PROJECT ABSTRACT

IoT Forest Fire Early Warning Node with Smoke Sensing

A solar-powered LoRa sensor node that reports smoke and abnormal heat from remote forest patches to a gateway dashboard, raising configurable early-warning alerts. Demonstrated as a multi-node network with the full sensor-to-alert chain working. An educational prototype — not a certified fire-safety system.

Project type: Hybrid (hardware node + software dashboard)

Availability: Built to order

Suitable branches: IoT & Embedded, Electronics / E&TC

Technologies: ESP32, SX1278 LoRa, MQ-2 smoke sensor, DHT22, solar power, Arduino firmware, web dashboard

Price: Request a quotation

Prepared by Projectech · projectech.in — for academic project reference.

1. Abstract

This project presents a solar-powered IoT sensor node that provides early warning of forest fires in areas without cellular or Wi-Fi coverage. Each node combines an MQ-2 smoke sensor with a DHT22 temperature-humidity sensor on an ESP32 controller, and transmits readings over a long-range LoRa link (433 MHz) to a gateway. The gateway forwards data over Wi-Fi to a dashboard that maps every node, displays live gauges and history charts, and raises early-warning alerts when smoke or temperature crosses configurable thresholds. Nodes run from a small solar panel with battery backup and sleep between readings to stretch autonomy. The deliverable is demonstrated as a multi-node network with the full sensor-to-alert chain working: real uplinks, a real alert banner, buzzer output and a timestamped event log. The build is an educational prototype demonstrating long-range IoT sensing and threshold-based alerting; it is explicitly not a certified fire-safety or fire-detection system.

2. Problem Statement

Forest fires spread fastest in their first minutes, yet most forest patches have no continuous sensing — discovery still depends on patrols, watchtowers or bystanders. Short-range IoT technologies (Wi-Fi, Bluetooth) cannot cover remote forest areas, and cellular coverage is unreliable or absent. A practical answer is an always-on, solar-powered node that reports smoke and heat anomalies over kilometres without infrastructure, and LoRa fits that link exactly. This project addresses the gap with a low-cost LoRa sensor node, a gateway receiver and a monitoring dashboard that together demonstrate threshold-based early warning on a multi-node forest-patch network.

3. Objectives

- Design a solar-powered sensor node combining MQ-2 smoke sensing with DHT22 temperature-humidity sensing.
- Establish reliable long-range communication between remote nodes and a gateway using LoRa (433 MHz).
- Build a gateway dashboard showing a node map, live gauges, history charts and a timestamped alert event log.
- Implement configurable threshold-based early-warning alerts with local buzzer output and notifications.
- Document a field calibration procedure for setting alert thresholds from measured ambient baselines.
- State the prototype's limitations honestly, including that it is not certified fire-safety equipment.

4. System Architecture

The system is organized in three layers. The **node layer** is an ESP32 controller with an MQ-2 smoke sensor, a DHT22 temperature-humidity sensor and an SX1278 LoRa radio, powered by a 5 V solar panel charging a Li-ion battery through a TP4056 module; firmware deep-sleeps between readings. The **gateway layer** is a second ESP32 with an SX1278 receiver that decodes LoRa packets and forwards them over Wi-Fi, driving a local buzzer on alert. The **application layer** is a web dashboard rendering the node map, per-node gauges, 24-hour history charts, configurable thresholds and the alert event log.

5. Technologies Used

- ESP32 microcontroller (node and gateway)
- SX1278 LoRa modules, 433 MHz ISM
- MQ-2 smoke/gas sensor
- DHT22 temperature-humidity sensor
- Solar power: 5 V panel, 18650 Li-ion battery, TP4056 charger
- Arduino (C++) firmware

- Web dashboard: HTML, CSS, JavaScript
- Gateway uplink: Wi-Fi

6. Working Principle

- The ESP32 wakes on a timer, powers the MQ-2 and DHT22, and samples smoke (analog voltage) plus temperature and humidity.
- Readings are packed into a compact LoRa payload with the node ID and battery voltage, then transmitted on 433 MHz.
- The gateway's LoRa receiver decodes the packet and forwards it over Wi-Fi to the dashboard backend.
- The dashboard updates the node's map marker, gauges and history chart, and logs the reading with a timestamp.
- If smoke or temperature exceeds the configured threshold for the configured number of consecutive readings (default 3), the alert state is raised.
- On alert, the dashboard shows a warning banner, the gateway buzzer sounds, and notifications are queued to the configured recipients.
- Between readings the node returns to deep sleep, stretching the solar-charged battery across cloudy days.

7. Key Features

- Combined smoke plus climate sensing: abnormal heat confirms a smoke event instead of one signal triggering alone.
- LoRa long-range uplink covering kilometres of forest with no Wi-Fi or cellular infrastructure.
- Solar-powered node with deep-sleep firmware targeting multi-day autonomy without sun (design target).
- Gateway dashboard with node map, per-node gauges, 24-hour history charts and a timestamped alert event log.
- Configurable alert thresholds, uplink interval and node ID without reflashing firmware.
- Documented field calibration procedure: thresholds set above a measured ambient baseline; no detection accuracy invented.
- Complete viva kit: report with LoRa link budget and sensor datasheets, PPT presentation and Q&A document.

8. Applications

- Forest-patch early-warning demonstration networks for academic and research projects.
- Teaching long-range IoT (LoRa) link design, solar power budgeting and threshold-based alerting.
- Rural and farm monitoring pilots where cellular coverage is unavailable.

- Smoke and heat anomaly logging for environmental study plots.

9. Limitations

- An educational prototype, not certified fire-safety equipment — it must not be presented or used as a real fire-detection or life-safety system.
- The MQ-2 senses smoke crudely and is not calibrated to any fire standard; dust, vehicle exhaust or nearby cooking smoke can cause false alerts.
- No detection accuracy or detection-range figure is claimed; alert thresholds are set by the buyer-run baseline procedure.
- LoRa range of 2–5 km is a design target — hills, dense canopy and antenna placement reduce it, and coverage is not guaranteed.
- Battery autonomy of 3–5 days without sun is a design target, not a measured figure; it depends on panel size, sunlight and uplink interval.
- The gateway needs Wi-Fi for the dashboard and notifications; a node cannot raise an alert if its LoRa link to the gateway is down.
- The dashboard demo ships with simulated data for the viva demonstration; live readings appear when the hardware is connected.

10. Conclusion

The IoT Forest Fire Early Warning Node with Smoke Sensing demonstrates how a low-cost LoRa sensor network can bring continuous smoke and heat monitoring to forest patches that have no cellular or Wi-Fi coverage. By pairing an MQ-2 smoke sensor with a DHT22 on a solar-powered ESP32 node, and closing the loop through a gateway dashboard with threshold-based alerts, the project covers the complete embedded-to-cloud pipeline: sensing, long-range wireless communication, solar power budgeting and a working monitoring application. Its limitations are stated plainly — crude smoke indication, no certified detection claims, and design-target range and autonomy figures — which makes it an honest, defensible final-year project in IoT and embedded systems.