IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⨳ Peer-reviewed & Refereed journal ⨳ Vol. 14, Issue 7, July 2026

DOI: 10.17148/IJIREEICE.2026.14706

LoRa-Based Wireless Emergency Alert and Response System for Tribal and Rural Areas

K. Srilekha[1], Dr. P. Sreesudha[2], Dr. Rajkumar L. Biradar[3], Dr. T. Sunitha[4], Mrs. A. Rajitha[5]

M.Tech Student, Department of Electronics & Telematics Engineering,

G. Narayanamma Institute of Technology & Science (For Women), Shaikpet, Hyderabad, Telangana, India[1]

Assistant Professor, Department of Electronics & Telematics Engineering,

G. Narayanamma Institute of Technology & Science (For Women), Shaikpet, Hyderabad, Telangana, India[2]

Professor & Head of Department, Department of Electronics & Telematics Engineering,

G. Narayanamma Institute of Technology & Science (For Women), Shaikpet, Hyderabad, Telangana, India[3]

Assistant Professor, Department of Electronics & Telematics Engineering,

G. Narayanamma Institute of Technology & Science (For Women), Shaikpet, Hyderabad, Telangana, India[4]

Assistant Professor, Department of Electronics & Telematics Engineering,

G. Narayanamma Institute of Technology & Science (For Women), Shaikpet, Hyderabad, Telangana, India[5]

Abstract: Cellular coverage for wide areas within India's hilly and tribal interiors is sparse or non-existent, and even if there is a limited cellular network coverage, this too is the first thing to be affected by any natural calamity like flood, landslide, etc. Thus, the people living in such areas have no way of contacting their medical and police services during any emergency situation. This paper describes an economical and low power emergency alerting system based on LoRa (Long Range) Radio Communication which works completely independent of cellular network and Internet. In each village, the node consists of a microcontroller board (Arduino Uno) interfaced to Semtech SX1278 (Ra-02) LoRa module working at 433MHz frequency. There are dedicated push buttons available in each node through which any person can trigger medical or police emergency. Accordingly the node will send a small identifying packet containing the village ID and kind of assistance required. The Hospital and Police Station Nodes are in constant receiving mode and keep showing alerts on 16×2 LCD display while sounding a buzzer and activating LEDs. As soon as an alert gets acknowledged, a confirmatory packet will be sent back to originating village through a status LED. Moreover, each node also features a light circuit for a street light controlled by LDR, which works independent of the alerting system, thereby demonstrating another example of how the same powersaving platform could be used. A prototype, consisting of two village nodes, a hospital node, and a police station node, has been developed and tested in real-world conditions; reliable communication was achieved up to 1 km distance in the open field, with each node consuming around 0.6 W of energy.

Keywords: LoRa, SX1278, Arduino Uno, Emergency Communication, Rural Connectivity, Tribal Areas, Wireless Sensor Network, Disaster Management, LDR Sensor, Internet of Things.

I. INTRODUCTION

Cellular and broadband coverage in India still persists in urban and semi-urban areas, with tribal hill areas and far flung rural agricultural villages covered by fewer towers [7]. The significance of this "last mile" challenge becomes extremely pronounced during flooding, landslides and forest fires, which are exactly those circumstances where the existing infrastructure is most prone to failure. If an entire village's only cellular connection fails during a flood, there is no way for them to call for a rescue boat, and if a family in rural India experiences a medical emergency at night, their only choice may be to physically reach out to the nearest town for assistance.

LoRa radio technology fills the gap in an ideal way – this is a wireless communication system that works on unlicensed sub-GHz frequencies, requires negligible energy consumption when idle, and sends small-sized messages for a few kilometers without any need for mobile towers, optical fibres or internet connection. The low energy consumption enables solar/battery-powered operations where there is no reliable electricity supply and lowcost of LoRa devices allows for deployment in rural areas, which otherwise would have been impossible with traditional telecom networks. Other methods such as satellite phones or specific radio systems are much more expensive and not versatile for daily usage in the village, creating a real gap that is filled with a hardware system that can be assembled and managed by the villagers with just an Arduino board and LoRa device.

DOI: 10.17148/IJIREEICE.2026.14706

Based on these characteristics, a compact and decentralized LoRa network is designed and prototyped in this work to link village nodes to the hospital and the police station in order to provide villagers with a means of raising an alarm through simple button press without using cell network or internet.

The major contributions of this work are summarized as follows:

1. An economical and energy-efficient LoRa-based emergency notification system is created for implementation in indigenous communities and villages without reliance on any existing cellular or Internet connectivity.
2. Push button functionality is created to enable a resident to request either a medical or police assistance, after which respective village node will automatically encode and send the alert.
3. Confirmation of acknowledgement is shown to be possible, meaning that a village making an emergency call will receive feedback on notification of the authorities.
4. A secondary function of an LDR-based street lighting is integrated into the same node to show how an energy efficient design can fulfill several purposes at once.
5. The designed prototype is tested for its range of communication, effectiveness of message delivery, and energy consumption.

II. LITERATURE SURVEY

A number of earlier works have been considered while designing the project. In Yarali, Ahsant, and Rahman [1], wireless mesh networking was considered as an alternative to the cellular or wired networks which are down; however, the complexity in routing and interference increases with the growth in the size of the network. Lien, Jang, and Tsai [2] designed a MANET for post-disaster communications which formed fast yet suffered from decreasing stability in routing, higher battery usage, and higher latency in accordance with the increasing number of devices. Alvarez et al. [3] developed Bluemergency - a temporal network based on Bluetooth-mesh communication to relay the emergency information; it has a benefit of having widespread hardware components yet it has limitations in terms of Bluetooth short distance and its dependency on the density of the devices. Banerjee and DasBit [4] used ZigBee for short hops and GSM for long hops thus making the system more reliable than the use of both technologies separately yet the availability of the residual GSM coverage is required whereas many target villages did not have it to begin with.

A more directly comparable set of literature uses LoRa for disaster-related communication and monitoring. Paul et al. [6] detailed LoRa based emergency communication solution using the same idea of village to responder alert. Bagwari et al. [8] did a review of low-cost sensors and LoRaWAN based landslide monitoring for hilly regions. Vega-Rodriguez et al. [9] designed a low-cost LoRa network based forest-fire detection solution providing a coverage similar to what we aim to provide in our project. And Seal, Ghosh, and Das [10] suggested LoRaWANbased early-warning systems for flood and fire detection with centralized sensor logging. Taken together, all of this literature establishes LoRa as a proven and validated means of communication for rural areas and disaster-prone locations, and provided direct inspiration for the point-to-point architecture with fixed nodes chosen in our project rather than a more complex MANET, Bluetooth, or a hybrid ZigBee-GSM solution.

III. SYSTEM MODEL

The proposed alert system considers the deployment area as a cluster of a few fixed nodes that have geographically diverse placements compared to other mobility schemes. Three types of nodes are considered in this design: Village nodes $V_N=\{V_1, V_2,\dots\}$, which generate alerts; a Hospital node H; and a Police-station node P, which are all part of the responder nodes $\mathscr{R}=\{H, P\}$. Each of the village nodes V_N has an alert alphabet of size two, a = {medical, police}. Button press at V_N picks one $a \in N$ and sends a packet $m = (V_N, a)$, which specifies the source of alert along with the service type required.

The basic structure of the node, whether the village node, the hospital node, or the police station node, revolves around a common hardware base (Fig. 1) that ensures consistency and ease of replication of the design in further villages. On the transmitting side, the Arduino Uno detects the status of the button, forms the packet, and operates the SX1278 (Ra-02) transceiver in SPI mode. On the responder node, the receiver operates in continuous receive mode; after successful detection of $m = (V_N, a)$, the alert message for the corresponding node is displayed on the 16×2 LCD display and both the buzzer and LED are operated at the same time. After getting the acknowledgment from the on-duty staff member by pressing the acknowledge control, the acknowledgment packet $r = (V_N, ack)$ is sent back through the same channel, and the village node turns an acknowledgment LED on receiving the r. Fig. 2 shows how the two village nodes, along with their corresponding LDR and status LED nodes, are interfaced to the end points H (hospital) and P (police station).

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 14, Issue 7, July 2026
DOI: 10.17148/IJIREEICE.2026.14706

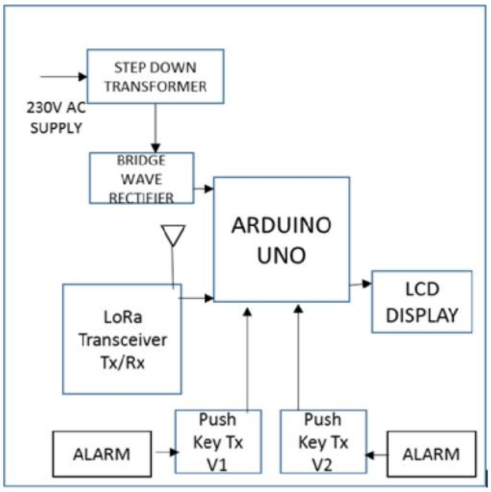

Fig. 1. Block diagram of a single node (identical circuit used at each village, the hospital, and the police station).

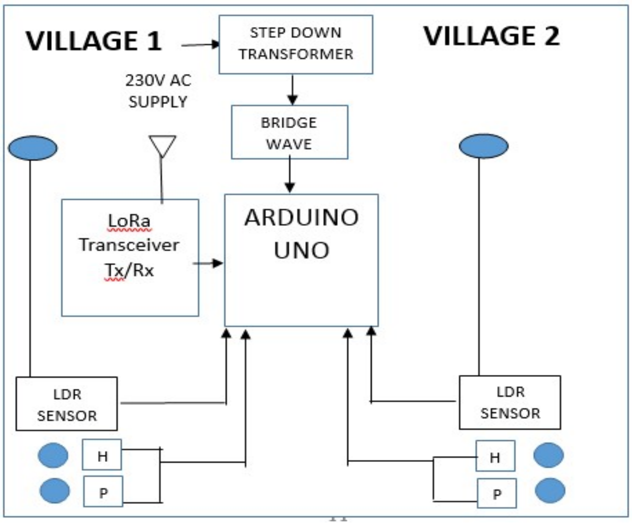

Fig. 2. Block diagram of the overall two-village network architecture, showing LDR sensors and the hospital (H) / police-station (P) links.

Apart from the alert path, each village node executes a separate low-cost day/night control routine based on the onboard LDR such that the LED street-light turns on whenever the ambient light level goes below a certain threshold and then turns off when the ambient light level is restored above that threshold. The secondary functionality requires no interaction with the alert logic but is carried out with the same microcontroller and same power supply, thus proving the ability to perform some additional task with negligible cost overhead.

The specification of the LoRa transceiver, forming the heart of the communication channel, is provided in Table 1.

Parameter	Specification
Transceiver chip	Semtech SX1278
Operating frequency	433 MHz
Operating voltage	3.3 V
Interface	SPI
Modulation	Chirp Spread Spectrum (CSS)
Rated range (open area)	Up to 15–20 km
Transmit power	Up to +20 dBm
Receiver sensitivity	Up to –148 dBm

Table 1. Specifications of the SX1278 (Ra-02) LoRa transceiver.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2026

DOI: 10.17148/IJIREEICE.2026.14706

The full node stack was coded using embedded C/C++ on the Arduino IDE: The LoRa communication library takes care of handling the packet sending and receiving on the shared medium; the SPI library deals with the fast connection between the master Arduino and the slave LoRa module; and the LiquidCrystal library controls the alert display. In order to enhance the chance of successful packet reception over the lossy channel, each packet m is sent several times over a short interval, as shown in Section IV with the reliability of messages.

IV. RESULTS

A working prototype made up of two village nodes, one hospital node, and one police station node, as seen in Fig. 3, was constructed and tested out under open-air environmental conditions. When pressing the button at the village node, the emergency message was activated successfully and correctly displayed at the appropriate receiving station along with the corresponding buzzer and LED lights. The acknowledgement messages that were transmitted back from the hospital and police stations were also successfully received and the right LED lit up in response to that reception. This is shown in Figs. 4 and 5 for the hospital and police station nodes, respectively, receiving an emergency message and displaying the message on their LCD displays. The light controlled by the LDR was also found to behave as expected when the ambient light level was low or high.

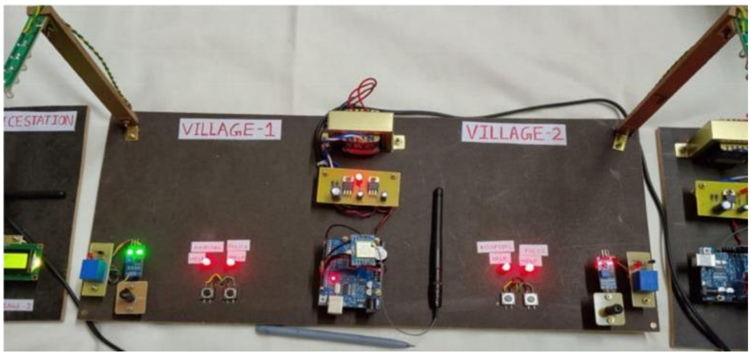

Fig. 3. Complete experimental setup showing the Village-1 and Village-2 nodes together with the hospital and policestation nodes used for prototype testing.

A. Communication Range

For range evaluation, the transmitter was held fixed at Village 1 location, but the receiver (hospital or police-station node) was placed increasingly far away from it. The emergency button was pressed and reception checked. Table 2 provides the findings that were obtained in an outdoor environment on open grounds, but indoor findings differed slightly due to obstacles, as LoRa signals usually do.

Distance	Communication Status
10 m	Successfully received
50 m	Successfully received
100 m	Successfully received
500 m	Successfully received
1 km	Successfully received

Table 2. Communication range test results (open area).

B. Hospital and Police-Station Node Behaviour

The Figure 4 above is the Hospital node after getting an alert from Village 1; the message shown in the LCD is “Village1 need Hospital” and the LED light is glowing with the buzzer alarm sounding. Figure 5 above is the police station node after getting a request for police help from Village 2; the message displayed in the LCD is “Village2 need Police Help.” In both cases the alert was still displayed until the staff on duty acknowledged it by pressing the acknowledge button.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 14, Issue 7, July 2026
DOI: 10.17148/IJIREEICE.2026.14706

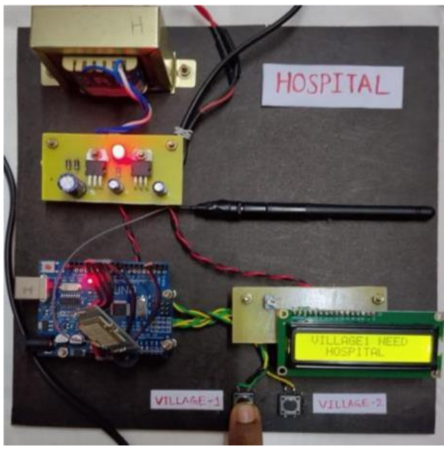

Fig. 4. Hospital node displaying a received alert ("Village 1 needs Hospital").

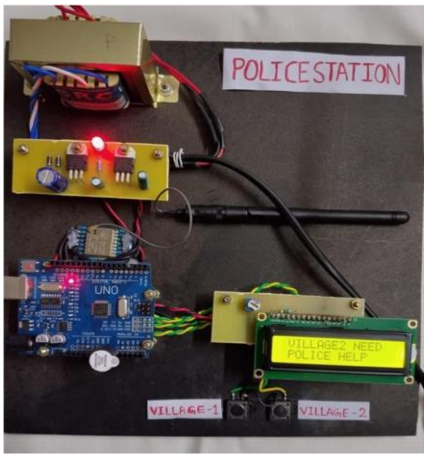

Fig. 5. Police-station node displaying a received alert ("Village 2 needs Police Help").

C. Power Consumption

Operating current was measured with a multimeter at the standard 5 V supply rail and found to be approximately 0.12 A. This corresponds to $P = V \times I = 5\ V \times 0.12\ A \approx 0.6\ W$ per node — low enough for the system to run comfortably from a small battery or a modest solar panel in locations without dependable grid power. ***D. Summary of Performance***

Performance Parameter	Measured Result	Remarks
Communication range	Up to 1 km (tested)	Long-range, low-infrastructure link
Power consumption	~0.6 W	Suitable for battery/solar supply
Message reliability	100% at tested distances	Repeated transmission improves robustness

Table 3. Summary of system performance.

E. Limitations and Summary of Results

The above findings clearly show that such a network using LoRa technology is capable of transmitting alert messages effectively and efficiently for distances covered between a village and the nearest hospital or police station, all this while still operating within the supply limit of the energy source used, which in this case was either a small battery or solar power. The tests done were restricted to open grounds with a range of up to 1 km; forests and hills with distances of more than 1 km would necessitate field testing to arrive at definite conclusions on the performance of such a network in harsh propagation environments.

V. CONCLUSION AND FUTURE SCOPE

In this work, the possibility of using a simple, inexpensive LoRa network in place of the cellular network in case of an emergency was explored for the tribal/rural communities. The prototype designed in this study proves that a simple LoRa

DOI: 10.17148/IJIREEICE.2026.14706

network can perform well to replace the existing cellular network at least at the studied level. The combination of an Arduino Uno board with the LoRa transceiver SX1278 at every node enables the villagers to send a message to the hospital/police station in case of any medical/any other kind of emergency just by pressing one button. The message is transferred to the receiver wirelessly from where it is displayed in the LCD, makes a buzzer sound, and finally sends back an acknowledgment to the village which originated the message. This was done within the 1-km radius with a power consumption of only 0.6 W.

Some possible ways to improve this research include using more villages in the testing by means of LoRa relay or gateway nodes, thereby extending the reach of the network beyond that seen here. Each node having its own GPS device would ensure that the alert itself contained an exact location and the responders would not have to guess where it came from. Using solar energy would make the nodes completely autonomous from any external power source, which is particularly useful when a disaster already knocked out the electrical power supply. As for drawing some ideas from landslide, forest fire and flood early warning systems (described in Section II [8], [9], [10]) for the push button alert, it can be also accompanied by sensors in order to make the network generate an alarm automatically once dangerous weather or other conditions were detected, instead of waiting for someone from the villagers to see them. In the longer run, linking the system to cloud based Internet of Things platform would enable logging and monitoring of alerts while a corresponding mobile or web application would provide a centralized real time access to information about the situation for hospitals, police stations and disaster management services.

REFERENCES

[1] Yarali, A., Ahsant, B., Rahman, S., "Wireless Mesh Networking: A Key Solution for Emergency & Rural Applications," 2009 IEEE, DOI 10.1109/MESH.2009.33.

[2] Lien, Y.-N., Jang, H.-C., Tsai, T.-C., "A MANET Based Emergency Communication and Information System for Catastrophic Natural Disasters," 29th IEEE International Conference on Distributed Computing Systems Workshops, 2009.

[3] Alvarez, F., Almon, L., Radtki, H., Hollick, M., "Bluemergency: Mediating Post-disaster Communication Systems using the Internet of Things and Bluetooth Mesh," IEEE Global Humanitarian Technology Conference (GHTC), 2019.

[4] Banerjee, D., DasBit, S., "Reviving Communication in Post Disaster Scenario Using ZIGBEE or GSM Heterogeneous Network," International Conference on Advances in Computing, Communications and Informatics (ICACCI), 2014.

[5] Shamsudheen, S., Karthik, G., Anoop, A., Gobinathan, P., "Internet-of-Things in Emergency Services: Architecture, Applications, and Research Challenges," 1st International Conference on Advanced Innovations in Smart Cities (ICAISC), 2023.

[6] Paul, B.S., Lalith, S., Pachamuthu, C., Siva, S., Sakthivel, P., "LoRa Based Emergency Communication System," International Scientific Journal of Engineering and Management, Vol. 03, Issue 05, May 2024, DOI: 10.55041/ISJEM01628.

[7] Augustin, A., Yi, J., Clausen, T., Townsley, W. M., "A Study of LoRa: Long Range & Low Power Networks for the Internet of Things," Sensors, vol. 16, no. 9, p. 1466, 2016.

[8] Bagwari, S., Gehlot, A., Singh, R., Priyadarshi, N., Khan, B., "Low-Cost Sensor Based and LoRaWAN Opportunities for Landslide Monitoring Systems on IoT Platform: A Review," IEEE Access, 2021.

[9] Vega-Rodriguez, R., Sendra, S., Lloret, J., Romero-Diaz, P., Garcia-Navas, J.L., "Low Cost LoRa Based Network for Forest Fire Detection," 6th International Conference on Internet of Things: Systems, Management and Security, IEEE, 2019, pp. 177-184.

[10] Seal, S., Ghosh, P., Das, A., "LoRaWAN-based early warning systems for flood and fire detection," Ad Hoc Networks, vol. 123, p. 102669, 2022, doi: 10.1016/j.adhoc.2021.102669.