6.2 Application of smart irrigation technologies

Automated irrigation systems based on soil moisture sensors can monitor and regulate root-zone water status in real time, providing a more stable moisture environment compared with fixed-schedule irrigation (Figure 3). Dirlik et al. (2025) developed an Arduino-based smart irrigation system for greenhouse tomatoes and found that maintaining soil moisture within a stable range of 70%-85%, compared with a fluctuating range of 55%-85%, increased fresh weight, dry weight, plant height, and fruit yield of mature plants by 52%, 78%, 121%, and 47%, respectively. Intelligent fertigation control systems also exhibit high operational accuracy. Li et al. (2024) reported that such systems achieved average decision-making and irrigation errors of only 1.1% and 0.8%, respectively, while increasing tomato yield by 7%-12% and reducing water and fertilizer inputs compared with conventional management practices.

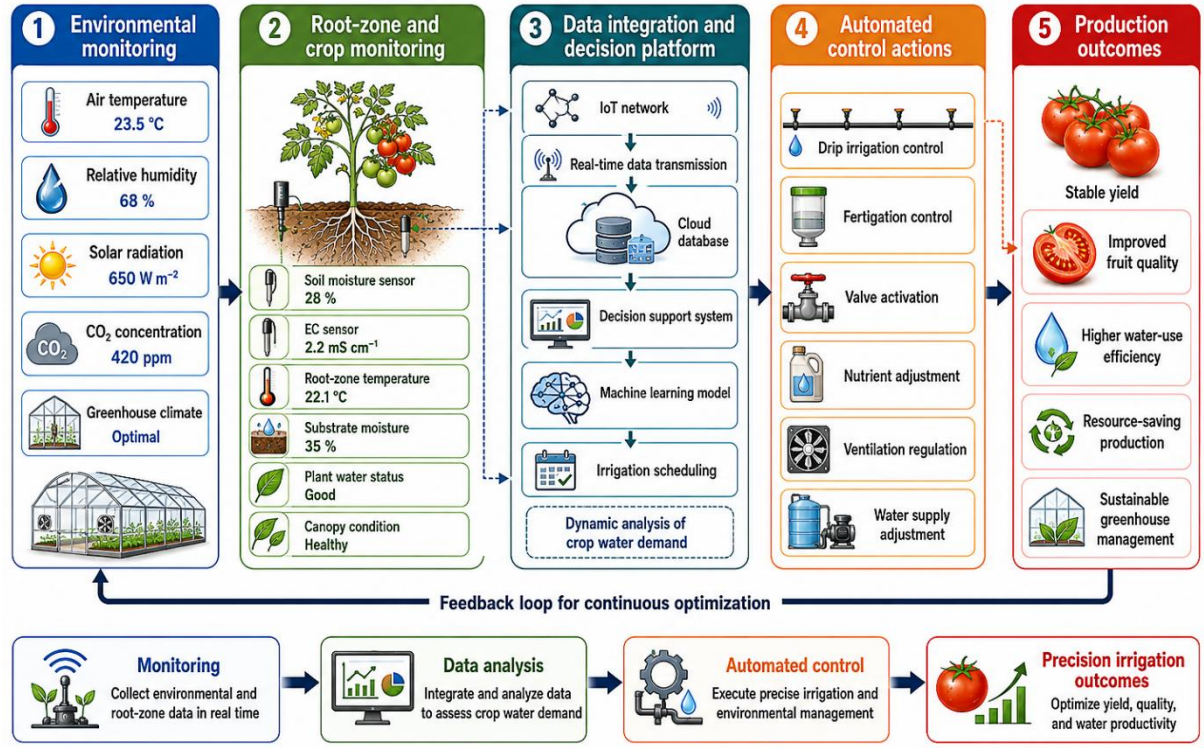


Figure 3 Framework of smart irrigation management for greenhouse tomato production

Image caption: Smart irrigation integrates environmental monitoring, root-zone sensing, data analysis, and automated control to achieve precise water management in greenhouse tomato production. Environmental parameters, including temperature, humidity, solar radiation, and CO_2 concentration, together with root-zone moisture status and crop physiological information, are collected through sensor networks. These data are transmitted to an intelligent decision platform incorporating IoT systems, cloud databases, and machine learning models to dynamically estimate crop water demand. The generated irrigation decisions are implemented through automated control systems, including drip irrigation, fertigation, nutrient adjustment, and environmental regulation. This integrated framework improves yield stability, fruit quality, water-use efficiency, and sustainable greenhouse production

Internet of Things (IoT)-based systems further extend beyond single-sensor control by integrating soil moisture, temperature, humidity, actuator devices, and data analysis modules to establish data-driven intelligent decision platforms. Ariss et al. (2024) indicated that smart greenhouse systems based on zonal management can use real-time monitoring data to adjust irrigation strategies according to crop growth stages and microenvironmental conditions. Experimental results showed that this approach improved tomato quality, yield, and resource-use efficiency. IoT-driven automated irrigation and fertilization systems can also enhance economic returns. In tomato production, threshold-based irrigation combined with 75%-100% of recommended fertilizer application increased yield by 4.8%-13.5%, reduced water consumption by 29%-39%, and achieved higher benefit-cost ratios than conventional management practices.