried out based on the planting patterns of each irrigation area, namely the Siulak Deras and Batang Sangkir irrigation areas with rice-rice-rice planting patterns.

The planting pattern used in this case study occurs once a planting season (MT). The planting season (MT) starts from November to February. Analysis of plant water requirements is calculated using Cropwat 8.0 software taken from the FAO (Food Agriculture Organization) database, namely rice plants. The steps for calculating plant water requirements using Cropwat 8.0 software are as follows:

1. Potential Evapotranspiration (ETo)

Evapotranspiration is the total amount of water from the surface of the land, water, and vegetation that is evaporated back into the atmosphere [21]. According to [22], plant growth will grow optimally if plant evapotranspiration is fulfilled and there is no interference from other factors. The dominant factors affecting potential evapotranspiration are solar radiation and temperature, atmospheric humidity, and wind [21]. In general, the magnitude of potential evapotranspiration will increase when temperature, humidity, solar radiation, and wind speed increase. The effect of solar radiation on ETo is through the process of photosynthesis in plants. Plants need water through the root-stem-leaf system. According to [21], the effect of wind on potential evapotranspiration is through the mechanism of transferring water vapor that comes out of the pores of the leaves. The greater the wind speed, the greater the rate of evapotranspiration that occurs. The effect of wind on the rate of potential evapotranspiration is smaller than the effect of solar radiation. Evapotranspiration is calculated using the Penman-Monteith equation in the Cropwat 8.0 software. The climate data input used comes from the Banjarangkan climatology post in 2022. The input data can be seen in Figure 2. The results of the calculation of potential evapotranspiration and land surface radiation energy using Cropwat 8.0 can be seen in Table 5.


Monthly ETo Penman-Monteith - C:\Users\koman\OneDrive\Documents\2023\MSP\Data Cro...

Country: Indonesia — Station: Banjarangkan

Altitude: 200 m. — Latitude: 8.90 °S — Longitude: 115.60 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	29.7	30.0	74	3	4.8	17.4	3.74
February	30.0	30.4	73	3	5.4	18.4	3.95
March	30.4	30.9	73	3	5.9	18.7	4.00
April	30.5	31.5	72	3	6.4	18.1	3.83
May	30.2	32.7	71	6	3.0	11.9	2.66
June	30.0	30.8	73	3	6.4	15.7	3.25
July	27.8	29.9	72	4	5.8	15.3	3.05
August	28.4	29.9	71	4	6.7	17.8	3.56
September	29.1	30.0	72	3	6.8	19.5	4.03
October	28.6	29.2	78	3	5.2	17.8	3.77
November	29.5	29.9	75	3	4.5	16.8	3.63
December	29.3	29.5	74	3	5.0	17.5	3.75
Average	**29.5**	**30.4**	**73**	**3**	**5.5**	**17.1**	**3.60**

Figure 2. Potential Evapotranspiration (ETo)

The following are the steps in determining radiation energy and potential evapotranspiration (ETo):

1) Input country data, namely Indonesia
2) Input station data, Banjarangkan station
3) Input Altitude data, the height of the recording station is 200 m
4) Input Latitude data, 8.09° LS
5) Input Longitude data, 115.45° BT
6) Input average temperature data (°C), 2022
7) Input relative humidity data (%), the input value is the average relative humidity value for each month during 2022
8) Input wind speed data (m/s), the input value is the average wind speed value for each month during 2022
9) Input solar radiation data (hours), the input value is the average solar radiation value for each month from 2022
10) The ETo results will automatically appear (mm/day).

Table 5. ETo Calculation Results

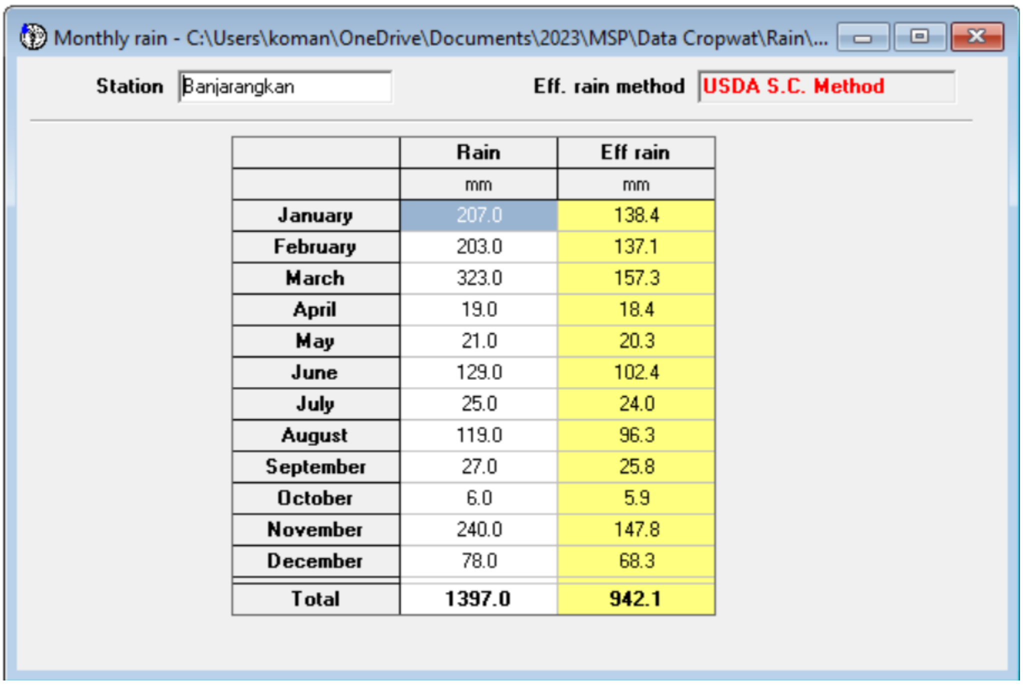
Month	Rad (MJ/m2/day	ETo (mm/day)
January	17.4	3.74
February	18.4	3.95
March	18.7	4.00
April	18,1	3.83
May	11.9	2.66
June	15.7	3.25
July	15.3	3.05
August	17.8	3.56
September	19.5	4.03
October	17.8	3.77
November	16.8	3.63
December	17.5	3.75
Average	17.1	3.60

Source: Calculation Results

Based on Table 5 above, it shows that the largest radiation energy is in September at 19.5 MJ/m2/day and the lowest in May at 11.9 MJ/m2/day. The average radiation energy is 17.1 MJ/m2/day. The highest ETo is in September at 4.03 (mm/day), while the lowest ETo is in May at 2.66 (mm/day) with an average daily ETo of 3.60 mm/day. This shows that the higher the air temperature and the duration of exposure, the higher the potential evapotranspiration rate (ETo).

2. Effective Rainfall (*Peff*)

Effective rainfall (Peff) is rainfall that falls in an area and can be directly utilized by plants to meet their consumptive water needs during their growth period. Factors that influence effective rainfall (Peff) are rainfall properties, climate, topography, soil physical properties, soil water retention capacity, and planting systems [23]. Effective rainfall (Peff) is used to determine the irrigation needs that will be given to plants. The input data for rainfall R80 can be seen in Figure 3.


Monthly rain - C:\Users\koman\OneDrive\Documents\2023\MSP\Data Cropwat\Rain\...

Station Banjarangkan   Eff. rain method USDA S.C. Method

	Rain	Eff rain
	mm	mm
January	207.0	138.4
February	203.0	137.1
March	323.0	157.3
April	19.0	18.4
May	21.0	20.3
June	129.0	102.4
July	25.0	24.0
August	119.0	96.3
September	27.0	25.8
October	6.0	5.9
November	240.0	147.8
December	78.0	68.3
Total	1397.0	942.1

Figure 3. Effective Rainfall (Peff)

Table 6. Effective Rainfall (Peff)

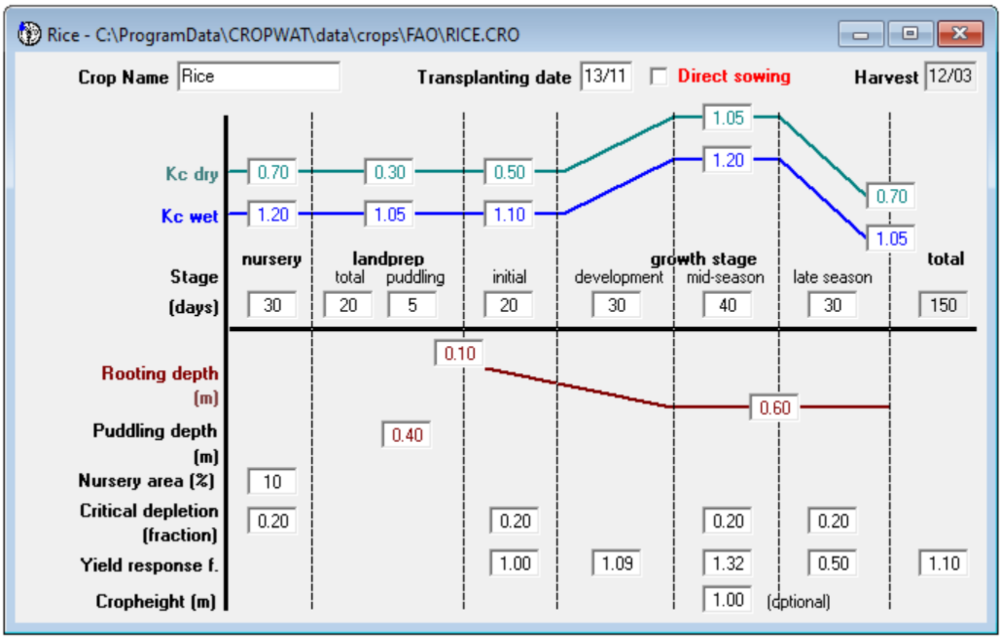
Month	Rad (MJ/m2/day	ETo (mm/day)
January	207.0	138.4
February	203.0	137.1
March	323.0	157.3
April	19.0	18.4
May	21.0	20.3
June	129.0	102.4
July	25.0	24.0
August	119.0	96.3
September	27.0	25.8
October	6.0	5.9
November	24.0	147.8
December	78.0	68.3
Average	1397.0	942.1

Based on calculations using cropwat 8.0 that have been carried out, it shows that the highest effective rainfall (Peff) is in March at 157.3 (mm), while the smallest effective rainfall (Peff) is in October at 32.9 (mm). Based on calculations that have been carried out, it shows that the higher the intensity of rainfall, the higher the effective rainfall (Peff). The results of the calculation of effective rainfall (Peff) are presented in Table 6. The steps in determining effective rainfall (Peff) using cropwat 8.0 software are as follows:

a) Input the average rainfall data, the input value is the average rainfall value for each month R80 for 1 year of 2022
b) Select and fill in the calculation method, the option to select a fixed percentage of 70%. Automatically, the effective rainfall (Peff) is calculated and the results are displayed directly (mm).

3. Crop characteristics

The next input data that needs to be entered into the Cropwat 8.0 Software is the plant coefficient value (kc). The rice plant coefficient value data is taken from FAO data (open-FAO-Rice) which is divided into four stages, namely initial, growth or development, mid-season, and late season. Then the plant coefficient value for each stage of plant growth will automatically appear and edit the initial planting date according to the planting schedule that has been determined in Subak Timuhun. Plant data input can be seen in Figure 4. Based on the FAO database available in the cropwat 8.0 software, it shows that rice plants have a plant coefficient (kc) at the initial stage of 1.10, a growth stage (development) of 1.09, mid-season 1.20, and late stage of 1.05. The largest plant coefficient (kc) in the middle period is 1.20 and the smallest in the late period is 1.05. The higher the kc value, the higher the plant needs water. At the end of the kc period, the plant will be smaller, this is because the plant experiences an aging process that requires less water. The duration of the rice plant in the early stages is 20 days, growth 30 days, mid 40 days, and the end 30 days. The total age of the rice plant to grow and develop is 120 days or 4 months. The start of the rice planting season is scheduled for November 13 and will be



harvested on March 12.

Figure 4. Plant Data Input

4. Soil Data

The next data input is soil-type data taken from the FAO database. Selected medium, soil data will appear automatically. The results of soil data input for rice plants can be seen in Figure 5. Based on the soil type map of the study location, shows that there are three types of soil, namely, Yellowish Brown Regosol.

In general, medium soil types have a total available soil moisture of 290 mm/meter, a maximum rain infiltration rate of 40 mm/day, a maximum rooting depth of 900 cm, initial soil moisture depletion, and initially available soil moisture of 290 mm/meter.

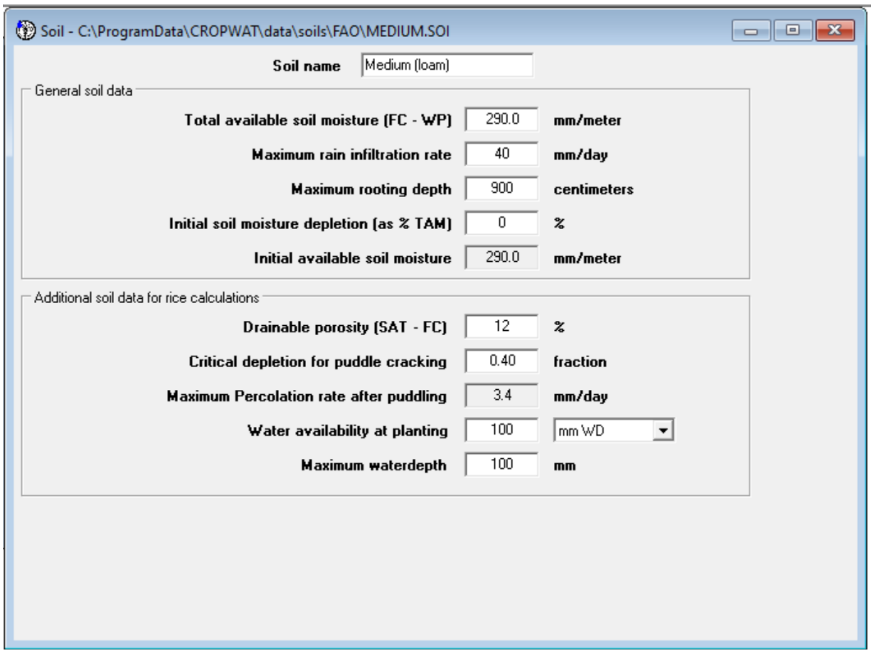
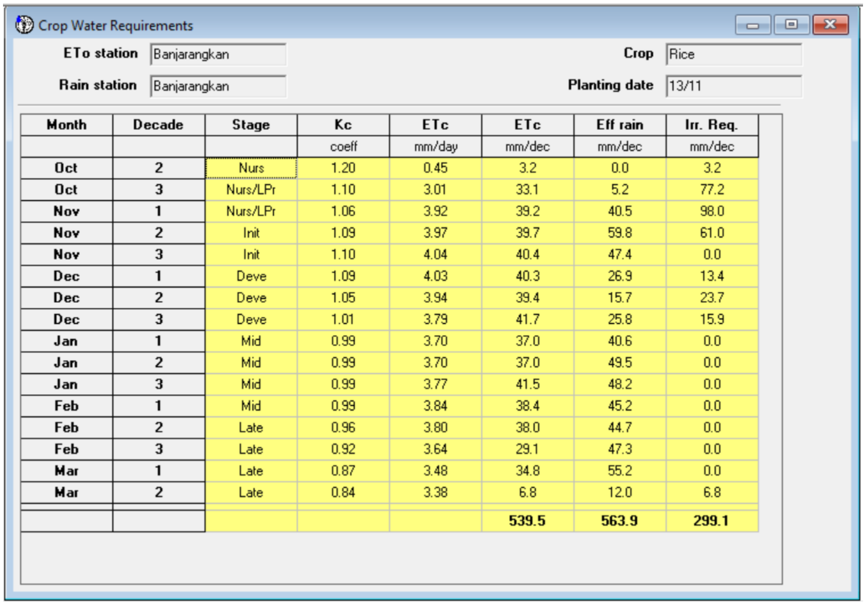


Figure 5. Soil Type Data Input

5. Crop Water Requirement (CWR)

The ETo value, effective rainfall, plant type, and soil type have been known, then the next stage is to see the results of plant evapotranspiration (ETc) also called actual evapotranspiration. Plant water requirements are presented in mm/dec units. One decade is equal to 10 days, so watering in one month is divided into three sessions per 10 days. Plant water requirements are divided into five stages, namely land preparation, initial, growth or development, mid-season, and late season. The output of plant water requirements can be seen in Figure 6.



Crop Water Requirements

ETo station: Banjarangkan — Crop: Rice

Rain station: Banjarangkan — Planting date: 13/11

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Oct	2	Nurs	1.20	0.45	3.2	0.0	3.2
Oct	3	Nurs/LPr	1.10	3.01	33.1	5.2	77.2
Nov	1	Nurs/LPr	1.06	3.92	39.2	40.5	98.0
Nov	2	Init	1.09	3.97	39.7	59.8	61.0
Nov	3	Init	1.10	4.04	40.4	47.4	0.0
Dec	1	Deve	1.09	4.03	40.3	26.9	13.4
Dec	2	Deve	1.05	3.94	39.4	15.7	23.7
Dec	3	Deve	1.01	3.79	41.7	25.8	15.9
Jan	1	Mid	0.99	3.70	37.0	40.6	0.0
Jan	2	Mid	0.99	3.70	37.0	49.5	0.0
Jan	3	Mid	0.99	3.77	41.5	48.2	0.0
Feb	1	Mid	0.99	3.84	38.4	45.2	0.0
Feb	2	Late	0.96	3.80	38.0	44.7	0.0
Feb	3	Late	0.92	3.64	29.1	47.3	0.0
Mar	1	Late	0.87	3.48	34.8	55.2	0.0
Mar	2	Late	0.84	3.38	6.8	12.0	6.8
					539.5	563.9	299.1

Figure 6. Output of Crop Water Requirements

4. Conclusion

The results of the calculation of plant water requirements (ETc) that have been carried out using the cropwat 8.0 software, obtained plant water requirements every 10 days. Plant water requirements are influenced by climate, plant coefficient (kc), plants, soil type, planting area, planting patterns, and soil processing.

Plant water requirements are influenced by the plant coefficient (kc) at each growth period. The higher the plant coefficient, the higher the plant water requirements. The highest plant water requirements are in December in the third decade of 41 mm/dec, while the lowest plant water requirements are in the final period of 6.8 mm/dec. Plant water requirements during soil processing are greater than plant water requirements during their growth period. The lowest plant water requirements are in the final period, which is caused by plants in the aging period.

Soil processing for rice requires more irrigation water because rice requires soil with a good level of saturation and in soft and loose soil conditions. Soil processing based on cropwat 8.0 software takes 2-3 decades before planting. The need for water for soil processing is influenced by the potential evapotranspiration (ETo) process that occurs.

The results of Cropwat calculations, that during the planting period on November 13, irrigation water was needed for irrigation of 299.1 mm/second. So the liter unit is 2.99×10-4 l/second.

The excess water remaining from community utilization is 1.97 l/second so that for a discharge of that size it can help provide irrigation water availability. The discharge of water coming out of the Manik Tirta Spring which is discharged into the river is quite large so that it can be reused as a larger source of irrigation water by renewing the Hydropande Pump device to a larger size.

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