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Estimation of Water Requirement of Crop by Using the CROPWAT

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ABSTRACT

Reservoir is a artificial storage which has been created due to construction of hydraulic structure across the length of river. Due to change in climate we get less as well as more intensity of rainfall over the catchment throughout year. To have the optimal operation of reservoir for irrigation, it is necessary to know the exact crop water requirement and Irrigation water requirement. Therefore this study aimed to assess the crop water demand (CWD), irrigation water demand (IWD), and optimal irrigation scheduling for key crops in the region using the CROPWAT mode by incorporating 21 years (2003-2023) hydrological data (rainfall) received from Bhatasa region official, climate data from NASA power , Soil data from Arc SWAT and National Bureo of Soil surevy Nagpur(NBSS).The findings indicated that the total CWR throughout the growing season for paddy, Nagali, Pulses, and Grass measured 585.4 mm/season, 241.5; 296.9; and 1343 mm, respectively. Meanwhile, the IWR for these crops over the entire season was recorded as 383.8 mm/dec ; 4.1 mm /dec; 4.1 mm /dec; and 940 mm, respectively. The rainfall contribution for paddy, Nagali, Pulses, and Grass stood at 747.8 mm/dec ; 662.3 mm; 692.8 mm ; and 2117 mm respectively.
Key Words : CLIMEWAT, CROPWAT, Soil data, hydrological data, climate data

1. INTRODUCTION

The CWR and IWR: The amount of water corresponding to the loss of water from a cultivated field due to evapotranspiration is called the CWR. It is expressed by the rate of *ET* in mm/day. The IWR is the depth of water required to meet crop water needs in excess of effective rainfall when a disease-free crop is grown in large fields under nonrestrictive soil and soil water conditions with adequate fertility. The IWR is higher than CWR when agriculture is completely dependent on irrigation. However, when agriculture is completely dependent on irrigation and rain- fall, the IWR is slightly lower than the CWR because the excess water is provided by rainfall. It can be calculated by Equation (1).

IWR = CWR - P_{eff} + Contribution of Groundwater

Irrigation scheduling

The proper amount of water for irrigation and the proper timing of irrigation are determined by irrigation sche- dulling. Different agronomic techniques and irrigation scheduling under diverse geographical and climatic conditions have a big impact on getting the optimum yield. Irrigation scheduling under different management conditions and water supply schedules is developed after calculating ET_o, CWR, IWR using the CROPWAT model. The data entered into the CROPWAT and CLIMWAT software, such as crop type, cultivation date, and soil type medium (clay), included the meteorological data of bhatsa region of shahapur district. Once all the data were entered into the software, it calculated the CWR, IWR.

2. CROPWAT AND CLIMATWAT MODEL

Utilizing water requirement models for irrigated agriculture is now more critical than ever. Such models not only enhance our understanding of current water consumption patterns but also aid in identifying sustainable pathways for future agricultural development. CLIMWAT is a climatic database that works with the computer application. CROPWAT to calculate crop water requirements, irrigation water requirements (IWR), and irrigation scheduling for a variety of crops at various cli- metrological stations across the world. CLIMWAT 2.0 for CROPWAT is a joint publication of the Water Development and Management Unit and the Climate Change and Bioenergy Unit of FAO. If local climatic data are not available, these can be obtained from CLIMWAT for over 5,000 stations in the world. CLIMWAT provides long-term monthly average values of seven climatic parameters, such as average daily maximum, mini- mum temperature, average relative humidity, average wind speed, average sunshine hours, average solar radiation, monthly rainfall, and effective rainfall .

CROPWAT 8.0 for Windows is a computer program for calculating crop water requirements, and irrigation requirements based on soil, climate, and crop data. In addition, the program allows the development of irrigation schedules for different farming conditions and the calculation of water demand for different cropping patterns.

CROPWAT can also be used to evaluate farmers' irrigation practices and estimate crop performance under both rainfed and irrigated conditions.

3. STUDY AREA

Ulhās River has major tributary called Bhatsa river basin. Multipurpose Bhatsa dam reservoir located on confluence of Bhatsa river and Chorana river near village Sajivali shahapur , Thane .Total area of watershed 374.15 Km^2.The annual average rainfall of the bhatsa river basin 2000 to 4000 mm (June to Sept) . Two Rain gauge station Kothale and Nadgaon .Reservoir lies between 19 ◦ 29' 41" N to 19 ◦ 36' 15" N Latitude and 73 ◦ 23' 41" E to 73 ◦ 32' 01". Max temperature 28.0 ◦ C to 35 .2 ◦ C and Min temperature 16.0 ◦ C to 26 .5 ◦ C . Height of Dam is 88.5 m, Length – 959 m.

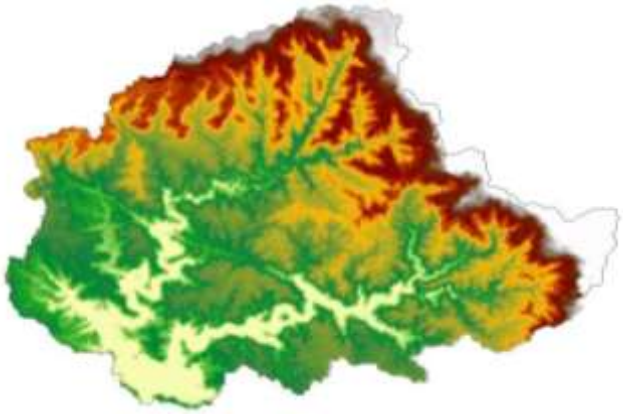


Figure No. 2.1: Digital Elevation Model of Bhatsa Dam (Source: Bhuvan).

4. METHODOLOGY FLOW CHART

Figure no 4.1. Methodology Flow chart

5. INPUT DATA REQUIRED

Three types of data are required to use the CROPWAT software, namely climate data, soil data, and crop data and World Weather Online. Hydrological data (rainfall) received from Bhatasa region official, climate data from NASA power, Soil data from Arc SWAT and National Bureo of Soil survey Nagpur (NBSS).

5.1 Meteorological data (Climate data):- For this study, climate data were obtained from the websites of NASA, the FAO software of CLIMWAT (FAO 2018). Climate data include maximum temperature, minimum temperature, relative humidity, wind speed, and sunshine hours. Shows the minimum and maximum temperatures in the study area taken from last 30 years from (1995-2025).

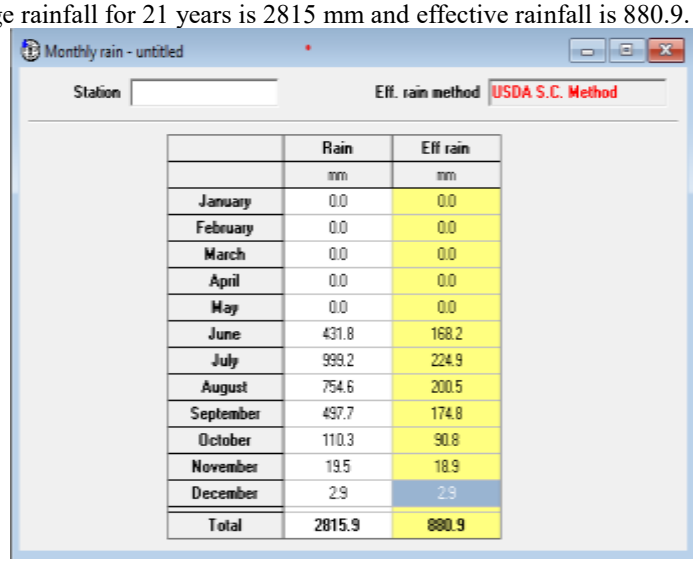
Monthly ETo Penman-Monteith - C:\kapil\BOMBAY-COLABA.pen

Country INDIA Station BOMBAY-COLABA
Altitude 11 m. Latitude 19.00 °N Longitude 73.00 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	19.3	29.6	77	164	8.6	17.6	3.61
February	20.0	29.6	76	164	8.9	19.9	4.00
March	22.6	31.1	78	190	8.7	21.5	4.59
April	25.0	32.3	80	164	8.9	23.0	5.01
May	27.0	33.4	79	190	8.8	23.2	5.41
June	26.3	32.0	89	242	5.7	18.3	4.09
July	25.3	30.1	92	268	2.9	14.1	3.10
August	24.9	29.6	92	268	3.3	14.5	3.07
September	24.9	30.5	87	164	5.1	16.5	3.57
October	24.8	32.5	85	147	7.9	18.9	4.07
November	23.0	32.9	79	147	8.5	17.9	3.95
December	20.9	31.6	80	164	8.5	16.9	3.61
Average	23.7	31.3	83	189	7.1	18.5	4.01

Figure no 5.1. Climate data of Study area

5.2 Rainfall data: - Rainfall data from 1995 to 2023 has been taken from bhatsa official Bhatsa Nagar Shahapur Thane. The total average rainfall for 21 years is 2815 mm and effective rainfall is 880.9.



	Rain	Eff rain
	mm	mm
January	0.0	0.0
February	0.0	0.0
March	0.0	0.0
April	0.0	0.0
May	0.0	0.0
June	431.8	168.2
July	999.2	224.9
August	754.6	200.5
September	497.7	174.8
October	110.3	90.8
November	19.5	18.9
December	2.9	2.9
Total	2815.9	880.9

Figure no 5.2. Rainfall data of Study area

5.3 Soil Data: - It is found that out of loamy sand of 53.07 % and loamy silt of 46.93 % of total study area found. {Source: Arc SWAT (SWAT2012.mdb) for User soil data).

5.4 Crop Data: - The Bhatsa region is located in the Thane district of Maharashtra, India. The agricultural calendar in this region is largely influenced by the monsoon, as farming is predominantly rain fed. The main crop grown in the study area paddy, Nagali, Pulses, and Grass. The timing of sowing and harvesting of the crops are given below.

Table 5.1 Crop data of study area

Sr.no	Crop	Sowing date	Harvesting date
1	Paddy (Kharif crop)	June-July, (15/06)	November to December (25/12)
2	Nagali (Kharif crop)	July-August (20/08)	October to December (20/11)
3	Pulses (Kharif and Rabi seasons)	June-July (01/06)	September-October (30/10)
4	Grass	June (20/06)	September (30/09)

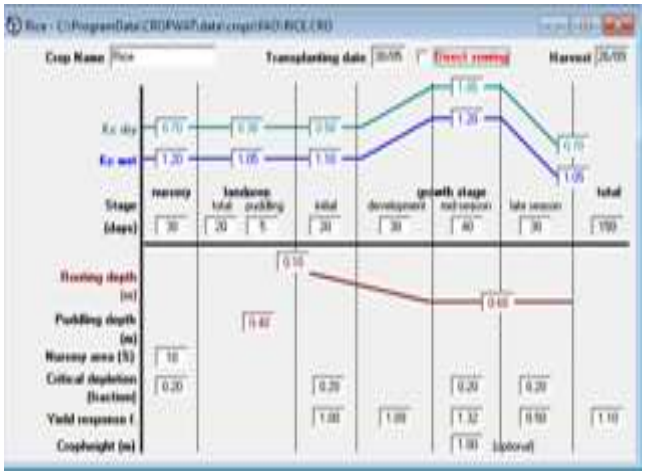


Figure no 5.4. Rice crop data of Study area

6. RESULTS AND DISCUSSION

6.1 Reference evapotranspiration (ET_o) and effective rainfall (P_{eff})

The reference evapotranspiration (ET_o) for the major cultivated crops; paddy, Nagali, Pulses, and Grass, in the district, was calculated. The ET_o for Rice crop was found 5.01 mm/day in the month of May and 3.07 mm/day in the month of August (Figure 5.1). The maximum and minimum value of P_{eff} (Figure 4) was 224.9 mm in the month of July and 2.9 mm in December , respectively.

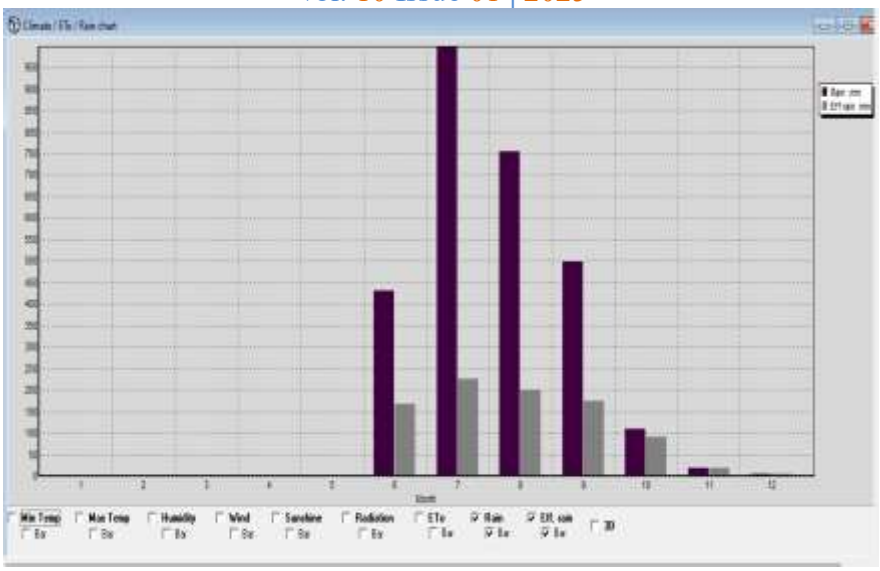
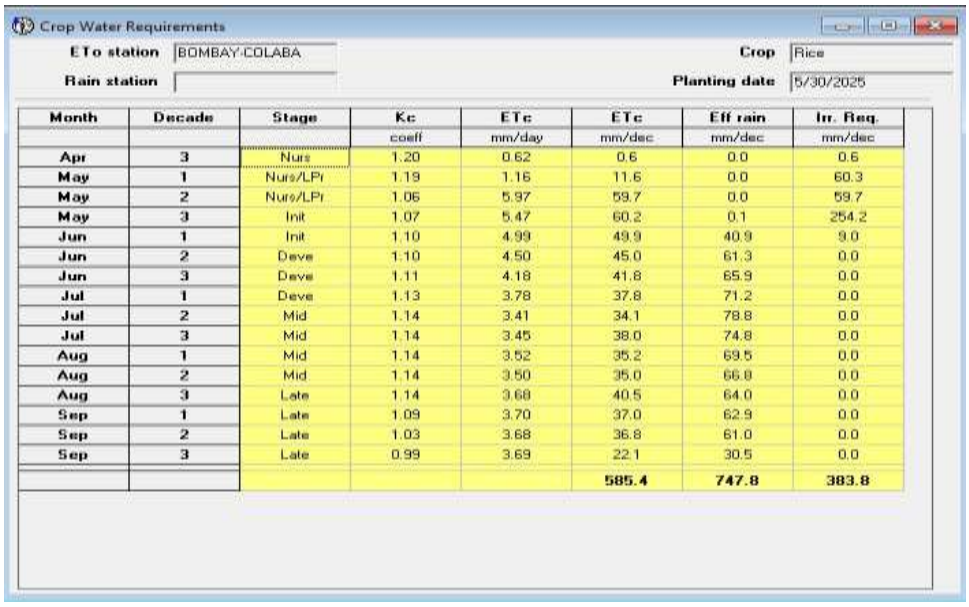


Figure 6.1 | Rainfall and effective rainfall in the study area.

6.2 The CWR, effective rainfall, and IWR

The total CWR, effective rainfall, and IWR for different crops obtained after the application of respective data of the study area in the CROPWAT model. The CWR, effective rainfall, and IWR for studied crops such as paddy, Nagali, Pulses, and Grass, for the entire crop season are summarized in table The total CWR for the entire growing season for paddy, Nagali(MILLET), Pulses, and Grass were found to be 585.4 mm/season, 241.5; 296.9; and 1343 mm, respectively. However, the IWR for paddy, Nagali, Pulses, and Grass for the entire growing season was found to be 383.8 mm/dec ; 4.1 mm /dec; 4.1 mm /dec; and 940 mm.,.



Crop Water Requirements

ETo station: BOMBAY-COLABA | Crop: Rice

Rain station: | Planting date: 5/30/2025

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Apr	3	Nurs	1.20	0.62	0.6	0.0	0.6
May	1	Nurs/LPr	1.19	1.16	11.6	0.0	60.3
May	2	Nurs/LPr	1.06	5.97	59.7	0.0	59.7
May	3	Init	1.07	5.47	60.2	0.1	254.2
Jun	1	Init	1.10	4.99	49.9	40.9	9.0
Jun	2	Deve	1.10	4.50	45.0	61.3	0.0
Jun	3	Deve	1.11	4.18	41.8	65.9	0.0
Jul	1	Deve	1.13	3.78	37.8	71.2	0.0
Jul	2	Mid	1.14	3.41	34.1	78.8	0.0
Jul	3	Mid	1.14	3.45	38.0	74.8	0.0
Aug	1	Mid	1.14	3.52	35.2	69.5	0.0
Aug	2	Mid	1.14	3.50	35.0	66.8	0.0
Aug	3	Late	1.14	3.68	40.5	64.0	0.0
Sep	1	Late	1.09	3.70	37.0	62.9	0.0
Sep	2	Late	1.03	3.68	36.8	61.0	0.0
Sep	3	Late	0.99	3.69	22.1	30.5	0.0
					585.4	747.8	383.8

Figure 6.2 | IWR, CWR and Effective rainfall for Rice crop

6.3 Effective rainfall: - Rainfall is a major input for various water management and hydro- logical studies. However, the proportion of rainfall (effective rainfall) was 747.8 mm/dec ; 662.3 mm; 692.8 mm ; and 2117 mm during the growing season of paddy, Nagali, Pulses, and Grass, respectively.

Table 6.3 | Summary of CWR , rainfall and IWR for various studied crops

Sr no	CROP	CWR (mm/crop season)	IWR (mm/crop season)	Contribution of effective rainfall (mm)
1	Paddy	585.4 mm/season,	383.8 mm/dec ;	747.8 mm/dec
2	Nagali,	241.5	4.1 mm /dec;	662.3 mm
3	Pulses	296.9	4.1 mm /dec; and	692.8 mm
4	Grass,	1343 mm	940 mm	2117 mm

7. IRRIGATION SCHEDULING

Irrigation scheduling is a simple tool to determine how much water to deliver to crops and when. Each crop has several stages, namely the initial stage, the developmental stage, the middle stage, and the late stage. At each stage, the irrigation requirement is different, so irrigation must be properly planned for the optimal use of water (Solangi et al. 2022).

Table 6.4 | Summary of NIR , rainfall and GIR for all crops

Sr no	CROP	NIR (mm/crop season)	GIR (mm/crop season)	Contribution of effective rainfall (mm)
1	Paddy	305.8	436.9 mm	887.3 mm
2	Nagali,	0	0	234.4 mm
3	Pulses	0	0	290.5 mm
4	Grass,	839.6 mm	1199.4 mm	2117 mm

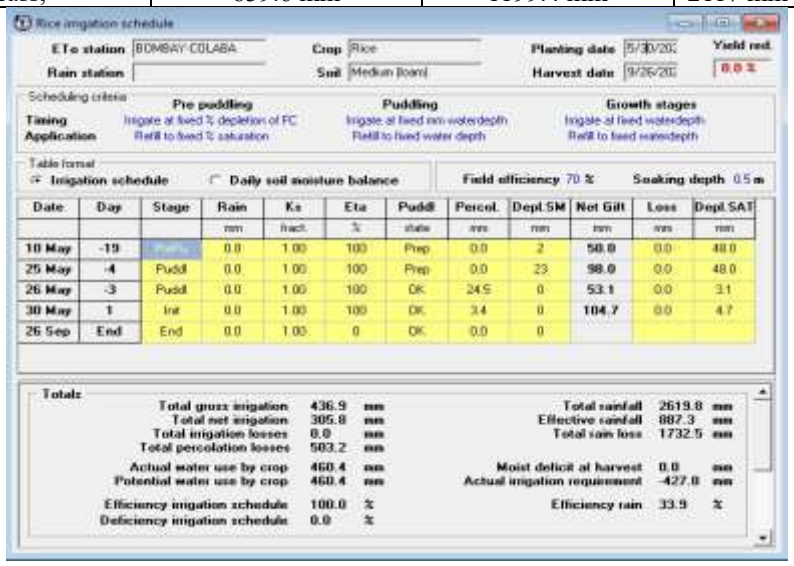


Figure 6.1 Irrigation schedule for Rice crop

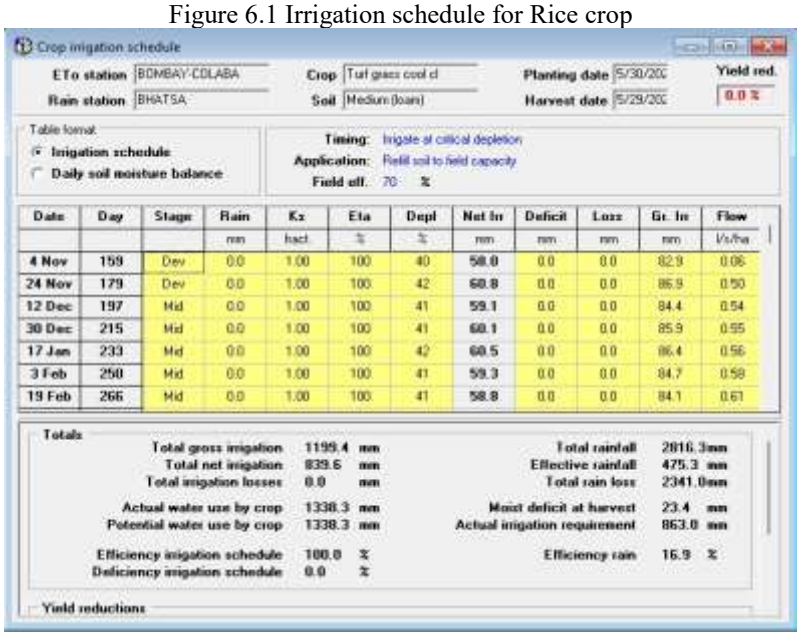


Figure 6.2 Irrigation schedule for Grass

8. CONCLUSION

The study indicated that the total crop water requirement (CWR) throughout the entire cultivation period for total CWR throughout the growing season for paddy, Nagali, Pulses, and Grass measured 585.4 mm/season, 241.5; 296.9; and 1343 mm, respectively.. Meanwhile, the IWR for these crops over the entire season was recorded as 383.8 mm/dec ; 4.1 mm /dec; 4.1 mm /dec; and 940 mm, respectively. The rainfall contribution for paddy, Nagali, Pulses, and Grass stood at 747.8 mm/dec ; 662.3 mm; 692.8 mm ; and 2117 mm respectively.

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