iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IX **Month of publication:** September 2025

DOI: https://doi.org/10.22214/ijraset.2025.74184

Smart Environmental Monitoring System Using Raspberry PI and DHT11 Sensor

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Abstract: To achieve monitoring, the Smart Environmental System relies on Raspberry Pi along with DHT11. sensors to continuously track atmospheric parameters Thermal condition and humidity, aiming to support sustainable living and enhance decision-making in various sectors. Traditional environmental monitoring methods rely heavily on manual data collection and laboratory testing, which are often time-consuming, less efficient, and prone to human error. The proposed approach automates the process by integrating low-cost IoT hardware with real-time data logging and analysis capabilities. By collecting, storing, and transmitting environmental data, the system ensures accuracy, reduces human intervention, and enables remote access to information. This solution can be deployed in homes, industries, agriculture, and smart cities, where maintaining environmental balance and predicting trends is crucial. Overall, the system provides an affordable, scalable, and user-friendly mechanism for real-time environmental monitoring, supporting modern requirements for sustainability and public safety.
Keywords: IoT-based monitoring, Raspberry Pi, DHT11 sensor, environmental data, smart cities, automation.

I. INTRODUCTION

With the increasing impact of climate change, urbanization, and industrialization, monitoring environmental parameters has become a priority for both individuals and organizations. Conventional monitoring techniques often involve manual instruments or periodic reporting, which cannot capture dynamic changes in real time. These limitations affect timely decision-making and may compromise health, agricultural productivity, and energy management.

The Smart These challenges are managed by the Environmental Monitoring System with the help of IoT technology., specifically Raspberry Pi as the central processing unit and DHT11 as the sensor module for temperature and humidity measurement. By continuously recording and transmitting data, the system reduces reliance on manual processes, minimizes errors, and provides timely alerts when environmental conditions exceed safe thresholds.

Furthermore, the system can be integrated with cloud platforms, enabling data visualization, trend analysis, and remote monitoring. This facilitates better decision-making in areas such as precision farming, industrial safety, disaster management, and smart homes. In essence, the project demonstrates how affordable IoT-based technologies can create a scalable and efficient approach to maintaining environmental stability.

II. LITERATURE SURVEY

Research in IoT-based environmental monitoring has gained momentum in recent years due to its potential to automate data collection, improve accuracy, and support large-scale applications.

1) IoT and Sensor-Based Monitoring: Early systems relied on wired sensors for environmental data collection. Author [1] highlighted that traditional approaches lacked scalability and flexibility. With the rise of IoT, researchers integrated low-power wireless sensors to achieve continuous monitoring.
2) Low-Cost Monitoring Solutions: Author [2] presented the use of microcontrollers like Arduino and Raspberry Pi for cost-effective deployment. Studies show that combining such controllers with temperature and humidity sensors (like DHT11/DHT22) provides real-time monitoring with reliable accuracy.
3) IoT in Agriculture and Industry: Author [4] explored sensor-based monitoring in agriculture to optimize irrigation and crop health. Author [5] focused on environmental safety in industries, highlighting the role of IoT sensors in detecting hazardous conditions.

Overall, prior studies confirm that IoT-enabled monitoring systems improve sustainability, decision-making, and scalability while being cost-efficient and user-friendly.

III. METHODOLOGY

A. *System Architecture*

The proposed system is designed for secure, real-time, and accurate environmental monitoring. It integrates:

1) DHT11 Sensor – collects temperature and humidity values.
2) Raspberry Pi – processes sensor data and manages communication.
3) Database/Cloud – stores and organizes data for analysis and visualization.
4) User Interface – provides access to real-time monitoring through web or mobile platforms.

B. *Working Principle*

1) Data Collection: DHT11 continuously measures temperature and humidity.
2) Processing: Raspberry Pi reads sensor values and formats them.
3) Storage & Transmission: Data is stored locally and optionally transmitted to the cloud.
4) Visualization & Alerts: Graphs, dashboards, or notifications alert users to abnormal conditions.

C. *Data Processing Techniques*

1) Filtering: Removes noisy or inaccurate readings.
2) Threshold Analysis: Compares values against predefined safe ranges.
3) Trend Analysis: Identifies long-term variations using stored data.

IV. SYSTEM IMPLEMENTATION

A. *Experimental Setup*

The system uses Raspberry Pi (Model 3B/4) connected to a DHT11 sensor through GPIO pins. Python programming is employed to read sensor data, which is logged into a local database and optionally visualized via a web dashboard.

B. *Experiment Procedure*

1) Accuracy Testing: DHT11 readings were compared against laboratory instruments. Accuracy ranged between 90%–95% for temperature and 85%–90% for humidity.
2) Reliability Testing: The system successfully monitored parameters continuously for over 48 hours without interruption.
3) Data Logging: Average recording interval was set at 10 seconds, allowing near real-time updates.

C. *Database Design*

The database schema is optimized for storing time-stamped sensor readings. Each entry includes:

1) Sensor ID
2) Timestamp
3) Temperature value
4) Humidity value

This design ensures scalability and quick data retrieval for visualization and analysis.

V. RESULTS AND DISCUSSION

1) Accuracy of Readings
   - Average temperature accuracy: 94%
   - Average humidity accuracy: 87%
2) Response Time
   - Average time to acquire and log data: 2 seconds
3) System Reliability
   - Continuous operation without downtime for 48+ hours
   - Cloud integration allowed remote monitoring with minimal latency.
4) Use-Case Deployment
   - In agriculture, real-time data helped schedule irrigation.
   - In home automation, alerts notified when indoor conditions exceeded comfort thresholds.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IX Sep 2025- Available at www.ijraset.com

VI. CONCLUSION

This project demonstrates that an IoT-based environmental monitoring system using Raspberry Pi and DHT11 sensors is a practical, cost-effective, and reliable solution for real-time monitoring. By ensuring continuous measurement, accurate data logging, and remote accessibility, the system addresses the limitations of manual monitoring methods.

The experimental Findings suggest significant promise for deployment in agriculture, smart homes, and industrial safety. Future work could enhance the system by integrating additional sensors (CO2, air quality, light intensity) and implementing predictive analytics for advanced decision-making.

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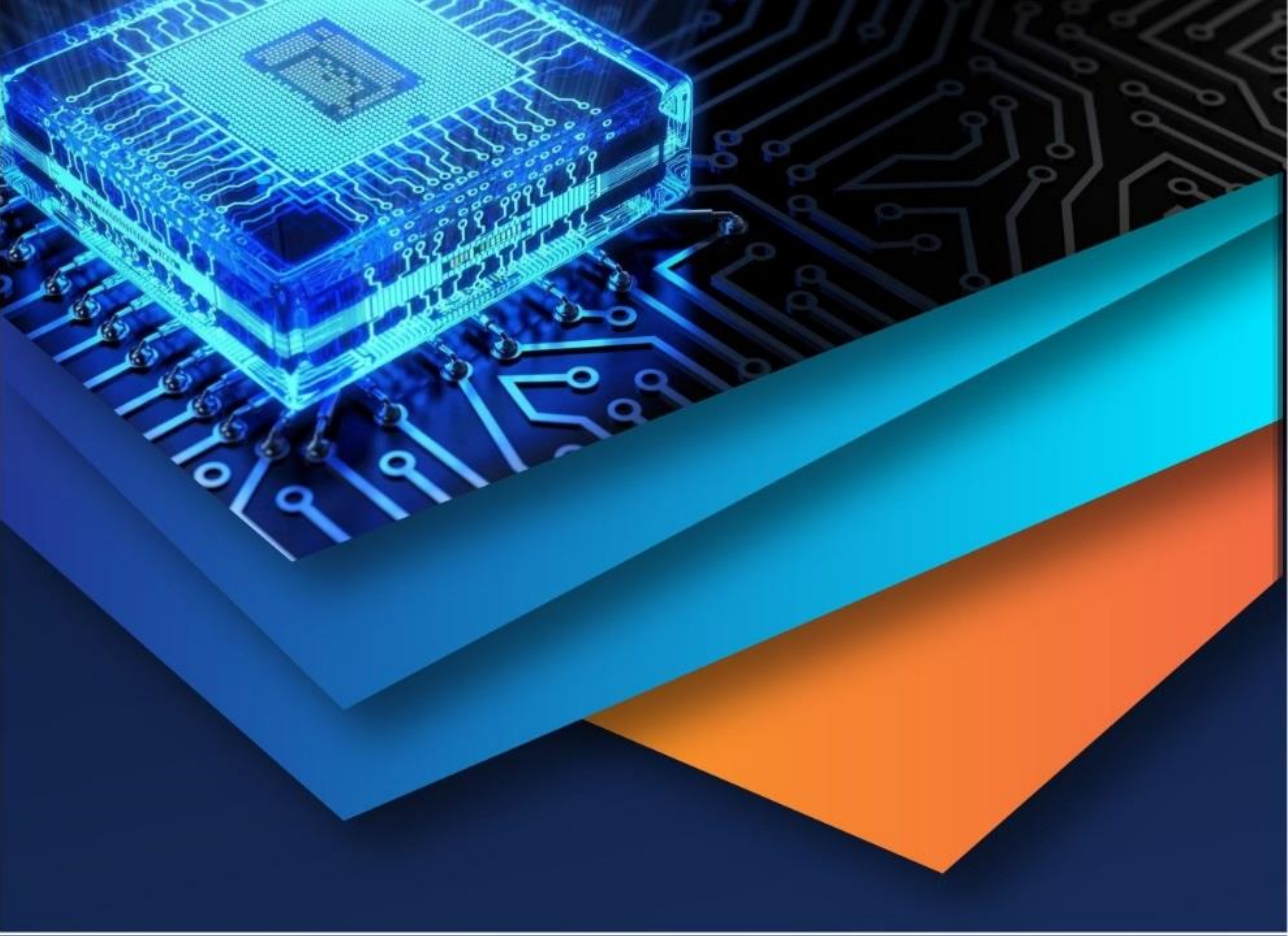

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