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***Short Communication***

# Crop water and irrigation requirements of major crops in coastal agro-climatic zone of Odisha

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Crop water requirements are estimated for agricultural planning and water management. It helps farmers and water resource managers enhance irrigation and conserve water. Thus, when assessing crop water needs, climate, water, and agricultural expansion must be considered more holistically (Poddar *et al.,* 2021). Climate, location, crop type, soil composition, growing season length, and crop cultivation frequency affect agricultural water needs (Mehta and Pandey, 2015). Addressing water scarcity, saving resources, and ensuring food security requires improving agricultural water utilization. Predicting agricultural water needs accurately helps optimize irrigation schedules, allocate resources, and conserve water (Kamel *et al.,* 2012). Remote sensing and modern irrigation systems are being used to estimate agricultural water needs. Food and Agriculture Organization suggested CROPWAT for crop water requirement estimates and irrigation water requirements for diverse crops. Thus, it has been used for crop evapotranspiration, reference crop evapotranspiration, irrigation scheduling, and cropping pattern prediction (Mehta and Pandey, 2016; Boualem, 2023). In order to tackle the issue of crop diversification, it has been suggested that farmers in the coastal region of Odisha should cultivate a broader variety of crops alongside rice. To maximize crop yields and ensure the sustainable management of water resources in agricultural production, it is necessary to establish an appropriate cultivation pattern. Assistance is required for local farmers to optimize irrigation efficiency while preserving crop production. Furthermore, they want assistance in effectively overseeing the utilization of their current water supplies. For sustainable resource management, it is important to make good use of the water and other inputs on the fertile soil in the eastern and southern coastal plains. The main goal of this study is to determine the irrigation needs of significant crops in several districts of East and South Eastern Coastal Plain of Odisha and to map out these requirements.

The East and South Eastern Coastal Plain Agro-Climatic zone of Odisha is selected as study area. Odisha is the eighth-largest state of India having 10 Agro-Climatic zones and 30 districts. The study area comprises seven districts Kendrapara, Khurdha, Jagatsinghpur, Puri, Nayagarh, part of Ganjam and Cuttack. The region has a hot and humid environment, with an average annual rainfall of 1577 mm. According to the Agricultural Statistics, Government of Odisha, the average highest temperature during summer is 39.0°C, while the average lowest temperature during winter is 11.5°C. The predominant soil types in the region include Saline, Lateritic, and Alluvial soils. Four commonly growing crops such as rice (*Oryza sativa*), maize (*Zea mays*), finger millet (*Eleusine coracana*) and green gram (*Vigna radiate*) were selected for estimation of crop water requirement in the seven districts of the study area. Details of crop parameters such as planting and harvesting date; rooting depth, crop coefficient etc. were acquired based on literature and reports (Table 1). Crop coefficients of various crops are obtained from literature study (Mohan and Arumugam, 1994; Tyagi *et al.,* 2000; Kar *et al.*, 2005; Srinivas and Tiwari, 2018).

CROPWAT 8.0 is decision support software for accurately determining the water needs of crops based on factors such as plant type, climate, and soil conditions, as outlined by Doorenbos and Pruit (1977). It is beneficial in formulating irrigation schedules for crops based on management techniques. There are various methods for calculations of reference evapotranspiration ($ET_0$) and effective rainfall in CROPWAT model, based on FAO Irrigation and Drainage Paper 56 (Allen *et al.,* 1998). The software uses the input parameters

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**Table 1:** Details of crop data for rice, maize, finger millet and green gram

| Crop | Rice | Maize | finger millet | green gram |
|---|---|---|---|---|
| **Planting and Harvesting Date** | | | | |
| Sowing date | 01-Jun | 10-Nov | 01-Jul | 01-Feb |
| Harvesting date | 28-Oct | 27-Feb | 08-Oct | 11-May |
| **Crop stages (days)** | | | | |
| Initial | 30 | 25 | 20 | 20 |
| Development | 30 | 30 | 15 | 20 |
| Mid | 60 | 25 | 25 | 30 |
| Late | 30 | 20 | 40 | 20 |
| Total | 150 | 100 | 100 | 90 |
| **Rooting depth** | | | | |
| Max. Rooting depth (m) | 0.8-1.2 | 1.0-1.5 | 1.0-1.5 | 0.8-1.2 |
| **Crop Coefficient** | | | | |
| Initial | 1.15 | 0.70 | 0.35 | 0.45 |
| Mid | 1.30 | 1.15 | 1.10 | 1.10 |
| Late | 1.10 | 1.00 | 0.65 | 0.50 |
| Critical depletion factor | 0.20 | 0.50 | 0.55 | 0.60 |
| Yield Response Fraction | 1.10 | 1.25 | 0.70 | 0.80 |

**Table 2:** Estimated crop water requirement (mm) and irrigation requirement (mm) of rice

| Districts | Land Preparation | | Initial | | Development | | Mid | | Late | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CWR | IR | CWR | IR | CWR | IR | CWR | IR | CWR | IR | CWR | IR |
| Khordha | 150.0 | 342.1 | 183.7 | 53.2 | 93.7 | 0 | 282.7 | 0 | 170.9 | 4.1 | 881.0 | 399.4 |
| Puri | 85.3 | 231.1 | 129.1 | 6.3 | 84.0 | 0 | 275.8 | 0 | 169.3 | 60.6 | 743.5 | 298.0 |
| Cuttack | 128.2 | 303.2 | 158.4 | 21.3 | 84.6 | 0 | 259.5 | 0 | 151.3 | 2.0 | 782.0 | 326.5 |
| Kendrapara | 120.4 | 288.4 | 153.7 | 11.6 | 82.8 | 0 | 232.1 | 0 | 130.1 | 5.5 | 719.1 | 305.5 |
| Ganjam | 93.9 | 251.9 | 139.6 | 26.3 | 86.1 | 1.1 | 279.7 | 5.2 | 166.9 | 13.9 | 766.2 | 298.4 |
| Jagatsinghpur | 135.3 | 274.6 | 168.9 | 31.3 | 91.4 | 0 | 276.6 | 0 | 140.7 | 0 | 812.9 | 305.9 |
| Nayagarh | 144.8 | 347.1 | 178.8 | 42.0 | 88.0 | 5.5 | 256.3 | 0 | 147.7 | 71.6 | 815.6 | 466.2 |

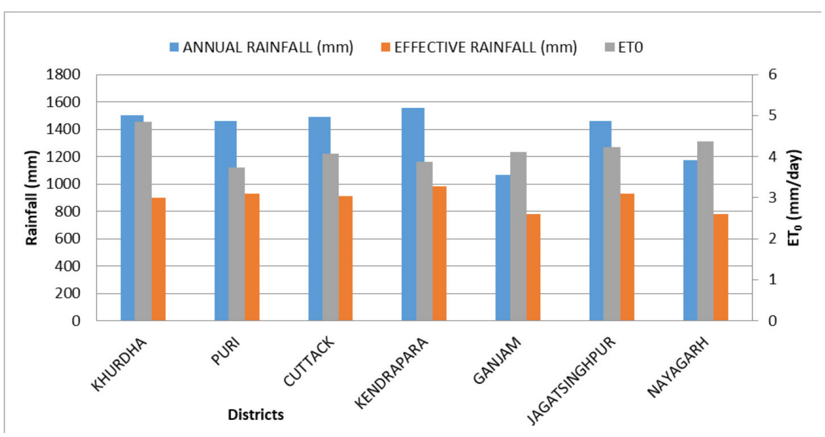


**Fig 1:** Graphical representation of variation in effective rainfall and evapotranspiration of various districts

as rainfall, average maximum and minimum monthly temperature (°C), relative humidity (%), sunshine duration (h day$^{-1}$) and wind speed (km h$^{-1}$). The meteorological data for the required districts are acquired from CLIMWAT 2.0 developed by FAO.

Fig. 1 displays a graphical depiction of the fluctuation in effective rainfall, annual rainfall and $ET_0$ throughout the seven districts. The Khurdha district recorded the greatest $ET_0$ value of 4.86 mm day$^{-1}$, while the lowest $ET_0$ value of 3.77 mm day$^{-1}$ was seen in the Puri district. The minimum $ET_0$ was seen in December, while the maximum value was reported in May. It was found that the district of Kendrapara received the maximum amount of rainfall, measuring 986.0 mm. On the other hand, the district of Nayagarh received the lowest amount of rainfall, measuring 778.6 mm.

**Table 3:** Estimated crop water requirement (mm) and irrigation requirement (mm) of maize crop

| Districts | Initial | | Development | | Mid | | Late | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CWR | IR | CWR | IR | CWR | IR | CWR | IR | CWR | IR |
| Khordha | 57.4 | 44.5 | 99.9 | 95.8 | 82 | 75.4 | 131.5 | 110.1 | 370.8 | 325.8 |
| Puri | 53.6 | 31.4 | 85.4 | 80.4 | 68.4 | 67 | 96.6 | 79.9 | 304 | 258.7 |
| Cuttack | 50.1 | 45.3 | 76.0 | 71.9 | 62.2 | 55.5 | 95.5 | 75.6 | 283.8 | 248.3 |
| Kendrapara | 43.4 | 34.2 | 42.1 | 32.0 | 58.5 | 57.3 | 94.1 | 69.0 | 238.1 | 192.5 |
| Ganjam | 59.4 | 29.3 | 99.4 | 93.3 | 80.6 | 80.1 | 119.7 | 107.3 | 359.1 | 310 |
| Jagatsinghpur | 46.3 | 30.2 | 79.1 | 64.4 | 66.9 | 63.1 | 105 | 67.8 | 297.3 | 225.5 |
| Nayagarh | 48.1 | 38.6 | 81.5 | 78.4 | 69.1 | 67.6 | 111.2 | 91.1 | 309.9 | 275.7 |

**Table 4:** Estimated crop water requirement (mm) and irrigation requirement (mm) of finger millet crop

| Districts | Initial | | Development | | Mid | | Late | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CWR | IR | CWR | IR | CWR | IR | CWR | IR | CWR | IR |
| Khurdha | 40.9 | 0 | 31.5 | 0 | 89.9 | 0 | 179.7 | 0 | 342.0 | 0 |
| Puri | 27.6 | 0 | 24.0 | 0 | 80.5 | 0 | 173.9 | 0 | 306.0 | 0 |
| Cuttack | 34.9 | 0 | 27.6 | 0 | 82.3 | 0 | 173.3 | 0 | 318.1 | 0 |
| Kendrapara | 37.3 | 0 | 29.5 | 0 | 88.1 | 0 | 179.6 | 0 | 334.5 | 0 |
| Ganjam | 30.1 | 0 | 25.6 | 0 | 82.4 | 0 | 176.4 | 0 | 314.5 | 0 |
| Jagatsinghpur | 33.9 | 0 | 26.7 | 0 | 80.5 | 0 | 155.7 | 0 | 296.8 | 0 |
| Nayagarh | 39.8 | 0 | 30.5 | 0 | 85.4 | 0 | 169.8 | 0 | 325.5 | 0 |

**Table 5:** Estimated crop water requirement (mm) and irrigation requirement (mm) of green gram

| Districts | Initial | | Development | | Mid | | Late | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CWR | IR | CWR | IR | CWR | IR | CWR | IR | CWR | IR |
| Khurdha | 41.0 | 24.9 | 75.7 | 58.0 | 229.6 | 203.8 | 143.7 | 125.6 | 490.0 | 412.3 |
| Puri | 29.6 | 15.6 | 49.8 | 36.4 | 134.3 | 122.7 | 71.8 | 68.1 | 285.5 | 242.8 |
| Cuttack | 30.6 | 15.9 | 55.1 | 35.4 | 163.6 | 130.9 | 98.6 | 76.7 | 347.9 | 258.9 |
| Kendrapara | 30.5 | 8.3 | 57.3 | 27.5 | 172.6 | 112.7 | 102.1 | 49.2 | 362.5 | 197.7 |
| Ganjam | 36.5 | 25.5 | 64.4 | 51.5 | 172.2 | 155.9 | 87.4 | 80.1 | 360.5 | 313.0 |
| Jagatsinghpur | 23.6 | 2.2 | 61.8 | 32.1 | 172.5 | 112.6 | 93.9 | 42.5 | 351.8 | 189.4 |
| Nayagarh | 35.3 | 18.6 | 64.8 | 41.3 | 191.8 | 153.2 | 114.1 | 93.0 | 406.0 | 306.1 |

***CWR and IR of rice***

The crop water requirement and irrigation requirement for rice are detailed in Table 2. It was found that the maximum crop water requirement was seen in Khordha district, measuring 881.0 mm, while the lowest requirement was found in Puri district, measuring 743.5 mm. The crop water requirement for rice also includes water required for land preparation stage. The irrigation demand was found to be the highest (466.2 mm) in Nayagarh district, while the lowest (298.0 mm) in Puri district. When analysing the crop water requirement on stage basis, it was found that the crop water requirement of rice is highest in mid stage. Water requirement is less in developing stage.

***CWR and IR of maize***

Table 3 displays the crop water requirement and irrigation requirement of maize crop for seven districts. The crop water requirement for maize was found to be the highest (370.8 mm) in Khordha district, while the lowest (238.1 mm) in Kendrapara district. The irrigation requirement of maize in Khordha district was found to be the highest (325.8 mm), whereas the lowest in Kendrapara district (192.5 mm). The highest crop water requirement was found during the late stage of maize; as a fully grown maize crop will need more water than a maize crop which has just been planted.

***CWR and IR of finger millet***

The calculated crop water requirement and irrigation requirement of finger millet was displayed in Table 4. While calculating the crop water requirement of finger millet for the seven districts of the study area, it was observed that the district of Khordha shows the highest crop water requirement (342.0 mm), and the district of Jagatsinghpur had the lowest crop water requirement (296.8 mm). This study revealed that during the *Kharif* irrigation is not necessary for finger millet cultivation as the rainfall in the region provides an adequate amount of water to meet the crop water requirement of finger millet. At late stage of the finger millet, the crop water requirement is highest.

***CWR and IR of green gram***

Table 5 shows the calculated crop water requirement and irrigation requirement of green gram. Crop water requirement of green gram varied among the seven districts of the eastern south-eastern coastal plain ago-climatic zone. The highest crop water requirement was observed in Khordha district, (490.0 mm), while the lowest crop water requirement was observed in Puri district, (285.5 mm). The irrigation requirement varied significantly across the districts, with Khordha district experiencing the highest demand (412.3 mm), while Kendrapara district had the lowest requirement (197.7 mm). While analysing crop water requirement, it is observed that green gram requires the highest water in the month of March, during the mid-season stage of plant growth. As the crop growth progresses, the water requirements gradually decrease.

Crop water requirement and subsequently the irrigation requirement of different district for specific crop would be useful in establishing the irrigation planning for better utilisation of water resources in agricultural land. A comprehensive research is recommended for the entire Odisha region, encompassing all ten agro-climatic zones. Furthermore, the spatial and temporal variability of this crop water parameter is highly important to consider in irrigation management, particularly in the context of climate change.

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