Climate Change and Its Impact on Irrigation Water Demand in Indian Agriculture

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Agriculture is the heart of India's economy, but it is also the most vulnerable to climate change. Farmers have been dealing with shifting patterns of rainfall, rising temperatures, and an increase in the frequency of catastrophic weather events during the past few decades. Across the nation, these changes are having a direct effect on crop yield, water availability, and irrigation needs. Historically, seasonal weather and regular monsoons were used to set irrigation schedules. Even for the same crops cultivated on the same area, the need for irrigation water is increasing due to irregular rainfall and longer dry spells. For instance, Y. Naga Lakshmi et al. (2022) conducted research in Bapatla region of India has demonstrated that agricultural water requirements for rice, maize and pulses can increase dramatically with an increase of 1°C in the average temperature. This increasing demand for water poses a challenge since surface water supply is becoming more unpredictable and groundwater resources are becoming scarce. For a reliable food supply in the coming decades, farmers and governments need to implement climate-smart irrigation systems that maximize water management (Sandeep Kumar et al. 2023). This article explores how climate change affects irrigation water demand in Indian agriculture, consequences for farmers, and potential strategies for improving irrigation's resilience and sustainability.

Climate change and its impact on Crop Water Requirement

The amount of water a crop needs for optimal growth and productivity is known as its crop water requirement (CWR). All these factors are changing because of climate change, which raises the need for water for crops. According to Moratiel et al. (2010), Evapotranspiration (ET) rates can increase by 2–3% at a mean temperature increase of just 1°C. This means that crops lose more water through soil and leaf evaporation. Farmers have to rely more on irrigation than on natural precipitation due to unpredictable rains. Water stress impacts crops more frequently, requiring more irrigation to maintain harvest outputs. This combination of rising temperatures, erratic rainfall and extended dry spells is making water management increasingly complex, especially in semi – arid and rainfed regions of India. (ICAR – CRIDA Vision 2030)

Evidence from India: Impact on major crops

There is significant proof of climate-induced changes in irrigation demand from research and field studies conducted throughout India. Rice, a Kharif crop that was historically cultivated in an environment with plenty of monsoon rainfall, today needs additional irrigation because of delayed or irregular monsoons. According to studies conducted in the Mahanadi (Kumar and Bassi (2021)) and Godavari basins (N R Nagireddy et al. (2023)), climate change scenarios might result in an 8–12% rise in future rice demand. Higher winter temperatures shorten the growing season for wheat, a Rabi crop, enabling the crops to reach maturity earlier. However, the demand for irrigation rises during critical growth phases like flowering. (Anand Madhukar et al. (2022)). While oilseeds and pulses are considered to be drought-resistant, they still require additional irrigation if there is heat stress situations. (Kumari, V.V. et al. (2021), Ahmad, M. et al. (2021) and Fahad, S. et al. (2017)). Due to their high sensitivity to water stress, horticultural crops including tomatoes, onions, and fruits are expected to require 10–20% more irrigation in many areas by 2050 (Majid Rashid et al. (2021)), (ICAR Vision 2050). Therefore, it is very clear that the demand for water is increasing across a wide range of crop systems and is no longer constant.

Why Traditional Irrigation Planning is inefficient currently

In India, for many years, irrigation scheduling was based on historical climate data, which predicted consistent cycles of temperature and precipitation. Farmers planned their crops for regular monsoon rainfall in order to restore soil moisture. However, there are number of reasons why this strategy is failing. Farmers are no longer able to depend on conventional sowing dates because of the unpredictability of the monsoon onset. In India, flood irrigation which is still widely used, wastes more than 40 to 50% of the water used (J Dhiman et al. (2015)). The inability of canal-based irrigation systems to handle fluctuating water supplies has made them unreliable. As a result, farmers depend heavily on tube wells but because of over extraction of groundwater and declining groundwater levels making the irrigation more expensive. Therefore, in the context of climate unpredictability, traditional irrigation planning is becoming outdated, highlighting the urgent requirement to transition to climate smart irrigation.

Smart Water Management Techniques

Farmers must switch from traditional flood irrigation to climate-smart techniques that conserve water while preserving yields in order to meet the growing need for irrigation. Compared to flood irrigation, drip irrigation saves up to 40–60% of water by delivering water drop by drop straight to the root zone, minimizing evaporation losses (Kaur, T. et al. (2025), Prasath, G. Arun et al. (2024) and Narayanamoorthy, A et al. (2020)). As sprinkler systems distribute water uniformly and minimize waste, they are beneficial for oilseeds, pulses, and vegetables.

Fig. 1. Different types of smart water management techniques

Mulching is another way which can be implemented where the soil is covered with crop residue or plastic sheets which reduces evaporation and prolongs soil moisture retention. By understanding how much water is available, how much water crops require and timing irrigation appropriately, farmers may practice water budgeting, which allows them to plan their water consumption similarly to a financial budget. As rainfall varies geographically, rainwater harvesting can be accomplished by building farm ponds, check dams, and storage tanks to collect excess rainfall during heavy rains and store it for use in irrigation during dry spells. With the help of these simple yet efficient methods, farmers can produce more with less water.

Role of Technology in Irrigation Planning

Due to incorporation of technology, irrigation is now becoming simpler and smarter. The integration of remote sensing and GIS, which use satellite data to watch crop development and estimate water demand in real time, or smartphones through mobile apps and Information and Communication Technology (ICT) tools, has made it possible for farmers to receive irrigation guidance on their cell phones based on weather forecasts and soil conditions. Farmers can estimate how much water certain crops will require under changing climatic scenarios with the assistance of crop scientists and climate model tools such as CROPWAT 8.0 and AquaCrop.

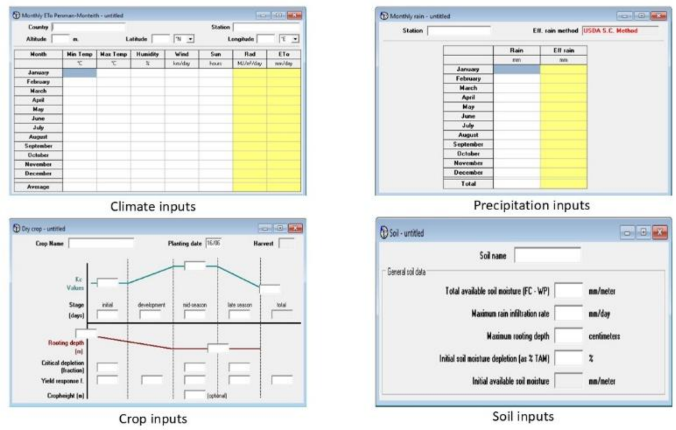

Fig. 2. Various inputs interface for finding Crop Water Requirements in CROPWAT 8.0

Farmers can avoid the problems of overwatering or underwatering by using affordable sensors, such as Soil Moisture Sensors, which can inform them precisely when to irrigate. Farmers can reduce their dependence on guesswork and make better irrigation decisions by integrating technological advances with indigenous knowledge.

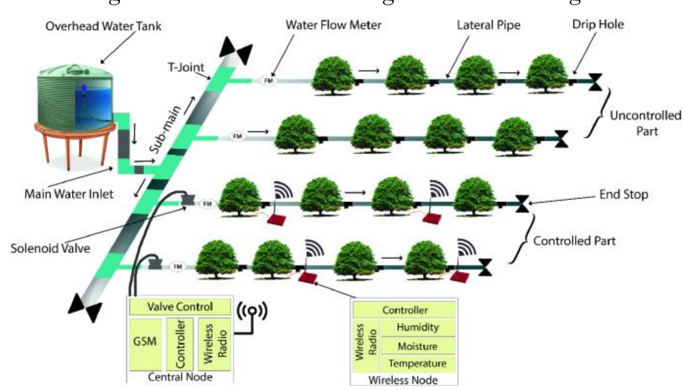

Fig. 3. IoT enabled Solar-Powered Automated Drip Irrigation System (Source: Barman et. al., 2019)

Policy and Farmer Level Adaptation

Climate change is a national challenge which requires both farmer involvement and government assistance in modifying irrigation techniques. The government should support watershed development projects to replenish groundwater, offer subsidies for micro irrigation systems, and train farmers through Krishi Vigyan Kendras (KVKs) and extension programs. Whenever feasible, farmers should switch from water-intensive crops like paddy to less thirsty ones. They should also use crop calendars that correspond with the most recent climatic projections and implement community-based irrigation systems in which farmers share ponds, tanks, and drip systems. Irrigation may become more climate resilient and sustainable in the future when farmers and lawmakers work together.

Conclusion

Climate change is fundamentally transforming the principles and practices that govern agriculture in India. Demand for irrigation is continuously rising due to erratic rainfall and rising temperatures, placing strain on farmers and water supplies. These issues can no longer be solved by conventional watering techniques. Instances from all around India demonstrate that adaptation is feasible. By switching to sprinkler systems instead of flood irrigation for wheat, many farmers in India have cut their water consumption by about 30% as reported in the studies of Water Management Technologies for Sustainable Agriculture, IARI (2014). Even in unpredictable monsoon years, Odisha farmer organizations backed by KVKs are maintaining steady production by combining drip irrigation for vegetables with rainwater gathering ponds. These success stories demonstrate that irrigation can be made climate-smart with appropriate land and water management techniques. The future of such methods can be increased through farmer training, legislative backing and technological acceptance. By doing this, India can preserve valuable water for future generations while protecting its crops from climatic uncertainties.

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