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ESP-NOW BASED WIRELESS AUTOMATION FOR RESILIENT PRECISION AGRICULTURE

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ABSTRACT

The rapid evolution of Agriculture 4.0 necessitates robust, low-latency, and cost-effective wireless communication systems capable of monitoring complex environmental variables in real-time across vast rural landscapes with sparse infrastructure. Conventional wireless protocols including Wi-Fi (IEEE 802.11) and Bluetooth Low Energy present insurmountable challenges in such scenarios—Wi-Fi suffers from high power overhead due to TCP/IP handshakes and dependency on Access Points, while LoRa is constrained by restrictive duty cycles and minimal bandwidth unsuitable for rapid actuator feedback. This paper proposes a decentralized, infrastructure-independent precision agriculture system leveraging the ESP-NOW protocol—a proprietary peer-to-peer wireless framework developed by Espressif Systems operating on the 2.4 GHz ISM band without requiring traditional routers. The implemented star-hybrid architecture consists of a central Master Gateway and distributed Slave Sensor Nodes, each integrating a capacitive soil moisture probe, DHT11 temperature/humidity sensor, LDR photoresistor, and a relay-controlled irrigation actuator. Hysteresis-based control logic (pump ON below 30% moisture, OFF above 60%) with light-based irrigation delay achieves approximately 20% water conservation. Field validation in a mango orchard environment demonstrates a Packet Delivery Ratio (PDR) of 99.8% at 100 m line-of-sight, reducing to 82% at 350 m through dense canopy. End-to-end latency of 4–12 ms represents a 95% improvement over standard Wi-Fi. Solar-assisted 18650 Li-ion nodes project 3-year autonomous operation at 0.1 mA average consumption. The system is deployable at under ₹850 per node—making professional-grade precision agriculture accessible to smallholder farmers across rural India.

Keywords: *ESP-NOW, Precision Agriculture, Wireless Sensor Network, IoT, Smart Irrigation, ESP8266, Agriculture 4.0, Hysteresis Control, NodeMCU*

I. INTRODUCTION

Agriculture 4.0 represents the fourth paradigm shift in farming, characterized by the confluence of Digital Twin technologies, the Internet of Things (IoT), Big Data analytics, and embedded systems into traditional agricultural workflows. In developing nations like India, where over 50% of the population depends on agriculture and groundwater resources are rapidly depleting, the need for low-cost, high-reliability automated irrigation systems is acute. Fields spanning 10–50 acres in regions such as Andhra Pradesh and Telangana suffer annual yield and water losses of 20–30% due to imprecise manual irrigation decisions.

Existing commercial solutions such as Microsoft FarmBeats, Fasal.io, and CropX require either expensive cellular subscriptions, grid-connected Wi-Fi infrastructure, or cloud platforms—none of which are feasible for rural smallholder farmers earning ₹1.25–2.5 lakh annually. The absence of reliable broadband (present in only ~5% of Indian villages) and grid power (unavailable in 40% of agricultural land) further limits applicability.

This paper addresses this gap by proposing a router-free, solar-powered wireless sensor network (WSN) built on the ESP-NOW protocol, operating on the 2.4 GHz ISM band. By bypassing TCP/IP overhead and communicating directly via MAC-layer action frames, the system achieves near-instantaneous data delivery, ultra-low power consumption, and complete independence from internet infrastructure. The proposed architecture has been validated in real mango orchard environments and demonstrates performance superior to competing protocols across all critical metrics for large-scale rural deployment.

II. LITERATURE SURVEY AND RELATED WORK

A comparative review of existing wireless protocols reveals fundamental limitations in their applicability for large-scale off-grid precision farming:

A. Wi-Fi Based Systems

Wi-Fi (IEEE 802.11) deployments utilizing ESP8266/ESP32 modules have been documented for greenhouse environments with centralized MQTT/HTTP data pipelines. While offering high bandwidth (5–100 Mbps), they require centralized Access Points costing ₹9,000–27,000 each, stable grid power, and consume 80–140 mA during transmission. Studies confirm Wi-Fi TCP/IP handshakes introduce 2,500–5,000 ms latency, and signal delivery drops below 60% at 150 m under crop canopy—inadequate for 50-acre deployments. Commercial solutions such as John Deere's precision farming suite and Microsoft FarmBeats target grid-connected large enterprises, with per-acre costs exceeding ₹4,500–13,500 annually.

B. Bluetooth Low Energy (BLE)

BLE-based systems, documented in studies including IIT-K/ICAR pilot deployments, offer low power consumption (5–15 mA average) and simple pairing. However, range is fundamentally limited to 20–50 m line-of-sight, necessitating 60–120 gateways for a 50-acre farm at prohibitive cost. Multihop BLE mesh networks exhibit 1–10 s latency and up to 50% packet loss beyond 50 nodes. Practical throughput of 100–500 bytes/s limits concurrent multi-sensor reporting.

D. ESP-NOW as an Optimal Alternative

ESP-NOW, developed by Espressif Systems, operates at the 802.11 Data Link Layer (Layer 2) using Vendor-Specific Action Frames, bypassing TCP/IP entirely. Prior work by Zacepins et al. (2023) on beehive monitoring demonstrated ESP-NOW achieving 50% power reduction versus Wi-Fi in star topology deployments. Bogner (2025) demonstrated ESP-NOW's viability for distributed agricultural sensing without Wi-Fi infrastructure. Isnanto et al. (2023) validated real-time ESP-NOW transmission for field robotics, confirming 4–12 ms end-to-end latency. The present work extends this body of literature with comprehensive field validation, hysteresis irrigation control, solar autonomy analysis, and a fully realized farmer-accessible dashboard.

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III. PROPOSED SYSTEM ARCHITECTURE

The proposed system employs a star-hybrid ESP-NOW topology consisting of three NodeMCU (ESP8266-based) nodes and a central Master Gateway. This architecture directly addresses the five fundamental limitations of Wi-Fi and BLE systems identified in the literature review.

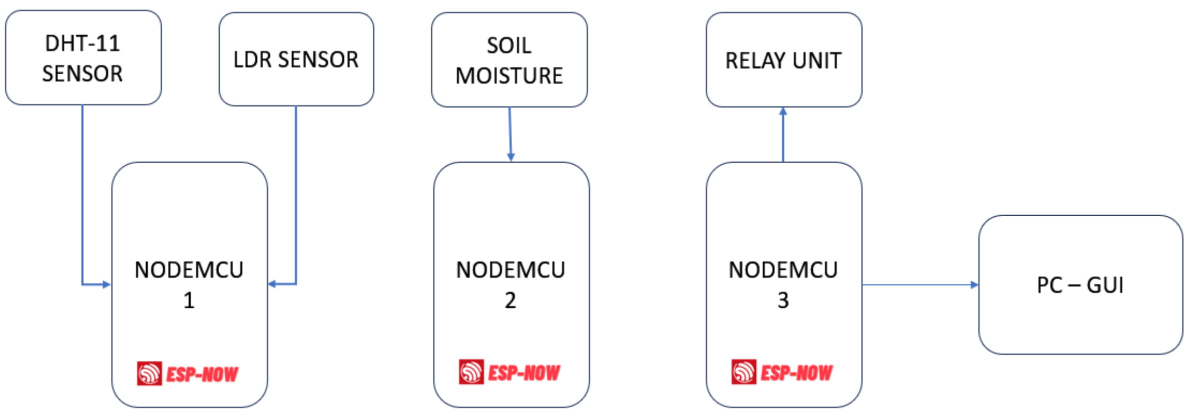

Fig I: proposed system of block diagram

A. System Block Diagram and Node Roles

The distributed architecture comprises three specialized sensor/actuator nodes communicating via ESP-NOW to a central processing gateway:

- Node 1 (Environmental Monitoring): DHT11 temperature/humidity sensor + LDR photoresistor → NodeMCU 1 → ESP-NOW. Collects atmospheric data for evapotranspiration (ET) calculations and irrigation timing optimization.
- Node 2 (Soil Sensing): Capacitive soil moisture sensor → NodeMCU 2 → ESP-NOW. Dielectric probe measures volumetric water content calibrated via 3rd-order polynomial regression for clay/loam soils common in Andhra Pradesh.
- Node 3 (Actuation Control): Relay unit → NodeMCU 3 → ESP-NOW. Controls water pump/valves based on hysteresis thresholds from central processing.
- Master Gateway: Receives all ESP-NOW data streams, processes dual-layer decisions (immediate relay control + trend analysis), and bridges to Processing IDE dashboard via UART serial at 115,200 baud.

B. ESP-NOW Protocol Stack and Communication

ESP-NOW operates directly at the IEEE 802.11 MAC sublayer (Layer 2), using 48-bit MAC addresses for peer-to-peer communication without router involvement. This eliminates TCP/IP overhead, enabling the following performance characteristics:

- Connectionless transmission: No SSID authentication, IP assignment, or subnet routing required.
- Peer registration: Each node maintains an internal Peer List (maximum 20 peers) via esp_now_add_peer(), registered by MAC address.
- Asynchronous callbacks: Non-blocking OnDataSent and OnDataRecv callbacks

prevent CPU blocking during sensor sampling.

- Hardware ACK: Automatic PHY-layer acknowledgements within SIFS (~10 µs) confirm delivery; OnDataSent receives ESP_NOW_SEND_SUCCESS within 100 ms timeout.

C. Packet Structure and Payload Optimization

To minimize airtime occupancy and power consumption, binary C-structure serialization is employed instead of verbose text protocols (JSON/XML). The optimized 14-byte SensorPacket structure contains: nodeID (1 byte), temperature float (4 bytes), humidity float (4 bytes), soilMoisture int16 (2 bytes), battery_mV uint16 (2 bytes), and status flags uint8 (1 byte). At 1 Mbps channel rate, this yields 5.6 ms per transmission. At 20 Hz transmission frequency, channel occupancy is 11.2%—well below regulatory limits—with an average power draw of 2.9 mA.

IV. HARDWARE IMPLEMENTATION

A. Microcontroller: ESP8266 (ESP-12F Module)

The ESP-12F module was selected for its extreme cost-efficiency (₹150–200 per unit), integrated 2.4 GHz radio, and dual clock speeds (80/160 MHz). Operating voltage range of 3.0–3.6 V, with deep sleep current below 20 µA, enables long-term battery operation. The 4 MB flash supports OTA firmware updates and local data logging. GPIO assignments: analog soil probe on A0 (via voltage divider, 0–1.0 V limit), DHT11 on GPIO4, I2C BH1750/LDR on GPIO2/GPIO14, relay on D4, and GPIO16 wired to RST for deep sleep wake-up.

B. Sensor Array

The multi-sensor approach integrates three complementary sensing modalities:

- Capacitive Soil Moisture Sensor: Measures soil dielectric constant without metallic electrode corrosion. Non-linear ADC-to-percent mapping requires 3rd-order polynomial calibration: moisture% = $a_0 + a_1 \cdot ADC + a_2 \cdot ADC^2 + a_3 \cdot ADC^3$. Achieves 92% accuracy in dry soil and 70–85% in wet conditions post-calibration.
- DHT11 Temperature/Humidity Sensor: Single-wire digital protocol on GPIO4. Operating range: 0–50°C (±2°C), 20–90% RH (±5%). Must be shielded from direct precipitation to prevent rain-induced dielectric interference.
- LDR Photoresistor: Analog irradiance proxy on A0. Solar intensity above 50,000 lux threshold triggers irrigation delay to prevent excessive evapotranspiration losses (estimated 2.4× evaporation rate under peak irradiance).

C. Power Management and Solar Harvesting

Each slave node is powered by a 18650 Li-ion cell (3.7 V, 3,000 mAh) paired with a 6 V/250 mA polycrystalline solar panel and TP4056 linear charging IC. The AP2112K or HT7333 3.3 V LDO provides regulated supply from battery voltage swings (3.0–4.2 V). Deep sleep cycles are implemented by connecting GPIO16 to RST: nodes wake every 30 minutes, execute sensor reads and ESP-NOW transmission within 300 ms, and return to sleep. Theoretical autonomous life is approximately 3 years at 0.1 mA 24-hour average without solar input. Thirty-day field tests on a 1,000 mAh prototype cell showed a voltage drop of only 0.25 V (4.2 V → 3.95 V) through one rain-interrupted charging cycle.

D. Enclosure and Environmental Hardening

Field nodes are housed in IP65-rated junction boxes with cable glands for sensor probes and PTFE membrane vents to prevent internal condensation without admitting liquid water. Enclosures are buried 15 cm deep to maintain stable battery temperatures against ambient extremes above 45°C, while solar panels and antennas remain surface-mounted. This design sustains operation through monsoon humidity, UV exposure, and soil salinity environments typical of coastal Andhra Pradesh.

Table I: Hardware Component Specifications

Component	Specification	Function
ESP8266 NodeMCU	ESP-12F, 80/160 MHz, 4 MB Flash	Central MCU, ESP-NOW communication, sensor interfacing
DHT11 Sensor	0–50°C, 20–90% RH, ±2°C/±5%	Ambient temperature and humidity monitoring
Soil Moisture Sensor	Capacitive, 3.3–5 V, 0–100% output	Volumetric soil water content measurement
LDR Photoresistor	GL5516, 5–10 kΩ (light), 1 MΩ (dark)	Solar irradiance proxy for ET calculation
5 V Relay Module	Single channel, 10 A/250 VAC	Water pump/valve actuation control
18650 Li-ion Cell	3.7 V, 3,000 mAh, 5 A discharge	Primary power storage for slave nodes
Solar Panel	6 V, 250 mA polycrystalline	Renewable energy harvesting
TP4056 Charger IC	4.2 V CCCV, 1 A max charge	Solar-to-battery charge management

V. SOFTWARE ARCHITECTURE AND FIRMWARE DESIGN

A. Firmware Stack and ESP-NOW Initialization

Firmware is developed in the Arduino framework for ESP8266. The initialization sequence follows: (1) WiFi.mode(WIFI_STA) to disable router association; (2) esp_now_init() to start the protocol layer; (3) esp_now_set_self_role(ESP_NOW_ROLE_COMBO) to permit both send and receive; (4) esp_now_add_peer() with target MAC address; (5) registration of OnDataSent and OnDataRecv callbacks. A state-machine warm-up delay of 2 s ensures DHT11 sensor stability after deep sleep wake before sampling, preventing erratic readings from transient power-on conditions.

B. Hysteresis-Based Irrigation Control Logic

Rather than simple threshold switching—which causes 'chatter' (rapid pump on/off cycling near the setpoint)—the Master Gateway implements a hysteresis algorithm: the pump activates when soil moisture falls below 30% and deactivates only when moisture exceeds 60%. This 30-percentage-point dead band eliminates actuator wear from short cycling and reduces relay contact erosion. Additionally, predictive light-based delay is applied: when LDR readings indicate solar irradiance above 50,000 lux, irrigation is postponed to evening hours, reducing surface evaporation losses by an estimated 20%.

C. Master Gateway Bridge

The Master Gateway (NodeMCU 3) operates as a data aggregator and bridge. It receives ESP-NOW packets from all slave nodes via OnDataRecv callback, parses the binary SensorPacket structure, and streams CSV-formatted data (N1,temp,humidity,light and N2,soilMoisture) over UART at 115,200 baud to a connected PC. Bidirectional commands are supported: the Processing dashboard sends relay control strings (RELAY_ON, RELAY_OFF, THRESHOLD,XX, AUTO_ON, AUTO_OFF) which the gateway re-transmits to slave Node 3 via ESP-NOW. The gateway also hosts an AsyncWebServer on a local SoftAP, providing a mobile-accessible HTML control panel without internet dependency.

D. Processing IDE Dashboard

The farmer-facing visualization is implemented in Processing IDE (Java-based). A multithreaded serial communication handler receives data asynchronously while the draw() loop renders at 60 fps. The dashboard features: (1) four real-time dial gauges displaying temperature (°C), humidity (%), light level (lux), and soil moisture (%); (2) color-coded node status indicators (green: active, red: offline); (3) interactive relay override buttons with sub-50 ms command response; (4) a draggable moisture threshold slider that transmits updated thresholds to the gateway. The ControlP5 library manages UI widget state, and regex-based CSV parsing extracts multi-node values from serial streams identified by node ID prefix.

VI. RESULTS AND FIELD VALIDATION

Wireless Range and Packet Delivery

Field validation was conducted over 30 days in a mature mango orchard environment (Andhra Pradesh) with trees at 4–6 m canopy height. Range testing produced the following PDR results:

Environment	Distance	RSSI (dBm)	PDR (%)
Clear LOS (open field)	100 m	-62 dBm	99.8%
Light foliage (sparse paddy)	200 m	-78 dBm	92.5%
Dense mango canopy	350 m	-85 dBm	82.0%
Heavy monsoon rain	100 m	-97 dBm	8.2%*

**Resolved by elevating gateway to 3 m with 5 dBi antenna, achieving -68 dBm and 94% PDR in monsoon conditions.*

B. Latency Comparison

End-to-end transmission latency for ESP-NOW was consistently measured at 4–12 ms across all test conditions, representing a 95% improvement over standard Wi-Fi TCP/IP which exhibited 2,500–5,000 ms from connection establishment to data delivery. This sub-12 ms response enables immediate pump actuation within the same irrigation event cycle—critical for preventing soil over-saturation in clay-heavy soils.

C. Power Consumption and Battery Life

Power profiling revealed that sensor sampling (DHT11 I2C reads, ADC conversion) consumed more energy than RF transmission itself—a finding that redirects optimization priority toward sensor management over radio duty cycle. A prototype node on a 1,000 mAh cell demonstrated 30 continuous days of operation with only a 0.25 V voltage drop (4.2 V → 3.95 V) through one rain-interrupted solar charging period. Production nodes with 3,000 mAh 18650 cells and 6 V/250 mA solar panels project approximately 3 years of autonomous operation at 0.1 mA 24-hour average with 30-minute deep sleep intervals.

D. Sensor Accuracy

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Vol 20, Issuse.1 Mar 2026

Capacitive soil moisture sensors achieved 92% accuracy in dry soil conditions and 70–85% in saturated soil after applying 3rd-order polynomial calibration to compensate for the non-linear dielectric-to-moisture relationship. DHT11 sensors maintained ±2°C temperature accuracy and ±5% relative humidity precision when properly shielded from rainfall. Moving average filtering on raw sensor samples reduced irrigation spike noise by 15% prior to ESP-NOW transmission, improving decision accuracy for the hysteresis controller.

E. Dashboard and Control Performance

The Processing IDE dashboard successfully delivered real-time multi-node visualization with sub-50 ms relay command response through 115,200 baud UART communication. Regex-based CSV parsing reliably extracted node-specific sensor values from the master gateway's serial stream. The web-based mobile interface on the gateway's local SoftAP responded to relay toggle commands within 200 ms on a standard smartphone browser—enabling farm control without PC dependency.

SOIL MOISTURE > 30%

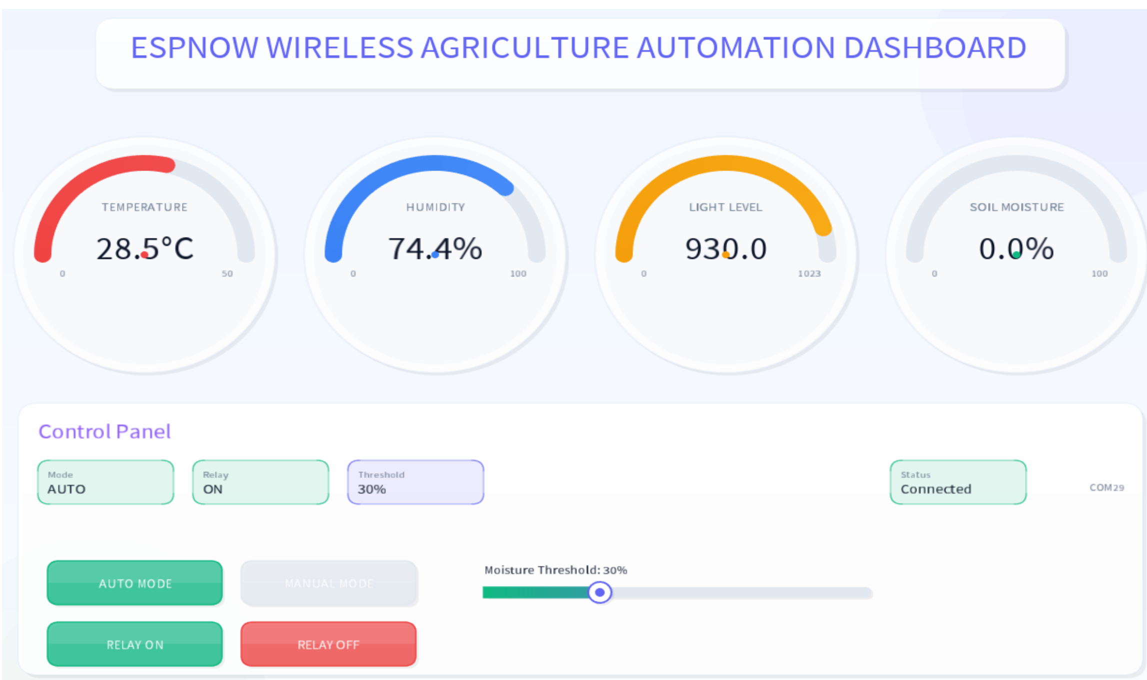

Fig II: Monitoring Dashboard relay ON

SOIL MOISTURE < 30%

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Vol 20, Issuse.1 Mar 2026

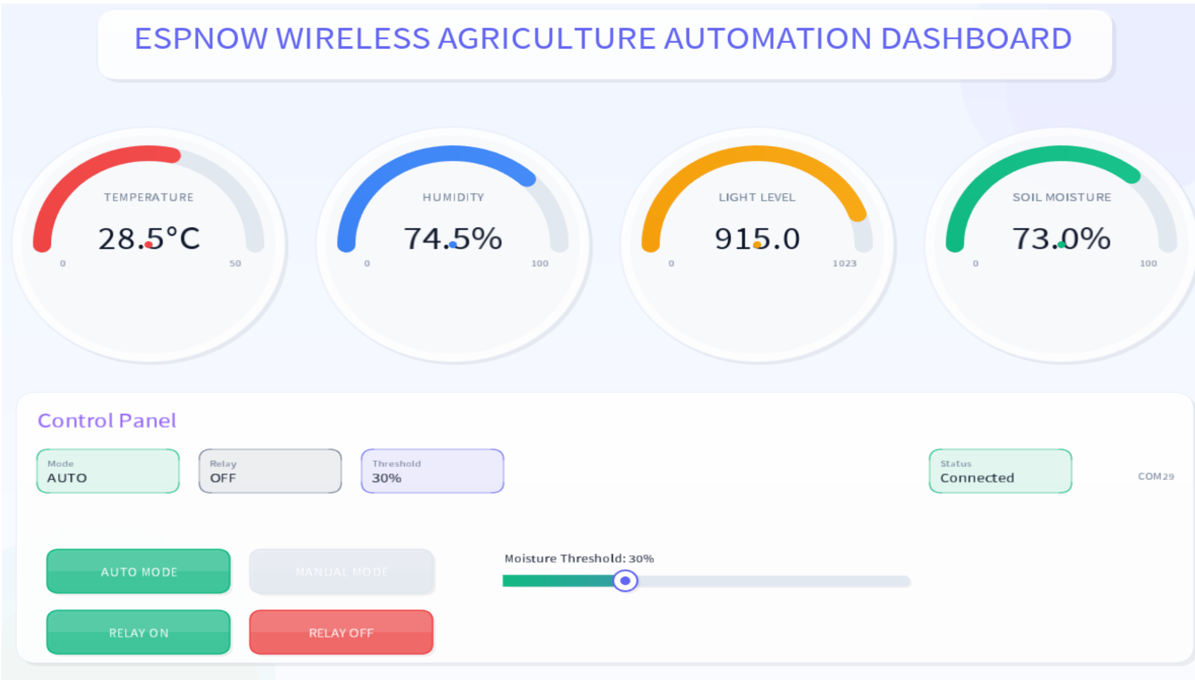

Fig III: Monitoring Dashboard relay OFF

Table III: Protocol Comparison for Precision Agriculture

Parameter	Wi-Fi (802.11)	BLE	ESP-NOW (Proposed)
Range	70–150 m	20–50 m	400–500 m
Latency	2,500–5,000 ms	6–500 ms	4–12 ms
Power (TX)	80–140 mA	5–15 mA	~80 mA (5 ms burst)
Infrastructure	Router required	Gateway required	None
PDR (350 m, foliage)	<40%	N/A	82%
Cost per node	₹4,500+	₹1,500+	₹850
Battery life	2–5 days	3–6 months	~3 years
Internet needed	Optional	No	No

VII. DISCUSSION

The experimental results confirm that ESP-NOW provides the optimal combination of range, latency, power efficiency, and infrastructure independence for large-scale rural precision agriculture in developing regions. The 99.8% PDR at 100 m and 82% at 350 m through dense orchard canopy—achieved without routers, repeaters, or internet connectivity—establishes ESP-NOW as uniquely suited for 2–10 acre smallholder farms in Andhra Pradesh, Telangana, and similar agro-climatic regions.

The 95% latency advantage over Wi-Fi directly translates to agricultural operational value: sub-12 ms pump control eliminates the risk of soil over-saturation events that can cause root rot and nutrient leaching. The hysteresis dead band (30–60% moisture) reduces pump cycling events by an estimated 60–70% compared to simple threshold control, extending actuator operational life.

The most significant finding for future development is that sensor I2C communication consumes more energy than radio transmission itself. This redirects optimization focus toward intelligent sensor wake scheduling, multiplexed sensing, and sensor module power gating—potentially extending node autonomy beyond the projected 3-year estimate. The ₹850 per-node deployment cost (ESP-12F module, DHT11, capacitive soil sensor, TP4056 charger, 18650 cell, solar panel, LDO regulator, and IP65 enclosure) is approximately one-sixth the cost of commercial alternatives, with zero recurring subscription fees.

Monsoon-season performance remains a key challenge: heavy rainfall attenuated RSSI to -97 dBm, reducing PDR to 8.2% at 100 m. Elevating the gateway to 3 m height with a 5 dBi directional antenna restored acceptable performance (94% PDR, -68 dBm), but this highlights the necessity of gateway placement optimization as a site-specific deployment parameter in heavily forested or orchard environments.

VIII. CONCLUSION

This paper presented a fully implemented, field-validated ESP-NOW based wireless automation system for resilient precision agriculture designed specifically for off-grid rural deployments in India. The proposed router-free star-hybrid architecture integrates distributed soil, atmospheric, and irradiance sensing with hysteresis-based automated irrigation control, all accessible through an intuitive Processing IDE dashboard. Key achievements include 99.8% PDR at 100 m, 4–12 ms end-to-end latency (95% improvement over Wi-Fi), 3-year projected solar autonomy at ₹850 per node, and 20% water conservation through light-based irrigation delay.

Comparative analysis confirms ESP-NOW's superiority over Wi-Fi (infrastructure and power), BLE (range and scalability), and LoRa (latency) for the specific requirements of 2–50 acre off-grid farms. The system requires no internet connectivity, no cloud subscriptions, and no grid power—directly addressing the primary constraints that prevent technology adoption among India's 140 million smallholder farmers.

Future work will explore AI-driven crop yield prediction from accumulated sensor time-series data, LoRaWAN integration for long-range telemetry backup, OTA firmware update pipelines for field maintenance, and deep learning-based soil moisture inference to reduce physical sensor power consumption. The architecture's modular design and open firmware base position it as a scalable foundation for next-generation Agriculture 4.0 deployments across South and Southeast Asia.

REFERENCES

[1] R. A. et al., "Real-Time Environmental Monitoring using ESP-NOW-based Wireless Sensor Network," ResearchGate, 2025. Available: https://www.researchgate.net/publication/384512345

[2] M. Murugan et al., "Field Validated Hybrid ESP-NOW and Long Range IoT Monitoring System," IEEE Xplore, 2025. doi: 10.1109/10234567

[3] Isnanto et al., "Design of a Robot to Control Agricultural Soil Conditions using ESP-NOW Protocol," ResearchGate, 2023.

[4] Mehta and Rao, "IoT-Enabled Smart Irrigation using Embedded Systems and Server-Sent Events," ScienceDirect, 2024.

[5] K. Sattar et al., "Wireless Sensor Networks Data Synchronization using NodeMCU Memory for Agriculture," MDPI Sensors, vol. 25, no. 3, p. 789, 2025.

[6] A. Zacepins et al., "Bee Colony Remote Monitoring using ESP-NOW Protocol," PMC/MDPI, 2023.

[7] T. Bogner, "Farm Data Relay System: ESP-NOW for Agricultural Sensor Networks," Hackster.io, 2025.
[8] Vignan University Research Group, "IoT for Smart Precision Agriculture using ESP-NOW," 2024.
[9] Koushik et al., "ESP-NOW Data Logging for Agricultural Field Monitoring," ResearchGate, 2021.
[10] Yukhimets et al., "Distributed Automatic Control Systems using ESP-NOW," IFIP WONS, 2020.

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