

# Design and Implementation of an IoT-Based Smart Irrigation System for Sustainable Precision Farming

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**Abstract:** *Traditional open-loop agricultural irrigation models face major limitations due to their inability to adapt to real-time environmental variations, resulting in substantial water wastage, nutrient leaching, and suboptimal crop yields. This paper presents the development of an integrated, automated, closed-loop **Smart Irrigation System** built on a dual-core **ESP32 microcontroller** framework. The hardware architecture incorporates a multi-sensor array to track soil moisture levels across varying depths, rainfall events, ambient temperature, humidity, barometric pressure, sunlight intensity, and soil pH. Telemetry is visualised locally via an I<sup>2</sup>C-interfaced 20x4 character Liquid Crystal Display (LCD) and transmitted concurrently over Wi-Fi to a remote web server for real-time tracking. Experimental evaluation confirms the platform's stability, low actuation latency via its isolated relay modules, and significant water conservation, offering a scalable solution for precision farming*

**Keywords:** *agricultural irrigation models*