



Short communication

Assessment of irrigation requirement and crop water demand for Bargarh canal command area: A CROPWAT-based simulation study

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The agricultural heritage of India not only shapes its economy, but also deeply influences its cultural identity and social fabric. However, it also presents challenges in terms of modernization and balancing agricultural traditions with the demands of a rapidly industrializing nation. The crop water requirement (CWR) is a crucial component in the agricultural sector which plays a vital role in sustainable agriculture and food security and is useful in water conservation, yield optimization, cost-effectiveness, environmental protection, drought resistance, and irrigation scheduling (Champaneri *et al.*, 2024). By comprehending CWR, farmers and agricultural managers can make decisions regarding irrigation practices, leading to improved crop productivity, resource efficiency, and environmental sustainability. The CROPWAT is a decision support crop model developed by Food and Agricultural Organization (FAO), which helps irrigation managers and researchers calculate crop water and irrigation requirements based on evapotranspiration, crop coefficient, environmental factors (soil, climate, crop data), and crop growth stages (Boualem, 2023). By providing site-specific recommendations, CROPWAT enables irrigation managers to tailor water application to actual crop needs throughout the growing season (Banerjee *et al.*, 2016).

In the present study, an attempt has been made to evaluate the CWR and irrigation requirement (IR) of eight commonly grown crops (rice, wheat, maize, finger millet, mung, groundnut, potato, chillies) using the CROPWAT 8.0 in the highly fertile Bargarh canal command area (BCCA) Odisha. The Bargarh canal command area (BCCA) of Odisha is located between latitudes of 20°43'N and 21°41'N and longitudes of 82°39'E and 83°58'E with a culturable command area of 1,30,235.32 ha. The mean altitude of the land surface found to be 180 m above the mean sea level

(Fig.1). The study area is bounded by the Mahanadi River to the east, the Bargarh main canal to the west, the Ong River to the south, and the Hirakud Reservoir to the north. The net sown area accounts for 86.10% of the total agriculture area, with an average cropping intensity of 133%.

The climatic data of 43 years (1981-2023) on average maximum and minimum monthly temperature (°C), sunshine duration (h day⁻¹), relative humidity (%), and wind speed (km h⁻¹) were collected from NASA power (<https://power.larc.nasa.gov/data-access-viewer/>). Soil and crop data were acquired and processed from the College of Agriculture, OUAT, Bhubaneswar. Data were used to calculate reference evapotranspiration (ET_o), crop water requirement (CWR) and irrigation requirement (IR) of different crops using CROPWAT 8.0 model. In addition, partial data were taken from the CLIMWAT 2.0 and FAO-56 manual depending upon the crop for different stages of the crops, such as initial, development, mid-season, late season, and harvesting (Allen *et al.*, 1998). The crop coefficients (K_c) values for different crops presented in Table 1 were collected from FAO-56 (<https://www.fao.org/land-water/databases-and-software/crop-information/en/>) and few literatures (Srinivas and Tiwari, 2018). Crop duration and area occupied for different crops is also represented in Table 1.

The monthly ET_o, computed using the formula and weather characteristics such as maximum and lowest temperatures, rainfall, and effective rainfall of the study area, is displayed in Table 2. At BCCA, the average minimum temperature and maximum temperature was found to be 20.6°C and 33.3°C. The mean humidity (%), wind velocity (km h⁻¹), and sunlight duration (hours) were 63, 5.13, and 7.1, respectively. The data on fluctuations in ET_o indicate that temperature significantly influences it (Boualem, 2023), since

Article info - DOI: <https://doi.org/10.54386/jam.v27i1.2826>

Received: 28 November 2024; Accepted: 13 January 2025; Published online : 1 March 2025

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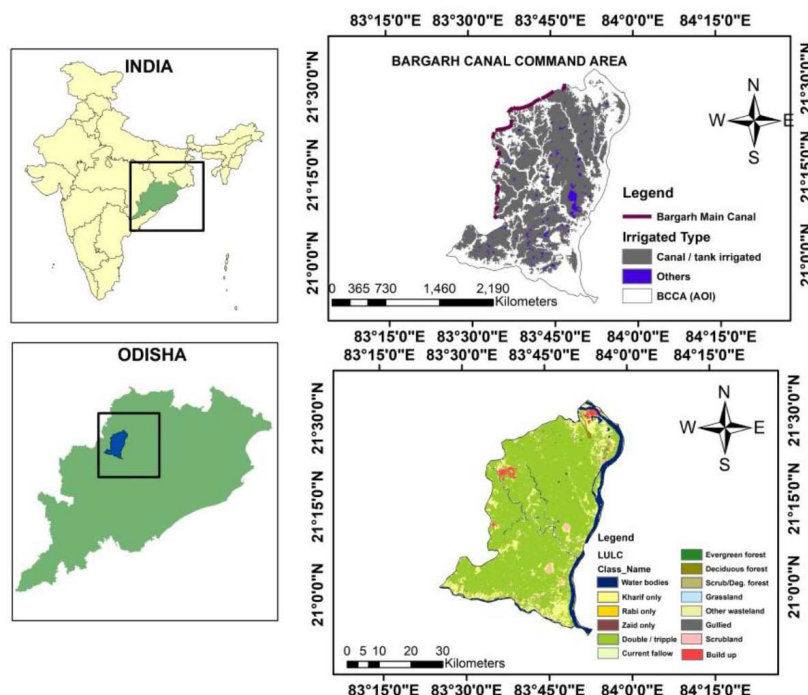


Fig 1: Location of the Bargarh canal command area (BCCA)

Table 1: Crop data of the different crops in different growth stages

Crops	Area (ha)	Crop stages (days)				K _c value		
		Initial	Development	Mid	Late	Initial	Mid	Late
Rice	78782	20	30	40	30	1.05	1.20	0.90
Potato	550	25	30	45	30	0.70	1.05	0.95
Maize	322	20	35	40	30	0.40	1.15	1.00
Wheat	11	30	30	40	30	0.35	1.15	0.45
Mung	8550	20	30	40	20	0.45	1.10	0.50
Groundnut	2800	25	35	45	25	0.45	1.15	0.60
Chillies	1592	30	35	40	20	0.45	1.00	0.60
Finger millet	145	15	25	40	25	0.35	1.10	0.65

the monthly variations in ETo correspond closely with temperature variations (Mehta and Pandey, 2015). It exceeded 7 mm day⁻¹ in May and fell below 3 mm day⁻¹ in January and December. For determination of effective rainfall dependable rain method have been used and also for the rest of the crops using equation (Bokke *et al.*, 2020).

The average annual precipitation is 1661.0 mm, with peak effective rainfall occurring in July. Rice is the primary crop grown in both *Rabi* and *Kharif*. During the *Rabi* season, rice is transplanted in October and harvested in March or April. In addition to rice fields, mung, vegetables, oil seeds, wheat, chillies, maize, and finger millet also cultivated. Most crops follow a similar growth pattern, with their initial stage occurring in December-January, followed by development in January-February, mid-stage in February-March, and late season in March-April. The significant variations in water needs among selected major crops grown in the command area highlight the importance of tailored irrigation practices, potentially leading to improved water conservation and

sustainable farming in regions with diverse crop cultivation. Table 3 presents the predominant stages, cropping pattern in the command area, including the IR and CWR, referred to as crop water demand, for various crops for different stages for *Rabi* season.

This study elucidates the relationship between climate variation, reference evapotranspiration (ET_o), effective rainfall, crop water requirement, and irrigation demand for eight diverse crops at BCCA. The study revealed that rice (714.5 mm) necessitated the highest CWR, whereas mung (334.8 mm) and finger millet (317.5 mm) exhibited the lowest requirements. In the context of stage-wise CWR analysis during the *Rabi* season, the mid-stage emerged as the period with the greatest water demand, whilst the initial stage displayed the least. The varying crop water needs across different crops and growth stages guide efficient water management strategies. Production in BCCA has been substantially impeded by canal water loss, waterlogging, and seepage. Farmers at the tail end do not receive the necessary water supply because of the excessive withdrawal upstream of the canal. Contemporary

Table 2: Monthly weather parameters and ET_o at BCCA

Months	Min. temp. (°C)	Max. temp. (°C)	Humidity (%)	Wind speed (km hr ⁻¹)	Sunshine (hours)	Radiation (MJ m ⁻² day ⁻¹)	ET _o (mm day ⁻¹)	Rain (mm)	Eff rain (mm)
January	12.6	28.2	61	3.0	7.9	16.0	2.81	19.0	1.4
February	14.9	30.5	54	3.7	8.0	1.1	3.57	25.0	5.0
March	18.7	35.4	44	4.3	9.5	22.3	4.99	23.0	3.8
April	23.8	39.6	39	5.3	10.6	25.5	6.55	12.0	0.0
May	27.6	42.1	41	6.7	11.3	27.0	7.88	24.0	4.4
June	26.9	37.2	60	8.0	6.1	19.0	6.02	238.0	166.4
July	24.9	34.5	83	8.3	3.3	14.8	3.71	503.0	378.4
August	23.0	31.9	87	7.4	3.4	14.6	3.54	476.0	356.8
September	24.8	31.5	81	5.4	4.8	15.8	3.70	262.0	185.6
October	22.0	31.5	74	3.8	6.0	15.9	3.60	68.0	30.8
November	15.8	29.3	67	3.1	7.3	15.7	3.10	9.0	0.0
December	12.2	27.7	64	2.6	7.4	14.8	2.57	2.0	0.0
Total/ Average	20.6	33.3	63	5.1	7.1	18.3	4.35	1661.0	817.4

Table 3: The crop water requirement (CWR, mm), irrigation requirement (IR, mm) of different crops in BCCA

Crop	Initial		Development		Mid		Late		Total	
	CWR	IR	CWR	IR	CWR	IR	CWR	IR	CWR	IR
Rice	97.1	96.7	105.2	103.8	268.9	261.3	243.5	242.5	714.5	704.3
Potatoes	27.0	26.6	71.8	69.2	256.1	248.7	182.8	182.7	537.6	527.1
Wheat	74.6	23.8	41.2	33.0	252.9	245.5	136.2	136.0	454.9	444.4
Mung	11.5	11.2	32.0	30.8	212.0	204.1	79.3	78.4	334.8	324.4
Maize	16.2	15.8	68.7	66.1	194.2	187.9	179.0	177.1	458.1	447.7
Groundnut	21.2	21.5	62.0	29.4	254.0	246.8	176.2	176.0	513.6	503.2
Chillies	49.2	48.4	83.2	79.2	196.7	191.3	157.9	157.9	487.0	476.6
Finger millet	13.0	12.9	30.9	30.3	179.8	172.5	93.8	91.6	317.5	307.1

scientific crop models such as CROPWAT can precisely assess the water requirements of crops and offer crop patterns and rotations can be implemented by farmers. These improvements could mitigate waterlogging and excessive withdrawal, thereby enhancing the region's agricultural sustainability.

ACKNOWLEDGEMENT

The authors acknowledge the Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology and College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar and Regional Research and Technology Transfer Station, Chiplima, Odisha for offering their advice and technical assistance in performing this study effort.

Conflict of Interest: The authors declare that there is no conflict of interest in the manuscript.

Funding: No source of funding received for this research work.

Data availability: All data used in this study are available in public domain of various organizations.

Authors contribution: P Mohapatra: Writing original manuscript

draft, data analysis; J. C. Paul: Formal analysis; A. P. Sahu: Data preparation, supervision; S. K. Raul: Writing review; D. M. Das: Editing and review; S. Saren: Visualization

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