IoT Based Smart Irrigation System for Enhancing Water Use Efficiency

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Agriculture consumes more than 60% of the fresh water available for irrigation. With the increasing pressure on available arable land and water resources, plant stress alleviation and avoidance has gained momentum in last decade. Traditional irrigation methods with low application efficiency and higher losses (evaporation, seepage and percolation) are aggravating issue with limited water availability. To mitigate this, farmers should use the minimum amount of water required to meet their yield goals and ensure adequate water supply for future generations. Different irrigation scheduling techniques, such as evapotranspiration and water balance, soil moisture condition, and plant water condition techniques, have been used through smart irrigation management. The ET-based irrigation techniques rely heavily on assessing local climate data. ET-based irrigation techniques rely on crop coefficients that are individual to each location and can be incorrect. With computed ET-based scheduling systems, cumulative mistakes might arise, which is why field-based

measurements are typically required to rectify error. Soil moisture sensor based irrigation have limitations of spatial variability, accuracy and precision of sensor based on method of measurement, installation and calibration errors. A combination of irrigation scheduling measures promotes crop irrigation scheduling and reduces water wastage. In a few studies, evapotranspiration (ET), soil moisture sensors, or plant-based smart irrigation technologies have been used to schedule irrigation events by considering the weather, soil moisture conditions, and plant water status. In recent years, agriculture has experienced a fourth evolution (Agriculture 4.0) as information and communication technology (ICT) has been merged with traditional agricultural techniques.

In precision irrigation, water is applied to a crop's root zone at the right time, amount, and place using an effective method. A precision irrigation system increases crop productivity and water use efficiency (WUE) at a lower energy cost per irrigation. Wired and wireless smart drip irrigation systems with soil moisture sensors can apply a precise amount of water to the right place at the right time. This can be done by using smart strategies to improve precision. The smart irrigation monitoring drip systems are very effective techniques to determine how much water needs to be applied based on the amount of water lost by the plant. A precisely planned irrigation system can maximize water use efficiency (WUE). Wireless sensor networks (WSNs) can improve real-time database monitoring. Installing sensors near the top of the active root system is critical for optimizing precision irrigation and irrigation

https://doi.org/10.52151/aet2025491.1819

scheduling

IoT-based smart irrigation technology measures soil moisture in the root zone of plants, which is decomposed by plant roots at an evaporation rate until a wilting point is reached. Soil moisture sensors can determine the timing of irrigation and irrigation stops in real-time. The amount and timing of irrigation can be estimated based on available soil moisture. It is a simple method and can be automated with commercially available systems. Earlier, agricultural monitoring systems deployed wired data acquisition systems, in which wires connected the sensor units for monitoring. Due to the limited wiring connection range, such systems had a limited deployment size for monitoring points. Further, strengthening these systems require extensive cabling, which leads to high installation and maintenance costs. Further they had high risk of physical damage due to weather and outdoor conditions.

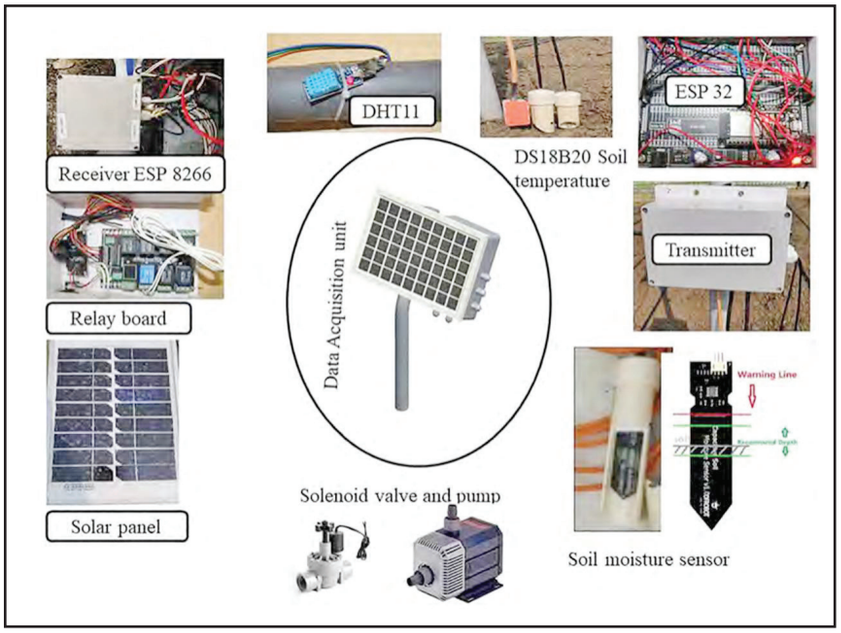

Fig. 1 Components of IoT based irrigation system

AI/IoT based irrigation ensures precise water management by monitoring soil moisture, weather, and plant needs in real-time. It enhances resource efficiency by accurately assessing soil moisture and environmental conditions, minimizing wastage. Automated systems adjust watering schedules based on crop growth stages, improving yield and produce quality. Remote monitoring via Smartphone's / computers enables timely adjustments, reducing manual work. Data-driven insights from AI algorithms inform decisions on crop health, soil, and water usage. Climate adaptation features adjust irrigation to changing weather conditions, ensuring adequate water supply. Overall, these systems

Fig. 2 IoT based irrigation system

optimize water usage, reduce labour, and boost crop productivity, yielding significant long-term cost savings. The intelligent irrigation systems consist of a soil moisture sensors and temperature sensor installed at the effective root zone of a specific crop in undisturbed soil. It also consists a micro sprinkler irrigation system, irrigation pump and electric solenoid valve in farmland fields using WSN, supported by communication technologies. The soil moisture data collected from soil moisture sensor and connected to IoT cloud platform for storage. The soil moisture characteristic curve was prepared threshold values were designed based on field capacity and wilting point. Based on soil moisture threshold and prediction of rainfall, the system shall actuate pump and valve for irrigation.

A developed hardware set up to measure soil moisture consisted soil moisture sensor interfaced with the Wi-Fi module. On Thingspeak cloud, the IoT data transfer protocol was implemented for receiving the weather and soil and soil moisture data. Raspberry Pi was used as a micro controller for IoT based intelligent irrigation system. Micro controller collects real-time weather data from weather website (https://weather.com) and sends it to cloud server. Micro controller based on weather data and soil moisture data from ThingSpeak platform, actuates relays for pump operation. The developed system was evaluated in wheat, pea and maize crops. In Maize, IoT based irrigation system improved yield by 10-12% with water savings up to 12-24% compared to ET based irrigation. In pea, significantly higher yields were observed under 50% of maximum allowable depletion level irrigation threshold with saving of 10% of irrigation water. Similar results were also recorded for wheat grain yield with 8-20% water savings with IoT compared to ET based irrigation.