CONESCAPANHONDURAS2025paper148.pdf

Institute of Electrical and Electronics Engineers (IEEE)

Document Details

Submission ID

trn:oid:::14348:477743609

Submission Date

Jul 31, 2025, 9:51 PM CST

Download Date

Aug 12, 2025, 6:34 PM CST

File Name

CONESCAPANHONDURAS2025paper148.pdf

File Size

699.3 KB

6 Pages

3,746 Words

21,193 Characters

11% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Match Groups

- **21** Not Cited or Quoted 10%
  Matches with neither in-text citation nor quotation marks
- **1** Missing Quotations 0%
  Matches that are still very similar to source material
- **3** Missing Citation 1%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

10% Internet sources
9% Publications
0% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **21** Not Cited or Quoted 10%
  Matches with neither in-text citation nor quotation marks
- **1** Missing Quotations 0%
  Matches that are still very similar to source material
- **3** Missing Citation 1%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

10% Internet sources
9% Publications
0% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Internet	arxiv.org	2%
2	Internet	api.crossref.org	1%
3	Internet	mdpi-res.com	<1%
4	Internet	scholar.dlu.edu.vn	<1%
5	Internet	www.mdpi.com	<1%
6	Internet	www.onlinescientificresearch.com	<1%
7	Internet	ojs.jurnaltechne.org	<1%
8	Publication	Nor Aida Abdul Rahman, Kamran Mahroof, Azizul Hassan. "Technologies and Tre...	<1%
9	Internet	publisher.uthm.edu.my	<1%
10	Internet	hamdarduniversity.edu.bd	<1%

11 Internet
www.coursehero.com <1%

12 Internet
dspace.cvut.cz <1%

13 Internet
dokumen.pub <1%

14 Publication
Ribeiro, Ricardo Ferreira. "Lifelog and Information Retrieval from Daily Digital Da... <1%

15 Internet
www.e3s-conferences.org <1%

16 Publication
Edwin Collado, Gokul Harish, Yessica Saez. "Design of a solar-powered air pollutio... <1%

17 Internet
www.florhamparknj.gov <1%

18 Internet
engrxiv.org <1%

19 Publication
Birudala Venkatesh Reddy, Y V Krishna Reddy, Md. Abdur Razzak, Surender Reddy... <1%

20 Internet
bigrep.com <1%

21 Internet
ebin.pub <1%

22 Internet
etheses.bham.ac.uk <1%

23 Publication
Hafedh Ben Hassen, Nadia Ayari, Belgacem Hamdi. "A home hospitalization syste... <1%

Geo Monitor: IoT environmental monitoring system with LoRa communication in tropical conservation areas

1st Given Name Surname
dept. name of organization (of Aff.)
name of organization (of Aff.)
City, Country
email address or ORCID

2nd Given Name Surname
dept. name of organization (of Aff.)
name of organization (of Aff.)
City, Country
email address or ORCID

3rd Given Name Surname
dept. name of organization (of Aff.)
name of organization (of Aff.)
City, Country
email address or ORCID

4th Given Name Surname
dept. name of organization (of Aff.)
name of organization (of Aff.)
City, Country
email address or ORCID

***Abstract*— This paper presents the design, implementation, and evaluation of *Geo Monitor*, an Internet of Things (IoT)-based environmental monitoring system intended for real-time observation of key ecological variables. The system combines ESP32 microcontrollers, LoRa communication, and a cloud-connected web platform to measure and transmit temperature, relative humidity, and rainfall data in natural conservation areas. The prototype was deployed and tested at "Jardín Botánico La Laguna" in El Salvador, where three emitter nodes collected data over a one-week field validation period. Results demonstrated consistent data transmission, reliable sensor accuracy, and effective web-based data visualization through interactive dashboards and CSV export. The system's low-power consumption, long-range communication, and modular hardware design make it suitable for remote or rural installations. Geo Monitor aims to support biodiversity conservation efforts and data-driven decision-making by ecological institutions. Future developments include integrating artificial intelligence for predictive analysis and expanding the monitored variables.**

Keywords— Biodiversity Conservation, Environmental Monitoring, ESP32, IoT, LoRa Communication, Real-Time Data, Web Platform, Wireless Sensor Networks

I. Introduction.

The accelerated impact of climate change and uncontrolled urban expansion have increased the vulnerability of tropical ecosystems, especially in countries like El Salvador. Protected natural areas and areas of high biodiversity usually face constant threats due to abrupt environmental changes, while the lack of real-time data limits response and conservation capacity.

In this context, environmental monitoring systems based on the Internet of Things (IoT) have emerged as accessible, scalable, and efficient solutions compared to traditional data collection methods. This paper presents Geo Monitor, a real-time environmental monitoring system that uses ESP32 microcontrollers, LoRa communication, and a web platform for measuring and visualizing critical variables such as temperature, relative humidity, and precipitation.

The system was implemented and validated in the field at the La Laguna Botanical Garden, a conservation area with a high diversity of tropical flora and fauna. Three transmitter nodes were deployed to evaluate the system's accuracy, robustness, and stability under natural conditions.

Unlike conventional solutions that require expensive infrastructure or constant connectivity, Geo Monitor offers long-range wireless transmission, low power consumption, and an accessible interface for visualizing historical and real-time data. This proposal aims to serve as a replicable model for ecological conservation and scientific research in vulnerable environments in the region.

The structure of this article is as follows: Section II presents project related work; Section III describes the system design; Section IV presents the results obtained; Section V discusses the findings and limitations; and Section VI presents conclusions and future work.

II. Project Related Work.

In recent years, several investigations have demonstrated the potential of the Internet of Things (IoT) and LoRa technology as key tools for real-time environmental monitoring, especially in rural or hard-to-reach areas. These systems have been proposed as alternatives to traditional methods, which often present high costs, limited scalability, and difficulties in remote environmental data collection [1], [2].

[1] explores IoT applications in agricultural greenhouses and smart homes, highlighting the ease of integrating sensors and GSM communication modules. On [6], they demonstrate the use of a Raspberry Pi with DHT11 sensors and the ThingSpeak platform in computer labs for thermal and humidity monitoring, while [7] uses a network of MQ2 and DHT11 sensors in critical industrial facilities to detect hazardous gases and adverse environmental conditions.

Regarding the use of LoRa, [2], [3], and [5] describe its implementation in air quality monitoring in rural and urban environments, as well as in bodies of water, using microcontrollers such as ESP32, DHT22 and MQ-X sensors, and platforms such as Ubidots or ThingSpeak. These studies highlight LoRa's reliability and low power consumption, although they also highlight limitations related to the lack of testing in densely vegetated environments, energy management, and resilience to failures [3]– [5].

In the context of natural disaster prevention, [6] and [7] propose systems that employ soil moisture sensors, inclinometers, and pedological analysis to anticipate landslides, while [8] uses ESP32-CAM and ultrasonic sensors for flood detection. However, these proposals have weaknesses in community integration, maintenance plans, and sensor accuracy assessment.

Finally, [9] introduces an IoT architecture based on ESP32 and the Blynk platform, projecting system scalability through star topologies. The future incorporation of techniques such as machine learning or blockchain is suggested to improve prediction and data security, although challenges such as calibration, data protection, and cost analysis remain.

This background demonstrates the technical feasibility of IoT and LoRa-based environmental monitoring systems, but also the need for more robust solutions, adapted to the local context, with low cost and the ability to operate in real-world field conditions.

III. SYSTEM DESIGN

The Geo Monitor system integrates hardware and software components, a robust mechanical design, and an efficient communications architecture for real-time environmental monitoring.

A. General system architecture:

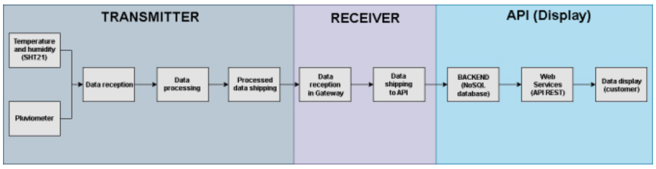

Figure 1. Project architecture.

The system is structured in three main stages: transmitter module, receiver module, and visualization API.

- **Transmitter Module:** Collects key environmental variables using sensors. This data is captured by a microcontroller and sent wirelessly using LoRa technology.
- **Receiver Module (Gateway):** Responsible for receiving the data sent by the transmitter module via LoRa, channeling it to an API.
- **API and Web Platform:** The data received through the API is stored in a NoSQL database and exposed through web services (REST API). This allows for real-time query and visualization from an accessible and easy-to-use web platform. The platform allows users to visualize the information and generate a historical record of results.

Communication is established wirelessly between the microcontrollers (transmitters and receivers) at approximately two hundred meters.

B. Hardware development:

1) Electronic Components.

Appropriate sensors were selected to measure critical environmental variables: an SHT21 sensor for temperature and relative humidity, and a MISO 1 sensor for precipitation quantification. These sensors were integrated with an ESP32 Devkit V1 microcontroller for data collection and processing. LoRa (Long Range) technology was implemented using the RYLR998 module for long-range data transmission, enabling communication in remote areas. A DS1302 RTC module was integrated for time management.

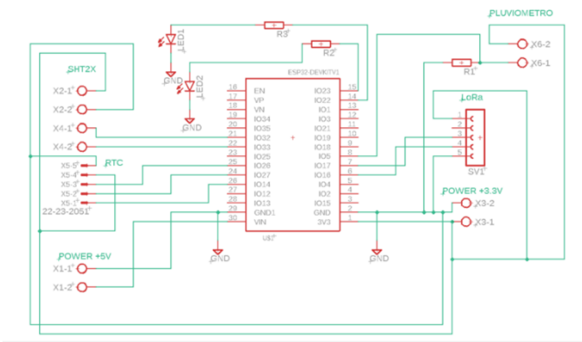

Figure 2. Electronic schematic of the system.

a) SHT21: This sensor offers a precise temperature and humidity measurement range of -40°C to 125°C with an accuracy of ±2% for humidity. It is suitable for Internet of Things applications due to its I2C connectivity, which ensures reliable data flow.

b) MISO 1: It uses a tipping bucket mechanism that records pulses per 0.27 mm³ increment, providing reliable, weather-resistant performance for extended use.

c) LoRa RYLR998: The RYLR998 LoRa module facilitates communication at distances of 2 to 15 km (depending on interference from the area's architecture). Its high compatibility and low power consumption make it particularly suitable for remote locations with limited Wi-Fi. This configuration allows the system to reliably collect and transmit environmental data from hard-to-reach regions; the frequency used for El Salvador is 915 MHz.

2) Mechanical Components.

During the conceptual phase, multiple designs were evaluated based on criteria of functionality, protection from environmental conditions, and ease of sensor integration. The first design, a box with ventilation slots, was discarded due to the risk of leaks. The second, with a conical shape, limits the usable internal space. The third, inspired by electrical insulators, combined ventilation with waterproofing, serving as the basis for the final design. In the final version, a square geometry was adopted, optimizing the internal space and allowing for the integration of the rain gauge, thus achieving a more compact and efficient solution.

During the detailed design phase, the initial CAD model, measuring 18 x 24 x 18 cm, evolved to a final 15 x 19 x 12 cm, reducing volume without compromising functionality. Sloping walls at 60° were incorporated to facilitate water drainage and allow passive ventilation without moisture ingress.

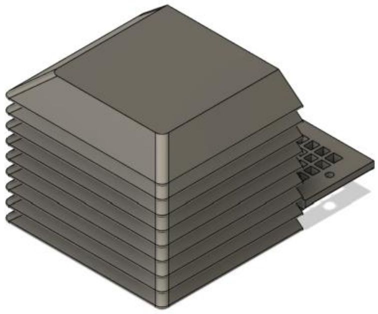

Figure 3: Emitting device case.

The receiving device, for its part, was designed in a simple and compact way (18×12×7cm), as it is intended to operate indoors.

Figure 4: Receiver device case.

Regarding the materials, PETG was chosen for the transmitter housing, given its good thermal performance and moisture resistance, making it suitable for warm climates and prolonged sun exposure. Its low water absorption, high dimensional stability, and thermal tolerance (up to 80°C) ensure reliable outdoor operation of the system.

C. Software development:

The ESP32 microcontroller was programmed using C++ to manage the collection and transmission of sensor data. A Node.js backend was developed with Express.js for API routing and MongoDB for data storage. A web-based visualization platform was developed using JavaScript for real-time data visualization and alert generation.

D. IoT development:

The LoRa communication protocol was implemented for efficient, long-range data transmission between the transmitter and receiver modules. Wi-Fi connectivity was used on the receiver module to upload data to the cloud-based backend.

E. Data management and visualization:

A NoSQL database schema was designed to efficiently store and manage environmental data, and a user-friendly web interface was developed for data visualization and real-time monitoring. An alert system using Telegram was also implemented to notify users of critical environmental conditions.

F. Testin and validation:

1) Remote testing of LoRa RYLR998 module.

The first step was to evaluate the range of the LoRa module, which is essential for data transmission and reception. This test was conducted at the Soyapango campus of Don Bosco University, reaching 250 meters, validating the technology's ability to send and receive data within a range appropriate for our project. However, it's worth mentioning that the tests were conducted in an environment with moderate vegetation and obstacles.

2) Test with sensors under different environmental conditions

Regarding the second test, the various environmental sensors were deployed to validate their calibration by performing various tests to ensure accurate measurements. Data was also transmitted continuously over the same distance of 250 meters. The sensors were exposed to various conditions. The objective of this test is to ensure that the system maintains stable performance in adverse situations and to validate the accuracy of the measurements in different scenarios. The results were satisfactory, demonstrating that the sensors were able to operate correctly.

3) Data transmission test LoRa + WiFi.

At this stage, the connectivity capabilities of one system to another were evaluated. The transmitting device collected data from the sensors and sent it via LoRa. The receiving device captured the data and sent it to the API via Wi-Fi. This test allowed us to validate the integration between the transmitting devices, ensuring that the cloud platform could receive the data in real time. Data upload to the API was successful.

4) Waterproofing test.

Finally, a protective case was designed and prototyped to house the transmitter's electronic components. It was subjected to a waterproofing test, with water jets applied to verify its ability to prevent the ingress of the selected materials and effectively protect the internal components from water or other liquids. This test was crucial since this prototype must be able to prevent liquids, withstand exposure to the elements, and look good. The prototype passed the test satisfactorily, demonstrating that the design and materials protect the internal components.

5) Thermal simulations.

To validate the suitability of PETG as a structural material for the emitter device, a thermal simulation was performed in Autodesk Fusion 360, applying material properties extracted from its technical data sheet. Environmental conditions simulating a sunny day in El Salvador were established: natural convection with a heat transfer coefficient of 10 W/(m^2 K) at an air temperature of 32°C, a radiation temperature of 25°C, and a surface emissivity of 0.9 for PETG [10].

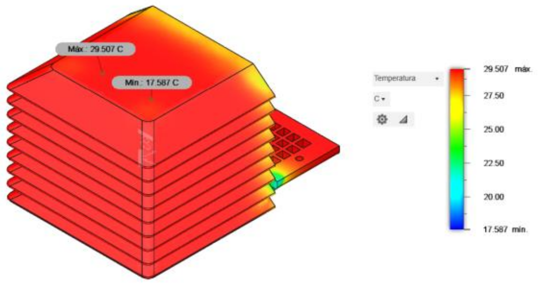

Figure 5: Thermal radiation analysis of the environment, emitting device.

The results obtained (Fig.5) show a surface temperature distribution between 17.6°C and 29.5°C. The maximum temperature remains below both the ambient air and the thermal limit of PETG (80°C) [11], [12], confirming its thermal viability outdoors.

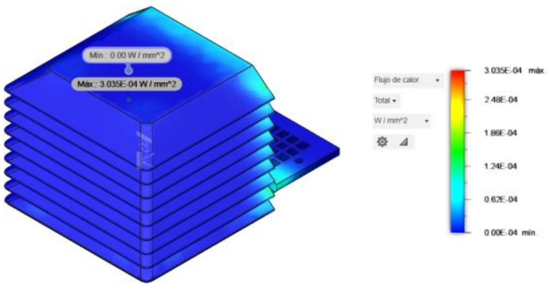

Figure 6: Heat flow analysis, emitter device.

Surface heat flow analysis (Fig. 6) reveals uneven heat transfer, with areas reaching up to 3,035e-04W/mm². These differences are due to variations in solar exposure and the efficiency of convective heat exchange.

PETG's white color contributes to improved thermal performance by reflecting a large portion of incident solar radiation. This optical property translates into lower heat absorption and slower heating than dark materials, in line with principles of radiative heat transfer.

Since the receiving device operates indoors and is not exposed to harsh environmental conditions, a detailed thermal analysis for this component was not considered necessary.

G. *User manual and documentation:*

A comprehensive user manual was developed for proper installation and operation of the Geo Monitor system, as well as how to interpret the data and a troubleshooting section.

H. *Iterative improvement:*

Design Thinking techniques were used throughout the development process, focusing on user needs and experiences. The system was continuously refined based on test results and feedback from testers.

This methodology ensured the development of a robust, user-centric environmental monitoring system capable of providing real-time data and alerts to communities at risk of landslides. The approach combined technical expertise with a strong focus on practical application and user accessibility.

IV. PROTOTYPING.

The three prototypes were installed at strategic points within the garden, with the goal of obtaining a representative average of the environmental variables across the entire site. Each device will be mounted on a fixed structure and equipped with a 9V, 460mA solar panel, responsible for keeping the batteries charged. This renewable energy source will allow for continuous, autonomous operation.

Figure 7. Completed prototype, transmitter module.

Figure 8. Completed prototype, receiver module.

Regarding the prototype's physical circuit, it met the original design. Throughout the document, the various integrated components are detailed, connected according to the planned electronic diagrams. The LoRa transmission system and the receiver module configuration were correctly adjusted to ensure reliable real-time data transmission, as planned in the initial design.

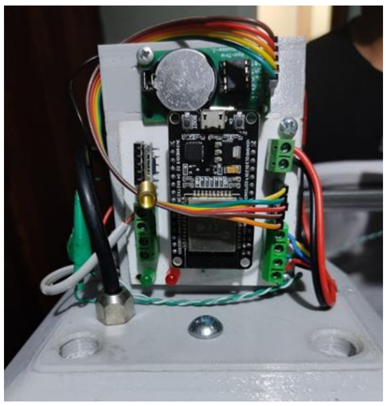

Figure 9. PCB board, transmitter module.

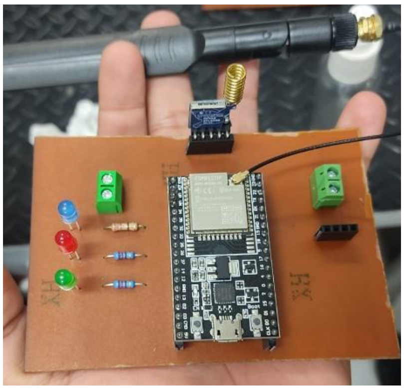

Figure 10. PCB board, receiver module.

V. RESULTS.

For the testing phase, the three devices were left operating at the La Laguna Botanical Garden Park, and data was collected from Tuesday, June 3, 2025, to Sunday, June 8, 2025.

To check the accuracy of the results, we compared the results obtained with the data generated by the Timeanddate.com page in Figures 11 and 12. To do this, we first had to request the corresponding meteorological data for the area to which the La Laguna Botanical Garden Park belongs, such as Antiguo Cuscatlán.

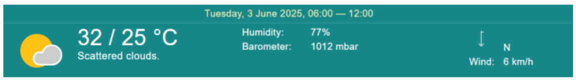

Figure 11. Historical record obtained from timeanddate.com, 6 AM – 12 PM, Tuesday, June 3.

Figure 12. Historical record obtained from timeanddate.com, 12 PM – 6 PM, Tuesday, June 3.

These data were compared with the data obtained by the three devices, as shown in Figure 13. For the purposes of this test, we analyzed data from Tuesday, June 3, and Thursday, June 5, between the hours of 6 AM and 12 PM, and from 12 PM to 6 PM.

	Temperature (°C)	Relative humidity (%)	Pluviometer (mm3)	Date and hour
Dev. 1	24.1	79.8	6.8	2025-06-03T08:19:45-06:00
	26.8	74.5	0	2025-06-03T12:00:56-06:00
	27.2	80.4	0	2025-06-03T15:59:34-06:00
Dev. 2	23.8	89.5	7.1	2025-06-03T08:20:33-06:00
	27.4	73.5	0	2025-06-03T12:01:20-06:00
	28.6	81.5	0	2025-06-03T16:00:08-06:00
Dev. 3	23.3	90.1	0	2025-06-03T08:20:56-06:00
	28.4	77.5	0	2025-06-03T12:01:39-06:00
	29.1	82.5	0	2025-06-03T16:00:29-06:00

Figure 13. Historical record obtained by the 3 devices at the required times: 8 AM, 12 PM and 4 PM, Tuesday, June 3.

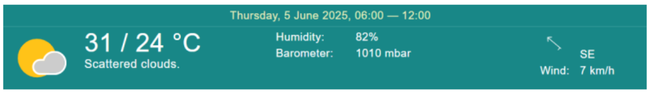

Figure 14. Historical record obtained from timeanddate.com, 6 AM-12 PM, Thursday, June 5.

Figure 15. Historical record obtained from timeanddate.com, 12-6 PM, Thursday, June 5

	Temperature (°C)	Relative humidity (%)	Pluviometer (mm3)	Date and hour
Dev. 1	23.2	90.4	5.1	2025-06-05T08:00:58-06:00
	27.4	75	2	2025-06-05T12:01:44-06:00
	27	78	6.2	2025-06-05T16:01:05-06:00
Dev. 2	23.8	91	4.8	2025-06-05T08:01:46-06:00
	28	76	3	2025-06-05T12:02:19-06:00
	27.1	78.4	6.6	2025-06-05T16:01:30-06:00
Dev. 3	23.1	90	0	2025-06-05T08:02:42-06:00
	27.5	75	0	2025-06-05T12:02:52-06:00
	26.9	78.2	0	2025-06-05T16:02:04-06:00

Figure 16. Historical record obtained by the 3 devices at the required times: 8 AM, 12 PM and 4 PM, Thursday, June 5.

Data from devices distributed across the three biomes of the Botanical Garden were compared with historical weather records from timeanddate.com for June 3 and 5, 2025. It was observed that the temperatures measured by the devices were slightly lower than those reported online, which could be attributed to differences in location, vegetation cover, and sun exposure. First, relative humidity showed good agreement between both sources. Second, precipitation had slight variations between the measurements and the website. The devices recorded light rain (up to 7.1 mm^3 on June 3 and 6.6 mm^3 on June 5) that were not reported by the web source, likely due to local events or the influence of vegetation. Device 3 did not record precipitation because it was indoors. Overall, the results highlight the importance of having local measurements to detect microclimates and small-scale weather events that do not appear in general sources.

VI. CONCLUSION.

Based on the results obtained during the implementation of Geo Monitor, it is concluded that both the general hypothesis and the specific hypotheses proposed in the design phase were met.

The system was able to collect reliable temperature, relative humidity, and precipitation data at established critical times, recording representative variations within the different sampling points of the La Laguna Botanical Garden. These data were consistent with the official meteorological sources consulted (timeanddate.com), which validates the accuracy of the emitting devices and presents a fundamental advantage over web-based meteorological sources. While sites such as timeanddate.com offer global or regional data, these macroclimatic averages lack the spatial resolution necessary for accurate monitoring of local conditions. Geo Monitor, in contrast, allows for the collection of precise and timely microclimatic information. This is crucial, given that conditions within a specific environment such as the La Laguna Botanical Garden can vary significantly from macroclimatic averages, directly affecting local ecosystems. In addition to providing this localized accuracy, Geo Monitor optimizes operations by automatically generating historical records, eliminating the need for manual daily data entry and the human effort required by park staff for data collection and recording.

The web platform proved to be functional, accessible, and intuitive, allowing for efficient querying of collected data in real time, as well as historical data, and downloading it in CSV format.

Finally, the device's physical design was verified to be compact, weather-resistant, and autonomous, as it was subjected to rain, strong winds, and extended exposure to sunlight during the week of testing, without compromising system performance. Therefore, the developed prototype meets the initial objectives and represents a valid solution for remote environmental surveillance and monitoring in protected natural environments.

REFERENCES.

[1] N. F. Voudoukis, "Design and Analysis Performance of IoT-Based Technologies of Environmental Variables Monitoring," European Journal of Electrical and Computer Engineering (EJECE), vol. 3, no. 4, pp. 1–6, July 2019. doi: 10.24018/ejece.2019.3.4.101

[2] J. Park, Y. Oh, H.-h. Byun, and C.-k. Kim, "Low-Cost Fine-grained Air Quality Monitoring System Using LoRaWAN," 2019 International Conference on Information Networking (ICOIN), Kuala Lumpur, Malaysia, 2019, pp. 439–441. doi: 10.1109/ICOIN.2019.8718193.

[3] N. A. A. Ali and N. A. A. Latiff, "Environmental Monitoring System Based on LoRa Technology in Island," in Proceedings of the 2019 IEEE International Conference on Signals and Systems (ICSigSys), Bangi, Malaysia, 2019, pp. 160–166. doi: 10.1109/ICSIGSYS.2019.8811066.

[4] E. Raghuveera, K. H. Kishore, D. P. B, P. Kanakaraja, C. T. Sriya, and B. S. K. T. Lalith, "An IoT Enabled Air Quality Monitoring System Using LoRa and LPWAN," in Proceedings of the 5th International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2021, pp. 453–459. doi: 10.1109/ICCMC51019.2021.9418440.

[5] M. Fadhli, A. Asriyadi, L. Lindawati, I. Salamah, G. Affrylia, M. Valerie, and A. Ramadhan, "Low-Cost Air Quality Monitoring System Using LoRa Communication Technology," 2021 9th International Conference on Information and Communication Technology (ICoICT), Purwokerto, Indonesia, 2021, pp. 427-431. doi: 10.1109/ICoICT52620.2021.9564032.

[6] C. A. Ezeh, F. E. Eke, and A. C. Okoro, "Analysis and Simulation of Landslide Processes and methods of prevention," 2022 International Conference on Science in Engineering and Technology (ICoSIET), Enugu, Nigeria, 2022, pp. 1-5. doi: 10.1109/ICoSIET56360.2022.9922986.

[7] L. C. Calegari and L. C. Ghizzoni, "The Role of Soil Type in Triggering Shallow Landslides in the Alps (Lombardy, Northern Italy)," Landslides, vol. 19, no. 12, pp. 2901-2917, Dec. 2022. doi: 10.1007/s10346-022-01999-5.

[8] N. M. Noor and N. F. Abdul Wahab, "Development of a Wireless Monitoring System to Monitor River Water Levels in real time," 2023 1st International Conference on Electrical Engineering and Intelligent Systems (ICEIS), Kuala Lumpur, Malaysia, 2023, pp. 1-5. doi: 10.1109/ICEIS58656.2023.10207860.

[9] S. A. G. S. Bandara and M. N. A. M. Hettiarachchi, "An IoT based Environment Monitoring System," in Proceedings of the 2024 International Conference on Innovations in Science, Engineering and Technology (ICISET), Malabe, Sri Lanka, 2024, pp. 1-6.

[10] BigRep, "PETG 3D Printing Filament - High Resistance Material," BigRep, 2025. [En línea]. Disponible: https://bigrep.com/filaments/petg/

[11] Ultimaker, "PETG vs. ABS: The Ultimate Comparison," Ultimaker, 2025. [En línea]. Disponible: https://ultimaker.com/learn/petg-vs-pla-vs-abs-3d-printing-strength-comparison/

[12] ThermoWorks, "Infrared Emissivity Table," ThermoWorks, 2021. [En línea]. Disponible: https://www.thermoworks.com/emissivity-table/