Mathematical Statistician and Engineering Applications
ISSN: 2094-0343
2326-9865

Determination of Crop Water Requirements for the Rice in the Veeranam Tank Irrigation Command Area

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Article Info
Page Number: 2084 – 2089
Publication Issue:
Vol. 71 No. 3s2 (2022)

Article History
Article Received: 22 April 2022
Revised: 10 May 2022
Accepted: 15 June 2022
Publication: 19 July 2022

Abstract. A study was conducted to determine how much water needs for rice crops in the Veeranam Tank Irrigation Command Area of Cuddalore district, Tamil Nadu, India. Rice, groundnut, sugarcane, banana and betel are the most important crops in and around the study area. CROPWAT 8.0 was used to look at 20 years of weather data to determine how much water the rice required. The rice was planted during the 2021 kuruvai season, and the crop coefficient was found. The FAO Penman-Monteith method was used to figure out crop evapotranspiration (ETo), and the USDA S.C. method was used to determine effective rainfall. In the study area, reference evapotranspiration (ETo) ranged from 3.66 to 5.81 mm/day. Crop evapotranspiration (ETo) and crop water requirement varied from 0.70 mm/day to 6.01 mm/day and 0.0 mm/dec to 269.4 mm/dec for rice. The average CWR is identified as 679.3 mm/dec

Keywords: Crop Water Requirement, CROPWAT, Irrigation Water Requirement, Tank Irrigation Command Area and Effective rainfall

1. Introduction

Water has been nicknamed "blue gold," It is a significant concern of the twenty-first century because of the growing population and water demand. Irrigation accounts for 75-80 per cent of total water consumption worldwide (Green et al., 2006). Water needs to be saved in irrigation by accurately planning and delivering the required amount of water to the crops in time and space. In most of Tamil Nadu, the rainfall gravitates only during the monsoon seasons, and the land is often dry for the rest of the year. When precipitation is insufficient, the primary goal of irrigation is to utilise the tank water to maintain the Crop Water Requirements (CWR). CWR is defined as the depth of water (millimetres) required to meet the water consumed through evapotranspiration (ETc) by a disease-free crop growing in large fields under non-restrictive soil conditions soil water and fertility and attaining full production potential under the given growing environment (Hess, 2005).

Several researchers across the world have utilised the CROPWAT model to analyse Crop Water Requirements (Bhat et al., 2017; Gabr, 2021; Moseki et al., 2019; Sharma & Tare, 2022; Surendran et al., 2015). Hence the study also utilised the CROPWAT model to analyse Crop Water Requirements for the rice in the command area of the Veeranam lake. In the study area, irrigation consumes 80% of the area's available water resources, of which the crop successfully

utilises less than 30%, and the remainder is consumed by deep percolation and inadequate management techniques. This wasteful consumption of water not only wastes it but also produces water logging and salinisation, which reduces the productivity of the area's irrigated land. As a result, the study is significant in the current situation.

2. Study area

Veeranam Lake is around 25 kilometres west of Chidambaram in the Cuddalore district. This lake is one of the oldest and most important reservoirs of water in Tamil Nadu. Between 907 and 955 AD, King Paranthaga Cholan of the Chola dynasty designed this lake. The lake has a surface area of 19.42 km^2 with a perimeter length of 43.64 kilometres. Veeranam Lake is located between the northern latitudes $11^0$10' and $11^0$25' and eastern longitudes $79^0$10' and $79^0$25'. The lake's average depth is 3.38 m, with a slope of 1.86 per cent (Priyanka and Manikumari, 2021). The lake has a total capacity of 1465 million cubic feet (mcft) and a diversified aquatic plant ecosystem and species that float and emerge. Figure 1 shows the location map of the study area.

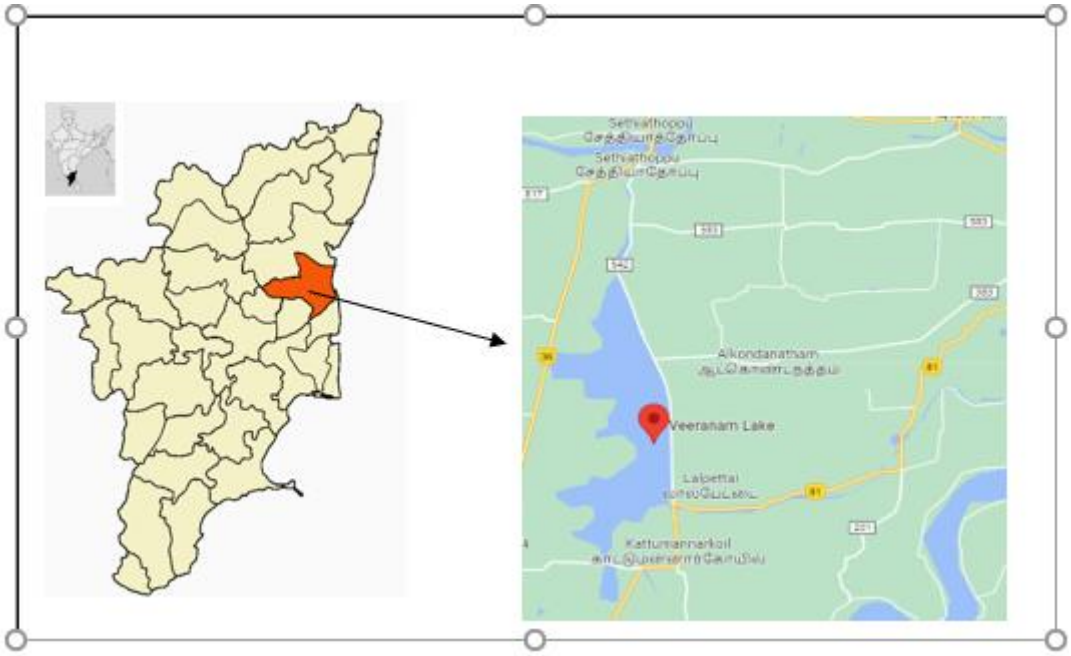

Figure 1. Location Map of the Study area

3. Methodology

3.1 Calculation of reference evapotranspiration

The FAO Penman-Monteith technique was used to determine the reference evapotranspiration ETo, based on the article "Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56" by Allen et al. (1998). To estimate ETo from meteorological data, The Food and Agriculture Organization of the United Nations (FAO) established the P-M (Penman-Montieth) approach as the global standard. The following equation expresses the Penman-Monteith equation used in the CROPWAT 8 programme.

$$ET_0 = \frac{0.408\,\Delta\,(R_n - G) + \gamma \frac{900}{T + 273}\,U_2\,(e_a - e_d)}{\Delta + \gamma(1 + 0.34\,U_2)}$$

where,

- **ETo: reference crop evapotranspiration, mm/d**
- **R_n: net radiation at the crop surface, MJ/(m2·d)**
- **G: soil heat flux, MJ/(m^2·d)**
- **T: average air temperature °C**
- **U_2: wind speed measured at 2 m height, m/s**
- **(e_a-e_d): vapour pressure deficit, kPa**
- **Δ: the slope of the vapour pressure curve, kPa/°C**
- **γ: psychrometric constant, kPa/°C**
- **900: conversion factor**

The FAO CROPWAT programme includes techniques for calculating reference crop evapotranspiration and crop water requirements and the ability to simulate agricultural water usage under various climatic, crop and soil circumstances.

This research assessed meteorological data from Annamalainagar meteorological station from 2002 to 2021. ETo was calculated using the station's latitude, longitude, and altitude, as well as the highest and lowest temperature (°C), relative humidity (per cent), wind speed (km/day), and sunlight hours. The wind speed measurement at 3m height in the meteorological station was converted into a 2m equivalent height for use in the P-M equation. ETo was computed every ten days and then averaged to provide monthly statistics. The soil variables used to estimate crop water requirements include available water content (mm/m) and soil depth (cm).

3.2 Crop data

The study focuses on rice because of its importance in this area. It is even the most important staple meal for most of the world's population. Crop Coefficient values (K_c) are employed for rice growth's all four phases.

3.3 Crop evapotranspiration (ETc)

ETo is multiplied by an empirical crop coefficient (Kc) to get an estimate of crop evapotranspiration (ETc)

ETc = Kc * ETo

where,

- **ETc: crop evapotranspiration**
- **Kc: crop coefficient**
- **ETo: reference crop evapotranspiration**

4. Results and discussion

ETo is a climatic parameter because its trend is affected by temperature, solar radiation, rainfall, wind, and the relative humidity of the air. With these parameters changing, ETo will change a lot from season to season and within each season. ETo was lowest at the height of the wet season and highest at the height of the dry season. The average ETo is identified as 4.75 mm/day in the study area.

Table 1. Monthly ETo Penman-Monteith Data of the study area (Station: Lalpettai)

Month	Min Temp °C	Max Temp °C	Humidity %	Wind km/day	Sun hours	Rad MJ/m²/day	ETo mm/day
January	20.8	27.9	77	173	8.0	18.9	3.83
February	21.2	29.0	75	164	8.5	20.9	4.29
March	22.9	30.8	74	156	9.1	23.1	4.91
April	25.7	32.8	74	181	8.7	22.9	5.31
May	27.1	35.7	69	199	8.3	22.0	5.80
June	27.0	36.9	61	181	7.2	20.0	5.81
July	26.1	35.4	63	173	6.1	18.4	5.31
August	25.4	34.5	67	156	6.6	19.4	5.09
September	25.1	33.8	70	138	7.1	20.1	4.94
October	24.3	31.5	76	112	6.8	18.7	4.21
November	22.8	29.0	79	164	6.8	17.4	3.78
December	21.5	27.9	77	181	7.2	17.3	3.66
Average	24.2	32.1	72	165	7.5	19.9	**4.75**

How much water a crop needs depends on its growth stage. The FAO give general lengths for the four growth stages and the total growing time for different climates and locations (Allen et al., 1998).

1. The first stage is when the seeds are planted, or seedlings are moved, and the crop covers about 10% of the ground. **(Init)**
2. The stage of crop growth: This stage starts when the first stage is over and lasts until the crop covers the ground completely (ground cover of 70–80%). This does not mean that the crop is at its tallest point. **(Deve)**
3. The midseason stage is from the end of the crop development stage until the crop is fully grown. This stage includes flowering and setting grain. **(Mid)**
4. The late season stage begins when the midseason stage ends and lasts until the last day of harvest. This stage includes ripening. **(Late)**

Crop Water Requirements (CWR) have been calculated for all four rice growth stages and are shown in Table 2. In the study area, rice is usually planted in June and harvested in October. More water is required for the nursery stage of the plant than in the other stages. The total

CWR for the rice in the tank irrigation command area of the Veeranam lake is identified as 679.3 mm/dec (10 Days).

Table 2. CROPWAT outputs on Crop coefficient (Kc), mean (mm/d) cumulative value (mm) of crop evapotranspiration (ETc), effective rain (mm) and irrigation requirement for each phenological stage of rice crop in the study area

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	1	**Nurs**	1.20	0.70	6.3	10.4	0.0
Jun	2	**Nurs/LPr**	1.08	5.64	56.4	9.9	168.8
Jun	3	**Nurs/LPr**	1.06	6.01	60.1	15.2	269.4
Jul	1	**Init**	1.10	6.00	60.0	21.4	38.6
Jul	2	**Init**	1.10	5.84	58.4	26.0	32.3
Jul	3	**Deve**	1.11	5.80	63.8	29.5	34.3
Aug	1	**Deve**	1.12	5.81	58.1	34.1	23.9
Aug	2	**Deve**	1.14	5.80	58.0	38.3	19.7
Aug	3	**Mid**	1.15	5.78	63.6	37.2	26.4
Sep	1	**Mid**	1.15	5.72	57.2	33.8	23.4
Sep	2	**Mid**	1.15	5.67	56.7	32.4	24.2
Sep	3	**Late**	1.15	5.39	53.9	38.5	15.3
Oct	1	**Late**	1.11	4.94	49.4	46.5	2.9
Oct	2	**Late**	1.05	4.42	44.2	52.4	0.0
Oct	3	**Late**	0.99	4.05	36.4	43.4	0.0
					782.6	**469.2**	**679.3**

5. Conclusion

Through the FAO CROPWAT model, the FAO-Penman-Monteith equation is recommended as the standard way to figure out reference and crop evapotranspiration and crop irrigation water requirements. The mean values of these parameters, ETc and IR, change as the rice crop grows and seasons change, depending on the weather and the soil. It showed how important it is for irrigation to be planned scientifically. The ETc and IR results gave us a practical way to figure out when to water rice grown in this tropical, semi-arid environment. The results can be used to make the best use of water and get the most rice grown in the Veeranam Command area.

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