# Abstract

The advancement of Wireless Sensor Network (WSN) technology offers significant potential in supporting smart agriculture through real-time environmental monitoring. However, the limited energy resources—especially in sensor nodes that typically rely on batteries—pose a major challenge for long-term WSN implementation. This research aims to develop and evaluate a hybrid energy harvesting system based on solar and wind energy, integrated with a coverage-awareness approach to enhance energy efficiency and network coverage in agricultural environments. The methodology involves literature study, the design of a hybrid renewable energy system, comprehensive testing on energy harvesting and storage performance, power management, network coverage, and inter-node communication. The system was tested under various environmental conditions to analyze energy conversion efficiency, power distribution, and network resilience to resource fluctuations. Results indicate that solar panels provide the main energy contribution, while wind turbines act as complementary sources. The implementation of the deep sleep mode on the ESP32 module significantly reduced power consumption from approximately 600 mW to around 44 mW. Additionally, the coverage-awareness approach successfully maintained optimal monitoring area coverage, with stable inter-node communication up to 8 meters. System evaluations showed that combining efficient power management and simultaneous utilization of renewable energy sources effectively extended the lifetime of sensor networks and supported sustainable WSN operations in agriculture. This study is expected to serve as a reference for the development of energy-efficient, reliable, adaptive, and environmentally friendly WSN solutions.



**Keywords:** Coverage Awareness , System Hybrid Energy Harvesting, Power Management, WSN.