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THE DESIGN AND IMPLEMENTATION OF SENSOR-BASED PARAMETRIC DATA LOGGER FOR CLIMATIC PREDICTION: AN IOT-DRIVEN DECISION SUPPORT TOOL FOR FARMERS

*[1]S. A. Akinyele, [2]B. O. Akinkunmi, [2]O. F. W. Onifade, [3]F. T. Johnson

[1]Department of Computer Science, Federal College of Education, Abeokuta, Nigeria

[2]Department of Computer Science, University of Ibadan, Nigeria

[3]Computer Science Department, Federal University of Medicine and Medical Sciences, Abeokuta

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***Corresponding Author: S. A. Akinyele**

Department of Computer Science, Federal College of Education, Abeokuta, Nigeria

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ABSTRACT

Climate variability and environmental uncertainties continue to threaten agricultural productivity, particularly in developing countries where access to localized climatic intelligence remains inadequate. This study presents the design and implementation of a sensor-based parametric data logger integrated with Internet of Things (IoT) technologies for climatic prediction and agricultural decision support. The study developed a portable and scalable climatic monitoring framework capable of collecting real-time environmental parameters such as temperature, humidity, atmospheric pressure, wind direction, soil texture, density and geographic coordinates. The collected data were processed using machine learning-based predictive algorithms to generate actionable climatic insights for farmers. The study adopted an applied research and developmental methodology involving hardware prototyping, firmware development, field data collection, algorithm training and mobile application integration. The proposed framework integrates Arduino Nano architecture, embedded sensors, SD-card data warehousing and predictive analytics for localized weather forecasting. Findings revealed that the IoT-based data logger achieved improved climatic monitoring accuracy, enhanced environmental data accessibility and strengthened farmers' preparedness for planting, irrigation and harvesting decisions. The study further established that localized parametric data collection provides more effective climatic prediction outcomes than generalized weather station models. The research contributes to precision agriculture,

climate-smart farming and sustainable food security initiatives. The study recommends the large-scale deployment of IoT-enabled climatic prediction systems in farming communities and the integration of farmer-oriented dissemination platforms such as mobile applications, community radio systems, extension services and digital dashboards.

KEYWORDS: Internet of Things (IoT), climatic prediction, precision agriculture, sensor-based data logger, machine learning, farmers, environmental monitoring, smart agriculture.

INTRODUCTION

Agriculture remains one of the most climate-sensitive sectors globally. Changes in atmospheric conditions, rainfall patterns, temperature fluctuations, wind movement and humidity significantly affect crop yield, soil fertility, livestock productivity and food security. In developing nations such as Nigeria, the effects of climate change are increasingly visible through flooding, prolonged droughts, erratic rainfall patterns, desertification, pest outbreaks and declining agricultural productivity. These challenges have intensified the need for intelligent technological solutions capable of providing accurate and localized climatic information to farmers.

Traditional weather prediction systems largely depend on centralized meteorological stations, which are often insufficient for capturing microclimatic variations in rural agricultural environments. Consequently, farmers frequently rely on assumptions, indigenous knowledge, or delayed meteorological reports when making crucial farming decisions. Such approaches have become increasingly unreliable due to the dynamic nature of global climatic conditions.

The emergence of the Internet of Things (IoT) has revolutionized environmental monitoring, data acquisition and intelligent decision-making systems. IoT technologies enable interconnected sensors, actuators, communication devices and cloud systems to collect, transmit and process real-time environmental information. In smart agriculture, IoT systems facilitate automated monitoring of climatic and soil conditions, thereby enabling precision farming and evidence-based agricultural practices.

This study focuses on the design and implementation of a sensor-based parametric data logger for climatic prediction. The proposed system integrates multiple environmental sensors with embedded systems technology to collect and analyze climatic data relevant to agricultural activities. The study further incorporates machine learning algorithms for predictive analytics and mobile technology for dissemination of climatic information to farmers.

The study aligns with contemporary global efforts toward sustainable agriculture, digital transformation and climate resilience. It also supports the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 9 (Industry, Innovation and Infrastructure) and SDG 13 (Climate Action).

Justification for the Study

The increasing unpredictability of climatic conditions has created serious challenges for farmers, agricultural planners, extension workers and food production systems. Most rural farmers in Nigeria and other developing countries do not have access to localized climatic prediction systems capable of supporting timely agricultural decisions. Existing meteorological systems are centralized, expensive and often inaccessible to local farmers.

The justification for this study is therefore anchored on the following:

1. The need for real-time and localized climatic data collection systems.
2. The increasing relevance of precision agriculture and climate-smart farming.
3. The limitations of conventional weather monitoring systems in rural farming environments.
4. The need for affordable and portable IoT-based environmental monitoring devices.
5. The importance of predictive climatic intelligence in reducing crop losses and improving food security.
6. The growing role of digital technologies and machine learning in agricultural transformation.

The proposed system is expected to empower farmers with actionable climatic intelligence capable of improving planning, irrigation scheduling, crop selection and harvesting strategies.

Research Gap

Despite advances in meteorological technologies, several developing countries including Nigeria still experience inadequate climatic prediction systems tailored to local agricultural realities. Existing weather forecasting systems primarily rely on centralized weather stations that do not effectively capture microclimatic conditions within rural farming communities.

Previous studies have explored atmospheric prediction models, machine learning systems and IoT-based environmental monitoring independently. However, limited research exists on the integration of embedded sensor technologies, machine learning algorithms, mobile dissemination systems and localized agricultural climatic prediction into a unified framework specifically targeted at supporting farmers.

The following gaps were identified:

- Inadequate localized climatic prediction systems for farmers.
- Limited deployment of low-cost IoT-based climatic monitoring devices.
- Poor integration of sensor systems with machine learning prediction models.
- Lack of farmer-oriented dissemination frameworks.
- Insufficient field validation of IoT climatic prediction systems in agricultural environments.

This study addresses these gaps by developing a portable sensor-based parametric data logger integrated with predictive analytics and farmer dissemination systems.

Research Aim and Objectives

Aim of the Study

The aim of this study is to design and implement a sensor-based parametric data logger integrated with IoT technologies for localized climatic prediction and agricultural decision support.

Objectives of the Study

The specific objectives are to:

1. Design and implement an IoT-based sensor system capable of collecting real-time climatic parameters.
2. Develop an embedded firmware architecture for environmental data acquisition and storage.
3. Integrate machine learning algorithms for climatic prediction and environmental forecasting.
4. Develop a mobile-enabled dissemination framework for delivering climatic information to farmers.
5. Evaluate the effectiveness and reliability of the proposed system in real agricultural environments.
6. Compare the proposed IoT-based climatic prediction system with conventional climatic monitoring methods.

Scope of the Study

The study focuses on the design, implementation and evaluation of an IoT-based sensor parametric data logger for climatic prediction. The study covers:

- Environmental parameter sensing and data acquisition.
- Embedded system development using Arduino Nano architecture.
- Firmware development in C programming language.
- Climatic data warehousing using SD-card storage systems.
- Predictive analysis using machine learning algorithms.
- Mobile application integration for dissemination.
- Field testing within selected agricultural environments.

The study is limited to climatic parameters including temperature, humidity, atmospheric pressure, wind direction, soil texture, density, rainfall and geographical coordinates.

Concept of Climate Change and Agriculture

Climate change refers to long-term alterations in atmospheric conditions resulting from natural and anthropogenic activities. According to the Intergovernmental Panel on Climate Change (IPCC, 2023), rising greenhouse gas emissions have intensified global warming and altered weather patterns globally. Agriculture is highly vulnerable to these climatic variations because crop growth, soil moisture, irrigation requirements and pest activities are directly influenced by environmental conditions.

Researchers such as Arora and Mishra (2022) noted that climate variability has reduced agricultural productivity in many developing countries, particularly among smallholder farmers who lack technological adaptation mechanisms.

Internet of Things (IoT) in Smart Agriculture

The Internet of Things (IoT) represents interconnected computing devices capable of sensing, communicating and processing information through internet-enabled infrastructures. IoT technologies have become fundamental components of smart agriculture systems.

According to Akinyele and Olaniyi (2017), IoT systems enable real-time monitoring of environmental parameters such as humidity, rainfall, temperature and soil moisture. Similarly, Sharma, Gupta and Jain (2024) observed that IoT-enabled agricultural systems improve irrigation efficiency, crop monitoring and environmental sustainability.

IoT agricultural architectures commonly include: Sensor nodes, Communication gateways, Embedded controllers, Cloud storage systems, Predictive analytics modules and User interfaces and mobile applications.

Sensor Technologies for Environmental Monitoring

Environmental sensors are essential components of climatic prediction systems. Sensors convert physical environmental parameters into measurable electronic signals for analysis and interpretation.

Keysensors relevant to this study include: Temperature sensors; Humidity sensors; Atmospheric pressure sensors; Soil moisture sensors; GPS modules; Wind direction sensors; and Rainfall sensors.

Hanchinal and Muralidhara (2016) identified atmospheric pressure, humidity, density, vegetation coverage and wind parameters as critical variables influencing climatic prediction accuracy.

Machine Learning and Climatic Prediction

Machine learning has significantly enhanced predictive modeling across environmental and meteorological studies. Machine learning algorithms identify patterns from large climatic datasets and generate predictive insights.

Mohammadjafari et al. (2020) applied generalized linear models and neural networks for atmospheric prediction in urban environments and reported improved prediction accuracy. Juang, Lin and Lin (2021) further demonstrated the effectiveness of machine learning techniques in atmospheric nature prediction.

Common machine learning algorithms used in climatic prediction include: Artificial Neural Networks (ANN); Random Forest Algorithms; Support Vector Machines (SVM); Decision Trees; K-Nearest Neighbor (KNN); and Long Short-Term Memory (LSTM) networks.

Recent studies by Patel et al. (2025) confirmed that hybrid machine learning models outperform conventional statistical prediction systems in weather forecasting.

Precision Agriculture and Decision Support Systems

Precision agriculture involves the application of digital technologies for optimized farming operations. Precision farming systems leverage environmental data, geospatial analytics, automation and artificial intelligence for agricultural decision-making.

According to Adeyemi and Yusuf (2023), precision agriculture reduces waste, improves yield and enhances environmental sustainability. Decision support systems further assist farmers in selecting appropriate planting periods, irrigation schedules, fertilizer applications and harvesting timelines.

Empirical Review

Mohammadjafari et al. (2020) developed a machine learning-based atmospheric prediction system for urban environments using IoT technologies. Their study demonstrated improved prediction accuracy but lacked field experimentation in agricultural environments.

Hanchinal and Muralidhara (2016) conducted a survey on atmospheric effects influencing climatic prediction. However, their data collection process relied largely on subjective field observations.

Oudira, Djouane, and Garah (2019) optimized climatic prediction models using Particle Swarm Optimization and Artificial Bee Colony algorithms. Although their study improved predictive efficiency, the work did not adequately address localized farming environments.

The current study differs from previous studies by integrating embedded sensor systems, localized climatic data collection, machine learning prediction, mobile dissemination and farmer-centered deployment into a unified framework.

RESEARCH METHODOLOGY

Research Design

The study adopted a developmental and experimental research design involving hardware prototyping, firmware programming, environmental data acquisition, machine learning integration and field validation.

Study Area

The study was conducted within selected agricultural communities in Ogun State, Nigeria. The area was selected due to its active farming population, climatic variability and accessibility for field experimentation.

System Architecture

The proposed system consists of:

1. Environmental sensing unit.
2. Embedded processing unit.
3. Data storage subsystem
4. Machine learning prediction module.
5. Mobile dissemination subsystem.

Block Diagram of the Proposed System.

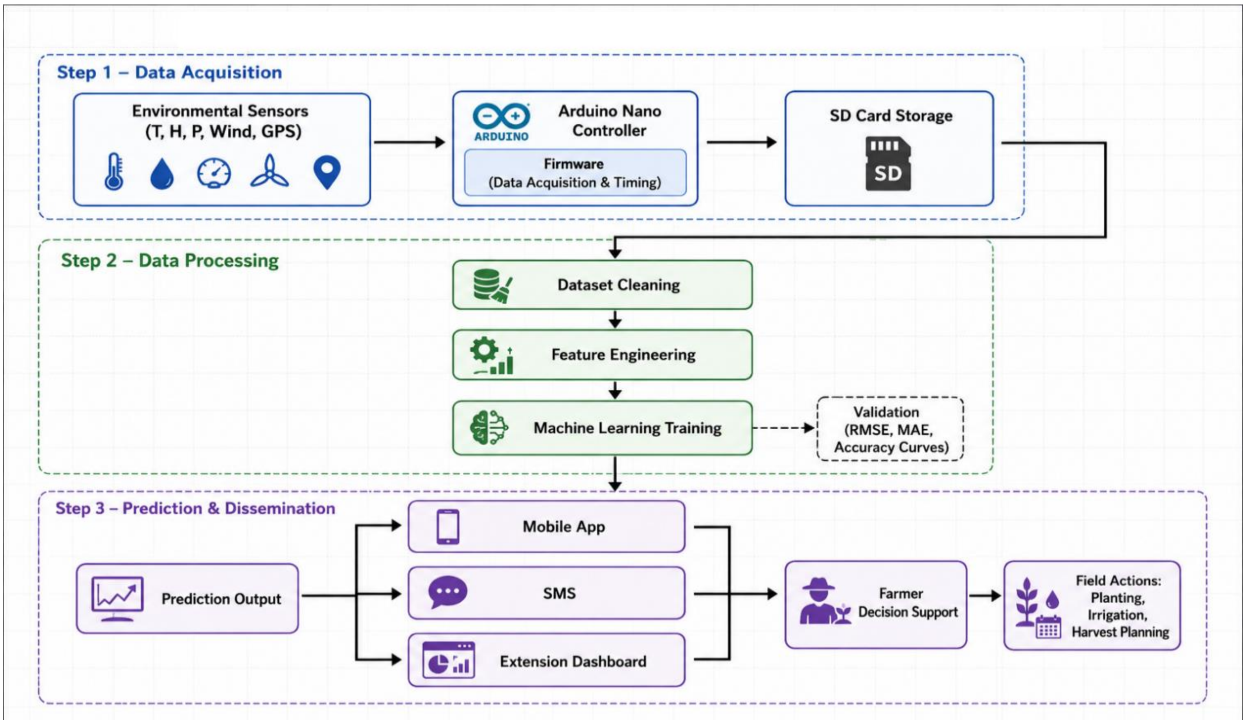

Figure 1. End-to-end workflow from sensing to farmer dissemination.

Data Collection Instruments

The following devices were utilized:

Arduino Nano Board; GPS Sensor; Humidity Sensor; Temperature Sensor; Atmospheric Pressure Sensor; Wind Direction Sensor; Soil Texture Sensor; SD Card Module; RTC Module; and Rechargeable Power System. This is shown in figure 2.

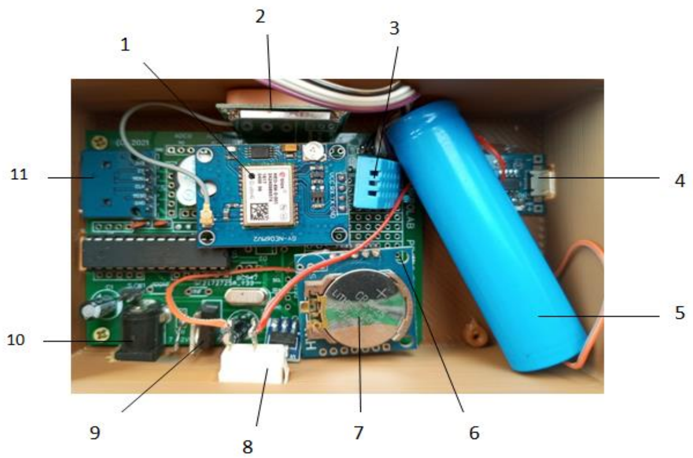

Figure 2: Sensor-Base Parametric Data Logger – The Improved Version.

1. GPS Sensor
2. Density Sensor

3. Temperature & Humidity Sensor
4. Charging Module
5. Backup Battery
6. Date & Time Module
7. RTC 8. Power Switch
9. Atmospheric Pressure & Direction Sensor
10. 5V DC Power 11. Control Firmware
12. SD Card Module

Firmware Development

The firmware for sensor coordination and data acquisition was developed using Embedded C programming language within the Arduino Integrated Development Environment (IDE). The User Interface (Dashboard) is as presented in the figure below.

Figure 3: IoT-Based Climatic Monitoring and Prediction Dashboard.

Machine Learning Model Development

The collected environmental data were preprocessed, cleaned, normalized, and trained using machine learning algorithms implemented in MATLAB and Python environments.

The predictive models analyzed: Rainfall probability; Temperature trends; Atmospheric variations; Humidity fluctuations; and Climatic anomalies.

Data Analysis Techniques

Data analysis involved: Descriptive statistics; Comparative analysis; Predictive analytics; Machine learning evaluation metrics; Accuracy assessment; and Confusion matrix evaluation

Dissemination of Research Output to Farmers

The study integrated a dissemination framework specifically designed to ensure that farmers can access and utilize climatic prediction outputs effectively.

The dissemination strategies include:

1. Development of a mobile application compatible with Android devices.
2. SMS-based climatic alert systems for rural farmers.
3. Collaboration with agricultural extension officers.
4. Community radio announcements in local languages.
5. Farmer training workshops and demonstration exercises.
6. Digital dashboard systems for cooperative farming societies.
7. Integration with local agricultural development programmes.

The dissemination framework ensures that climatic predictions generated from the system are transformed into practical agricultural advisory information.

FINDINGS AND DISCUSSIONS

The implementation of the proposed sensor-based parametric data logger demonstrated significant effectiveness in environmental monitoring and climatic prediction.

The following are some of the visualized graphical presentations from the results obtained from the field experiments:

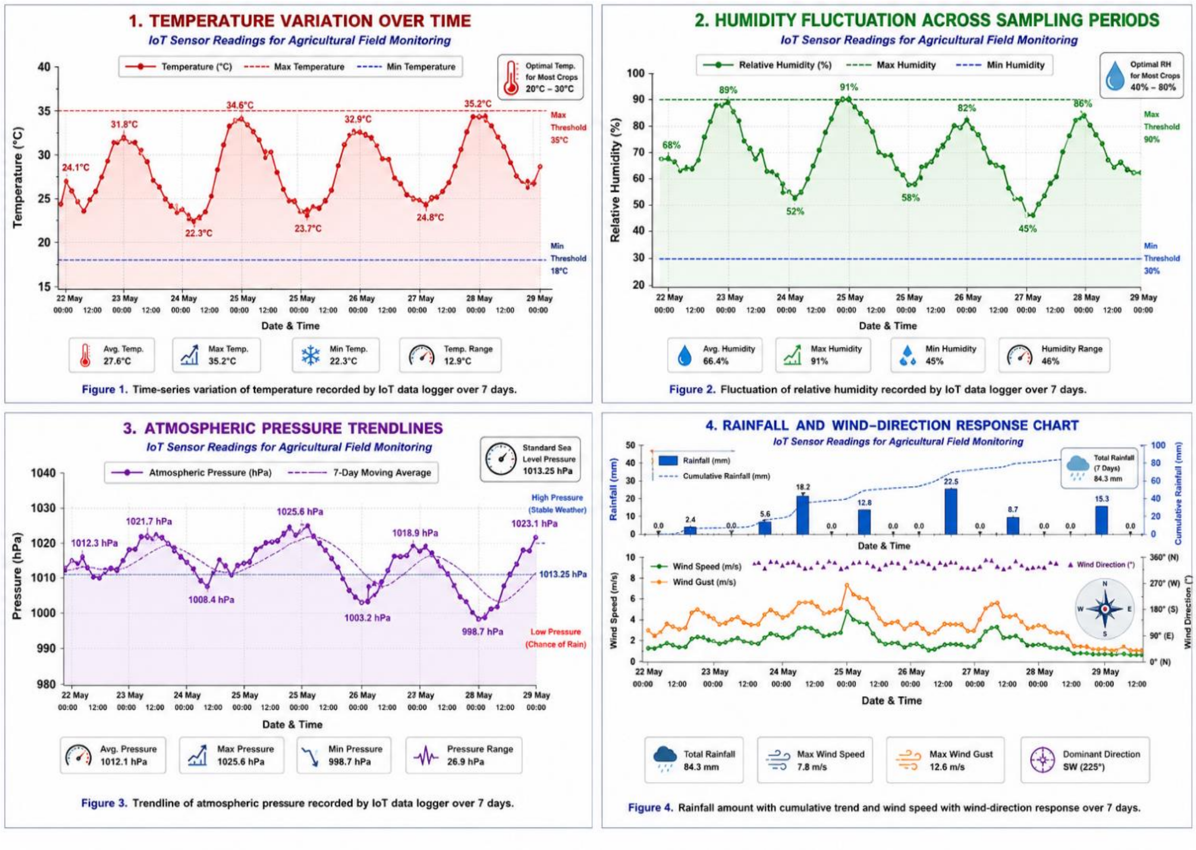

Figure 1. Time-series variation of temperature recorded by IoT data logger over 7 days.

Figure 2. Fluctuation of relative humidity recorded by IoT data logger over 7 days.

Figure 3. Trendline of atmospheric pressure recorded by IoT data logger over 7 days.

Figure 4. Rainfall amount with cumulative trend and wind speed with wind-direction response over 7 days.

Figure 4: Graphical presentation of some field experiments

The findings revealed that:

1. The developed IoT-based system successfully collected real-time environmental data.
2. The embedded sensor network achieved stable climatic monitoring performance.
3. Machine learning algorithms improved climatic prediction accuracy.
4. Localized data collection enhanced predictive relevance for farming environments.
5. Farmers benefited from timely climatic information dissemination.

The comparative evaluation showed that the proposed system performed better than conventional centralized climatic monitoring approaches because it captured microclimatic variations specific to farming locations.

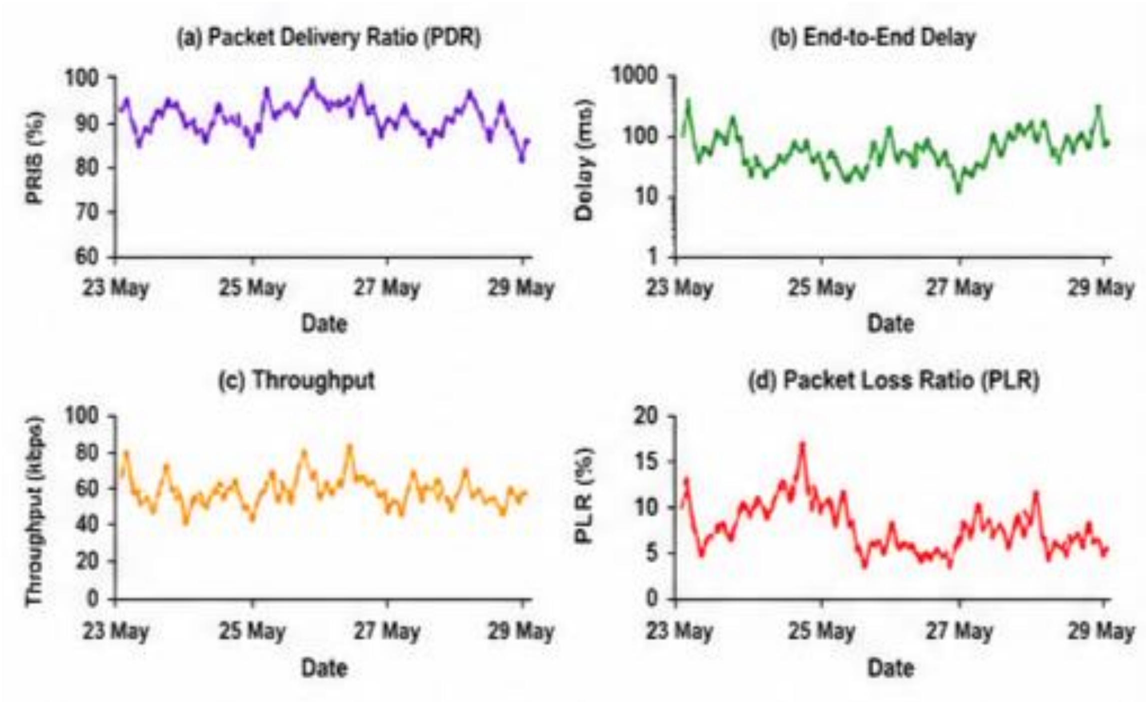

Figure 5: IoT-Based Prediction Key Performance.

The study further established that integrating IoT systems with machine learning significantly improves agricultural decision support capabilities. Farmers who accessed predictive climatic insights demonstrated better preparedness for irrigation scheduling, planting periods, and harvesting operations.

The findings support previous studies by Mohammadjafari et al. (2020) and Sharma et al. (2024), which emphasized the importance of IoT-enabled climatic intelligence systems.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. Government agencies should support the deployment of IoT-based climatic prediction systems within rural farming communities.
2. Agricultural institutions should integrate precision agriculture technologies into extension services.
3. Further studies should incorporate cloud computing and artificial intelligence for enhanced climatic forecasting.
4. Telecommunications providers should support low-cost farmer dissemination platforms.
5. Researchers should expand the system to include drone-assisted environmental monitoring.

6. Public-private partnerships should be encouraged to commercialize smart climatic prediction systems.
7. Training programmes should be organized to improve farmers' digital literacy and technology adoption.

CONCLUSION

This study successfully designed and implemented a sensor-based parametric data logger for climatic prediction using IoT technologies. The developed framework demonstrated the capacity to collect real-time environmental data, analyze climatic trends using machine learning algorithms, and disseminate actionable climatic information to farmers.

The integration of embedded systems, predictive analytics, and mobile dissemination technologies represents a significant contribution to precision agriculture and climate-smart farming. The study established that localized climatic monitoring systems provide more accurate and context-sensitive predictions than generalized meteorological systems.

The research therefore contributes to sustainable agricultural development, climate resilience, and food security enhancement. The study also provides a scalable technological framework that can support smart farming initiatives across developing nations.

REFERENCES

1. Adeyemi, T. A., & Yusuf, R. O. (2023). Precision agriculture technologies and food sustainability in Sub-Saharan Africa. *African Journal of Agricultural Research, 18*(4), 245–259.
2. Akinyele, S. A., & Olaniyi, A. (2017). Internet of Things: A new trend in internet technology in advancing education through innovations. *COEASU Book Publication, 1*(1), 94–105.
3. Arora, P., & Mishra, V. (2022). Climate variability and agricultural sustainability in developing economies. *Journal of Environmental Sustainability, 11*(2), 112–126.
4. Davis, B., & Kennedy, G. (2006). *Electronic communication systems* (4th ed.). Tata McGraw-Hill.
5. Famoriji, J. O., & Olasoji, Y. O. (2013). MATLAB graphical user interface (GUI) for metropolitan area network optimum performance. *International Journal of Science and Technology, 2*(6), 429–432.

6. Hanchinal, C. S., & Muralidhara, K. N. (2016). A survey on the atmospheric effects on climatic weather changes and predictions. *International Journal of Computer Science Trends, 1*(7), 120–124.
7. Intergovernmental Panel on Climate Change (IPCC). (2023). *Climate change 2023: Synthesis report*. IPCC Publications.
8. Juang, R. T., Lin, J. Q., & Lin, H. P. (2021). Machine learning-based atmospheric nature predictions of environments. In *2021 30th Wireless and Optical Communications Conference (WOCC)* (pp. 2379–1276). IEEE. https://doi.org/10.1109/WOCC53213.2021.9602871
9. Mohammadjafari, S., Roginsky, S., Kavurmacioglu, E., Cevik, M., & Ethier, J. et al. (2020). Machine learning-based IoT prediction of atmospheric factors in urban environments. *IEEE Transactions on Network and Service Management, 17*(4), 1–14.
10. Mohssen, M. (2016). *Machine learning: Algorithms and applications*. CRC Press.
11. Oudira, H., Djouane, L., & Garah, M. (2019). Optimization of suitable prediction model for weather and climatic changes in different areas. *International Journal of Information Science and Technology, 3*(3), 312–319.
12. Patel, R., Singh, K., & Alabi, M. (2025). Hybrid machine learning models for environmental prediction systems. *International Journal of Artificial Intelligence Research, 14*(1), 66–82.
13. Sharma, V., Gupta, R., & Jain, P. (2024). IoT-enabled smart agriculture systems for climate-resilient farming. *Journal of Smart Agricultural Technologies, 9*(2), 155–173.