Precision Irrigation Management through Automated Sensors

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OPEN ACCESS

Keywords

Precision irrigation management, automated sensors, productivity, efficiency

How to cite this article:

Thakur, A., Bhushan, L., Sankhyan, N. K. and Simran. 2024. Precision Irrigation Management through Automated Sensors. *Vigyan Varta* 5(6): 144-147.

ABSTRACT

Water resources can be sustainably managed by precision irrigation using various automated sensors which comprises water application to the crop at the right time, right amount, right place and right manner. It utilizes a systems approach to achieve 'differential irrigation' treatment of field variation (spatial and temporal) as opposite to the 'uniform irrigation' treatment that underlies traditional management systems. The precision irrigation water management system utilizes the components like drip irrigation, GPS (Global Positioning System) and GIS (Geographic Information System) technologies, VRI (variable rate of irrigation) and monitoring and automation. These technologies aid in better control and management for irrigation purposes.

INTRODUCTION

An important factor in global food security is irrigation, which produces forty percent of the world's food production despite making up only 20% of all cultivated area. According to FAO projections, irrigated land in developing nations would rise by 34% by 2030, but because of better irrigation technologies and management, the water utilized in agriculture will only rise by 14% (FAO). Globally, 70% of fresh water is applied in irrigation of crops, making irrigation the largest consumptive user of fresh water. The numbers are even shocking for India as of the total fresh water 90.4% is

utilized for agriculture. Currently, conventional techniques are commonly used in India, where water is applied evenly throughout the field without consideration for the spatial heterogeneity of soil and crop water requirements. It results in an unequal water distribution. Therefore, it makes no sense to keep using traditional watering techniques. In Punjab water table is declining year by year because of over extraction of ground water. To get over the restrictions, other methods must be used, such as providing water to the roots of the plant so that plant directly absorbs it. The irrigation needs for each crop vary based on the plant's growth stage as well. Productivity improves by supplying irrigation requirements at any particular growth stage. The environmental characteristics can put to use to further improve plant watering and using automated sensors can do all of these.

PRECISION IRRIGATION MANAGEMENT

It is applying optimum quantity of water (right amount) only when needed by crop (right time) by selecting the adequate irrigation technique to be applied (right manner) and applying water at the appropriate location (right place).

This guarantees that plants will receive the best support for their water needs. Precision irrigation meets a crop's unique needs at every stage of growth, improving the standard of the fruit in the process. Weeds are less likely to appear because undesirable plants don't receive enough moisture from the soil, as water is provided only to the area surrounding the plant. Automated precision irrigation saves labour costs by removing the need for human inspections and notifying operators when maintenance is needed. Environmental regulators mandate the use of sustainable farming practices to preserve water and increase yields, which will feed the growing global population. Precision irrigation aids the agriculture sector in achieving both goals by demonstrating sustainable practices and, with the right technology, accurately reporting on water utilization.

The components of precision irrigation management are remote sensing (imaging technologies that capture data from a distance), geographic information system (software tools used for management, analysis and visualization of data), unmanned aerial vehicle (drones equipped with cameras for aerial data collection), global positioning system (a satellite-based navigation system used for precise mapping and guidance), machine learning (AI algorithms that analyze large data sets and make predictions), internet of things (network connected devices that collect and transmit data), variable rate technology (technology that allows for variable application of inputs) and decision support system (software tools that assist with crop management decision making based on data analysis)(Brahmanand and Singh2022).

STEPS IN PRECISION IRRIGATION

1. **Data acquisition:** With a variety of sensors and tools, precise in situ geographical and temporal real-time data about the weather, crops, and soil are gathered.

2. **Data interpretation:** An appropriate frequency and temporal scale are used to analyse and interpret the data that has been obtained. To foresee crop response to various applications or treatments, several multidimensional modelling/simulation software/tools are available. Software called Decision Support System for Argo Technology Transfer (DSSAT) is frequently used to simulate crop dynamics under various irrigation and meteorological circumstances.

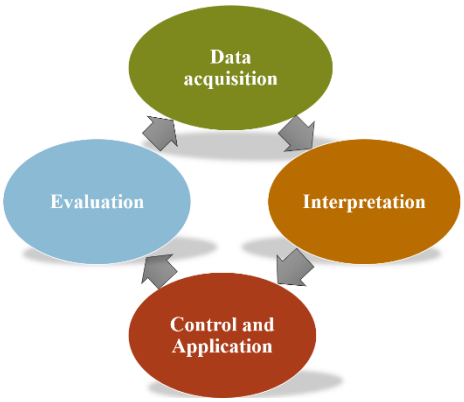

Fig. Steps involved in precision irrigation

3. **Control:** The inputs are managed and modified irrigation techniques at the appropriate temporal and spatial scales, variable amounts of water are applied over a field.

4. **Evaluation:** Closing the loop or evaluating is an essential step. Feedback and system performance optimization depend on an evaluation of the irrigation system's agronomic, engineering, and economic performance. (Anjum *et al.*2023)

AUTOMATED SENSORS

Numerous sensors are used to acquire data are:

Type of sensor	Application
Soil moisture sensor	Soil moisture
Temperature sensor	Soil temperature, Air temperature
Compact weather sensor	Air temperature, air humidity, wind speed, air pressure
Pressure sensor	Ensures optimum pressure level
Ultrasonic sensor	Monitor water level in tanks
Humidity sensor	Air humidity
Radiation sensor	Measures intensity of light
Drone sensor	Hyperspectral and multispectral, thermal, RGB sensors

ADVANTAGES OF AUTOMATION

- **Automatic operation:** It removes the need for manual valve opening and closing.
- **Optimizing energy requirement:** It optimizes energy consumption by starting and stopping the pump precisely when needed.
- **Efficiency:** It possesses very high-water use efficiency and fertilizer use efficiency.
- **Operational flexibility:** The irrigation system can be turned on at any time because it may be impossible to visit the farm at night.

CHALLENGES

- Small land holdings and marginal and small-scale farmers' inability to invest.
- Cropping System-Mismatch: The main arrangement of the drip system for the rabi crop differs from the kharif crop, creating issues with the precision cropping system's successful adoption.
- Technical Services: Insufficient technical personnel, particularly locally, who are qualified to operate and maintain precision irrigation systems at the regional or national level. Furthermore, learning new skills is necessary due to the complexity of the tools and processes used in precision irrigation.
- Infancy of canal automation: Drip irrigation is impractical for certain field crops, such as rice, in certain habitats, particularly in lowlands. In such cases, canal automation is still in its infancy in India but has the potential to improve the water use efficiency.

- Crop diversification at a slow speed: Agricultural diversity is a prerequisite for the increased adoption of precision irrigation, as farmers favour it for certain high-value crops.
- Low level of field demonstrations: Farmers in India must be taught about the advantages and operation of precision irrigation water management technology through detailed field trials and success stories.

CONCLUSION

Precision irrigation management using automated sensors helps to manage the field variability of water in turn increases the crop productivity and water use efficiency along with reduction in energy and labour cost on irrigation. Moreover, irrigation systems can be remotely controlled and monitored.

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