

Automation in drip irrigation

for increasing the water productivity of cereals in India

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Water is a critical and essential factor for harvesting a good crop and for the survival of living beings. Due to the increasing human population, climate change, and demand in other sectors, water scarcity is becoming one of the greatest challenges for human beings. Agriculture uses over 70% of all freshwater on the earth, and up to 95% in some developing countries, making it the most water-intensive sector in the world. The conventional methods of irrigation water application are inefficient and irrigation efficiency is only 35–40%, water productivity is also low, and thus cannot provide long-term food security. Recent advancements in wireless sensor networks (WSNs) and the Internet of Things (IoT) technologies may be effective in the automation of drip irrigation systems. To safeguard global water resources and ensure food security, water resources should be used more effectively and sustainably in agricultural production. To expose people to the latest advancement in irrigation practices, we have compiled the most efficient water management strategy, i.e. automation in drip irrigation systems, to address the problem of low irrigation efficiency and water productivity, and at the same time increase the productivity of cereal-based cropping systems in a sustainable manner.

Keywords: Automation, Drip irrigation, Water productivity, Wireless sensor networks

By 2050, the world's population will have risen to 9.15 billion, up from 7.79 billion now. India's population is ~17.9% of the total. According to the UN population estimates, India has surpassed China as the world's most populous country. India supports ~18% of the human population with 4% global freshwater resources, and now India is exporting some food grains to other countries also. The annual availability of water in India was ~3000 cubic meters (m³) per capita before 1951, but it has since fallen to 1458 m³ per capita due to increased population and water usage in other areas of the economy. A country with renewable water availability ≤1700 m³/capita/year is classified as water stressed, based on the Falkenmark Index, a commonly used indicator of water shortage. Systems based on cereals, notably rice and wheat [10 million hectares (Mha)], are the

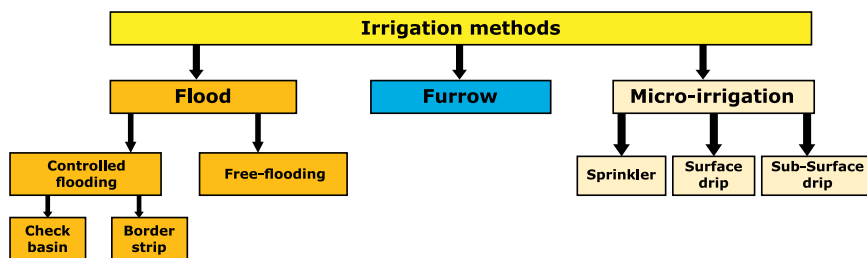
foundation for India's food security.

In India's rice-based cropping systems, rice is grown over ~44 million hectares and uses a large volume of irrigation water. The amount of irrigated area has increased because of groundwater development; ~63% of all irrigated land is now covered by groundwater irrigation. Most Indian farmers follow conventional methods of irrigation such as check basins, flood, and border strips, the overall irrigation efficiency of these methods is between 35–55%. Many states give heavily subsidized or free pumping power, which enhances the use of groundwater for agriculture, but this has also pushed users to overexploit deeper groundwater, resulting in water table depletion and deterioration in many locations. Water logging is a different issue that has contributed to the emergence of both inadequate drainage of irrigated lands and excessive

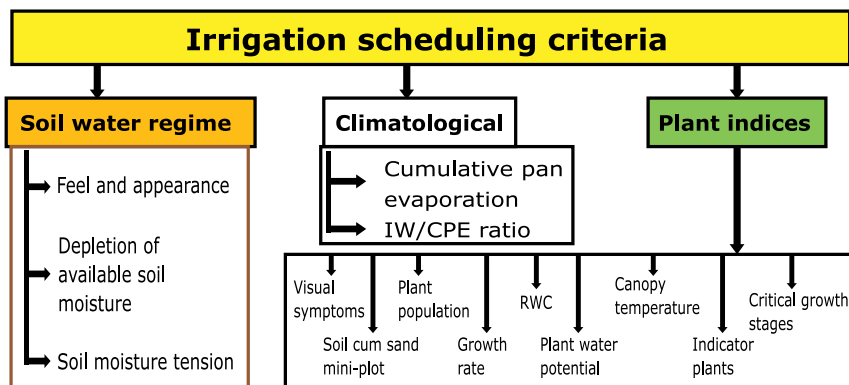
irrigation water consumption in canal commands. Developed or water shortage countries are very critical about their water use priority, they are not producing those crops which need more water for grain production, and they prefer to import the same food grain from other countries like India. Moreover, the expected consequences of climate change (increased warmth and unpredictability in rainfall owing to a reduction in the number of wet days and increased intensity of rain) have a considerable detrimental influence on agricultural water supply. Therefore, it is very essential to manage irrigation water precisely, protect groundwater resources and increase the water productivity of the cereal-based cropping system.

Automated drip irrigation in agriculture: Progress and prospects

Andhra Pradesh (1.38 Mha), Maharashtra (1.31 Mha), Gujarat



Various types of irrigation methods used in farming



Schematic diagram representing the irrigation scheduling criteria

(0.80 Mha), and Karnataka (0.72 Mha), are the key states in India to adopt drip irrigation, and at all India levels the area is ~5.96 Mha. An automated irrigation system refers to the operation of the system with no or minimal manual intervention, with the aid of timers, sensors, computers, or mechanical appliances. In India, irrigation systems are still managed manually. But in order to feed a growing population in the context of limited water resources and rising demand brought on by climate change and industrialization, new methods, and technologies would need to be introduced, notably for more precise irrigation water utilization. Field irrigation systems that are semi-automated and automated are increasingly being deployed to replace uncontrolled surface irrigation systems. For the crop-water relationship, an automated irrigation system may irrigate fields based on the available soil moisture, soil type, and climatic parameters. These technologies are ideal for precisely irrigating fields using drip irrigation systems in the existing water and manpower constraints. Intelligent, automation-based irrigation systems can help to get a better yield per drop while saving

water by significantly improving water efficiency.

Sensors-based automated drip irrigation

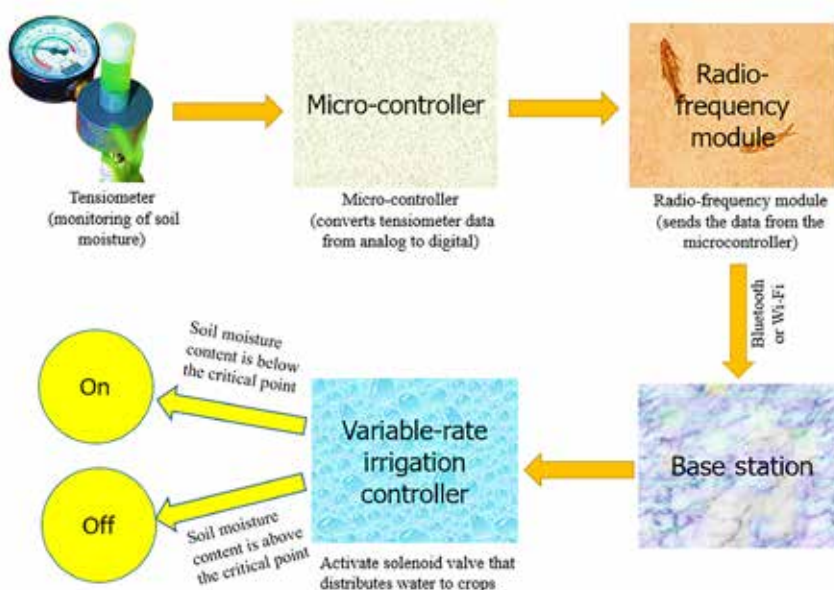
Precision irrigation is a data-driven process that requires real-time data on soil moisture, temperature, and weather data. There are two types of sensor-based automated systems: (1) systems that assess soil moisture content based on weather and other parameters, and (2) systems that measure soil

moisture content directly using sensors.

The sensors (tensiometer, capacitance, and 10 HS coded) are used to monitor and sense the soil moisture in real-time, which is useful for irrigation system planning. The data from the moisture sensor is sent to the microcontroller, which converts it from analog to digital. A radio-frequency (RF) module sends the data from the microcontroller. These data can be sent to the base station via a Bluetooth or Wi-Fi-based wireless transmitter. The soil moisture and flow levels are displayed on the microcontroller LCD. This enables the variable-rate irrigation controller to be evaluated from afar and monitored in real time. When soil moisture content falls below a predefined critical point, an irrigation controller is used to activate a solenoid valve that distributes water to crops. When the soil moisture content is low, the electricity turns on the pump, and water from the tank begins to flow through the pipe. When the soil moisture reaches a pre-defined, soil-specific saturation level, the power goes off, and the water stops.

Internet of Things (IoT) for automated irrigation systems

Based on the moisture level of the soil, an IoT-based automatic irrigation system turns on and off the pump.



Automated wireless controller drip irrigation



IoT-based automation drip irrigation
Source: www.skyfilabs.com

irrigation based on factors like soil moisture, weather conditions, and crop needs. This leads to precise water application, preventing overwatering or underwatering.

Resource efficiency: By delivering water and nutrients directly to plants, micro-irrigation reduces water wastage, fertilizers, and energy use.

Labour savings: Automation reduces the need for manual monitoring and operation, saving labour costs and enabling farmers to manage larger areas efficiently.

Yield improvement: Properly managed micro-irrigation systems lead to healthier plants and improved crop yields.

Environmental benefits: Reduced water use and controlled nutrient application minimize environmental impacts, such as soil erosion and groundwater pollution.

Challenges in automated micro-irrigation

Cost: Initial investment in automation technology and micro-irrigation infrastructure can be a barrier for small and marginal farmers.

Technical know-how: Farmers need training to effectively use and maintain automated micro-irrigation systems.

Maintenance: Regular maintenance of sensors, controllers, and other components is essential for reliable operation.

Policy and awareness: Government support, subsidies, and awareness campaigns can

A soil moisture sensor determines the precise moisture content of the soil, and this information is used to control the pumping motor through an operational amplifier.

Through IoT, farmers may view the soil moisture status via a mobile application or on a web page using a modem. A soil moisture sensor estimated soil water content, a pump delivered the appropriate amount of irrigation water to the crop, and a Wi-Fi module provided Internet access to sensed data. The sensor values were saved on a web server that functioned as the main base station and was relayed to the Internet in real-time. A user may accurately monitor the soil moisture content in the field based on the analysis of these signals. As the water pump is switched on or off based on the moisture level of the soil, the system tells the farmer in real time if the supply of irrigation water is insufficient or excessive.

with a magnetic switch having switching capability at the desired soil matric potential (SMP), which sent a signal to the electrically operated tube-well and solenoid valve whenever the SMP fell below a predetermined critical level (15 kPa) in rice and (35 kPa) in wheat. The rice-wheat systems' grain yields and irrigation water saving and productivity differed due to automated irrigation systems like ZT with subsurface drip (ZT-SSD), and ZT with surface drip (ZT-SD) over CT with flood irrigation (CT-F), ZT with flood irrigation (ZT-F). The results showed that no-till coupled with an automated drip irrigation system provided much greater rice-wheat yields than an automated flood-irrigated system. By adopting automated drip irrigation, farmers can increase up to 100% irrigation water productivity of rice over the conventional method.

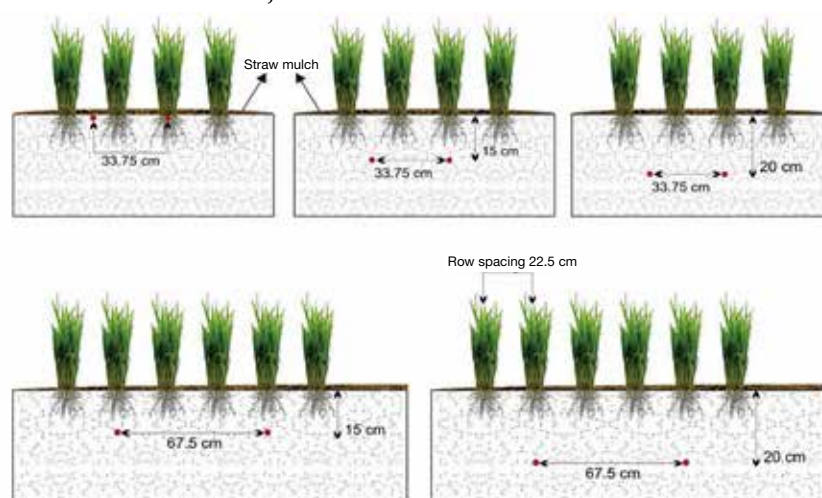
Benefits of automation in micro-irrigation

Precision irrigation: Automation allows for real-time adjustment of

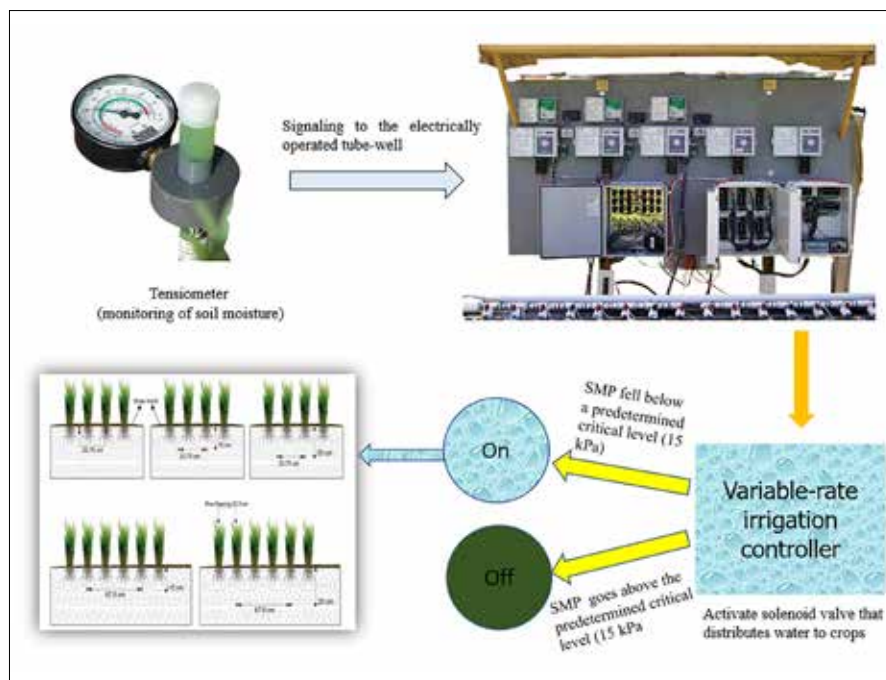
Case study

At the Borlaug Institute for South Asia (BISA), International Maize and Wheat Improvement Center (CIMMYT), Ludhiana, Punjab one of the first studies on an automated micro-irrigation system in a Conservation Agriculture (CA)-based rice-wheat rotation were conducted.

The automated sensor can be used in conventional-till (CT) and zero-till (ZT) flood-irrigated systems with rice-wheat rotation for both surface drip (SD) and subsurface drip (SSD) irrigation systems. In this study, they employed a tensiometer for the estimation of soil matric potential (SMP) for real-time irrigation systems. Tensiometer



Automated sub-surface drip irrigation in rice-wheat rotation
Source: Sidhu et al. (2019)



Process of automated sub-surface drip irrigation in rice

irrigation water efficiency. The Indian government has launched schemes like the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) to promote micro-irrigation and efficient water use in agriculture. These initiatives aim to encourage adoption through financial incentives, capacity building, and technical assistance. Collectively, the Indian and state governments are offering substantial subsidies, ranging between 70% and 90%, to facilitate the widespread adoption of micro irrigation systems. The automation of micro-irrigation systems in India presents a promising solution to address water scarcity and enhance agricultural productivity. The integration of automation technology enhances the effectiveness of these systems. However, challenges related to affordability, education, and maintenance need to be addressed to achieve widespread adoption. By adopting automation technology, farmers can optimize water use, reduce costs, and contribute to sustainable farming practices.

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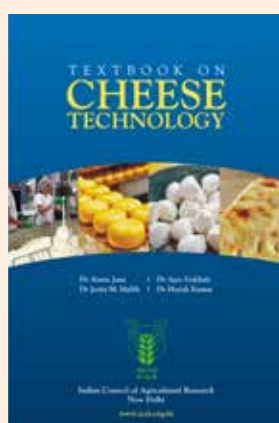
encourage wider adoption of these technologies.

SUMMARY

With changing climatic conditions, rising global population, expanding water requirements across various sectors, and shifting attitudes towards water usage priorities in developed nations, it

is imperative that we initiate efforts to promote, raise awareness and implement innovative techniques such as automation in drip irrigation at the grassroots level. Automated drip irrigation not only conserves water but also contributes to weed control and mitigates the effects of salinity on plants, culminating elevated crop yields and enhanced

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