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IoT-Based Smart Poultry Farming: Enhancing Security and Monitoring for High-Quality Production

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Abstract— Poultry producers are having to respond to profound changes on the global farm, a sector that plays a key role in global food security. This research presents a smart poultry farming system using IoT to improve production by ensuring better safety and environmental monitoring. The system utilizes wireless temperature control devices, networked sensors, and associated response mechanisms to regulate temperature, humidity, and ammonia levels, meeting the needs of poultry health and welfare. The system automatically activates exhaust fans based on temperature thresholds (above 35°C and below 20°C) and alerts the owner when ammonia levels exceed 7 ppm. Real-time alerts and on-site analysis are deployed to preempt security risks such as theft and environmental hazards. This comprehensive approach, utilizing real-time data for informed decision-making and exploring future integration of AI for disease detection, highlights significant safety, efficiency, and overall productivity improvements on poultry farms enabled by IoT technology and exemplifies an encouraging direction in which the poultry farm industry is quickly moving.

Keywords- Internet of Things (IoT), Wireless Temperature, Systematic Optimization, Environmental Monitoring, Poultry Farming.

I. Introduction

Poultry farming is a crucial part of the global agriculture sector and has long been fundamental in providing an adequate supply of meat, eggs, and feathers [11,2]. It encompasses breeding broilers and layers as well as other related operations. Beyond meeting nutritional needs, poultry farming plays a vital role in creating investment opportunities and diversifying agricultural aspects while contributing to economic empowerment [1,5].

However, as critical as it is, poultry farming presents severals challenges and uncertainties, which is exemplified by the disruption of the supply chain of fast-food chains [13]. At the same time, many of them are due not to economic factors such as inflation, but to the absence of technological solutions that help effectively monitor and manage poultry farm operations. From this perspective, it is necessary to bridge the described gap to ensure that poultry production is conducted at a high level. One of the “solutions” from this perspective is related to the affordable processing materials, connectivity, and universal algorithms, which create favorable conditions for integrating poultry farming into some technological process [19]. Consequently, it is possible to enhance the security and monitoring levels through IoT-based smart poultry farming. [14].

Smart poultry farming, driven by technologies like the Internet of Things, has the potential to revolutionize poultry production [10]. Additionally, IoT systems provide online monitoring by accumulating data from traditional critical poultry performance indicators [8]. Moreover, IoT systems offer predictive capabilities rather than simply monitoring data because they can forecast possible trends and repercussions. Farmers can now use developments in sensors and networks to obtain real-time intelligence on environmental factors. These systems enable poultry farmers to take active measures to protect the birds while also improving output efficiency [16].

The effects of such technologies as IoT and computer vision on the poultry industry are immense, and new trends are evolving quickly. The health and growth of poultry were, are, and will be the most critical consideration for farmers. The environmental conditions, such as the air temperature, humidity, etc., are vital [11,17,18]. Heat stress and excessive ammonia levels pose severe obstacles not only to the welfare of poultry but also to productivity and product quality. Only thorough monitoring, data collection, and systems that can receive and verify this information and make autonomous adjustments can substantially reduce the risks [12,15].

A smart poultry farm equipped with advanced technology offers a comprehensive solution to these challenges. By continuously monitoring environmental variables like temperature, humidity, acidity, and ammonia levels, such farms can optimize conditions for poultry welfare and productivity [7,3]. Additionally, the integration of surveillance cameras enhances security measures, deterring theft and intrusions while ensuring the safety of poultry assets. Automated techniques for monitoring the behavior and welfare of broilers and laying hens: towards the goal of precision livestock farming [6,10].

To combat the many associated challenges, a smart poultry farm with intelligent technologies is the ideal solution. Farm requires regular monitoring of environmental parameters such as temperature, humidity, acidity, and ammonia levels [9,18,5]. Smart farms use current monitoring of farm conditions to create the required high-quality conditions for birds and poultry productivity. The installation of surveillance video cameras is also a good idea for extensive farms, which increases the level of security in the farm and prevents such activities as poultry theft and theft [4].

To conclude, the implementation of technology in poultry farming is a game-changer that opens completely new horizons for the industry stakeholders. Using IoT and other high-tech solutions, poultry farmers can feel confident to operate efficiently and in line with the current requirements of the challenging field of agriculture, promising a bright future for poultry farming.

II. DESCRIPTION OF DEVICES FOR SECURITY AND MONITORING

This section describes the different devices that have been integrated into the Internet of Things (IoT) smart poultry farming system to enhance environmental monitoring and security. Together, these gadgets which contain motion sensors, gas sensors, temperature and humidity sensors, lighting controls—create a comprehensive and automated system. Through advanced surveillance and alert systems, these devices enhance farm security while ensuring ideal conditions for poultry health and productivity by continuously monitoring critical environmental parameters and giving real-time data.

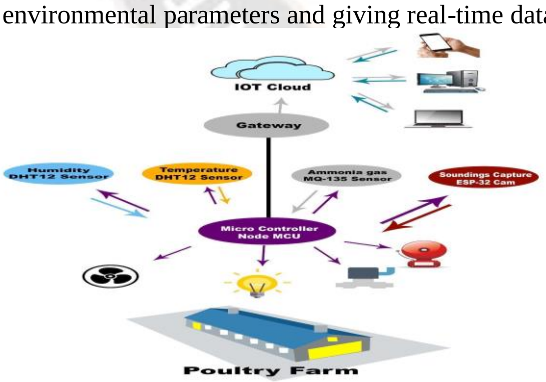

Figure 1. System Architecture

Illustrates the comprehensive implementation of Internet of Things (IoT) technologies within a modern poultry farm. Figure 1 depicts the pivotal components of the IoT system integrated into the farm infrastructure. The proposed system architecture is visualized to showcase the key elements contributing to enhanced monitoring and security.

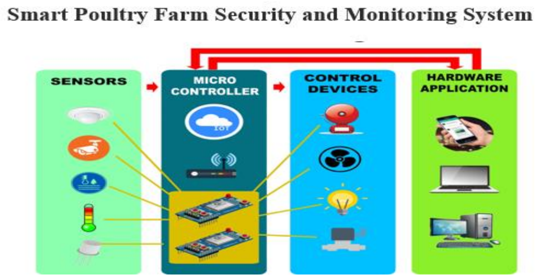

Figure 2. Architectural Insight of Smart Poultry Farm Security and Monitoring System.

The intricate architecture of the envisioned smart poultry farming system. At its nucleus is a cutting-edge IoT device that intricately orchestrates a network of sensors and devices, culminating in the automation and optimization of poultry farm management. The central processing unit, NodeMCU, seamlessly integrates data from environmental sensors, including the DHT22, specifically designed to monitor critical parameters such as temperature, humidity, and ammonia levels within the poultry farm. The system dynamically responds to temperature fluctuations, automatically activating fans when thresholds are exceeded. Automated fan control orchestrated by NodeMCU fine-tunes environmental conditions. A pivotal component, the gas sensor, diligently safeguards poultry health by promptly notifying farm owners of elevated ammonia levels, prompting timely and targeted cleaning measures. Fortification of security is achieved through a PIR sensor that activates the ESP32-Cam to capture and transmit real-time images upon detection of motion, thereby enhancing overall farm security. The Light-Dependent Resistor (LDR) intelligently manages ambient lighting. Continuous real-time monitoring coupled with a robust alert system empowers farmers to take immediate and informed action in response to anomalies, ensuring the sustained well-being of poultry and the seamless efficiency of farm operations.

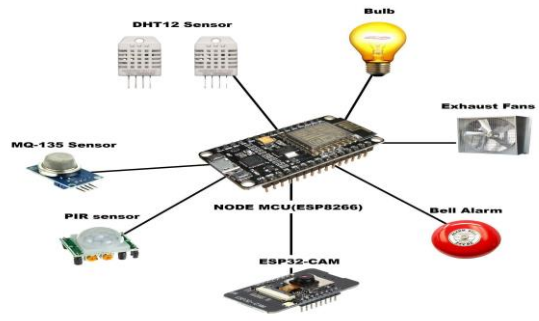

Figure 3. Sensors and Microcontroller

A visual representation of the sensors and the microcontroller is shown in Fig. 3. Sensors and Microcontroller, illustrating their physical configuration. The sensors, intricately interconnected, seamlessly integrate with the microcontroller to form a cohesive unit. This symbiotic relationship allows for streamlined communication and operation, collectively enhancing the overall efficiency and functionality of the system.

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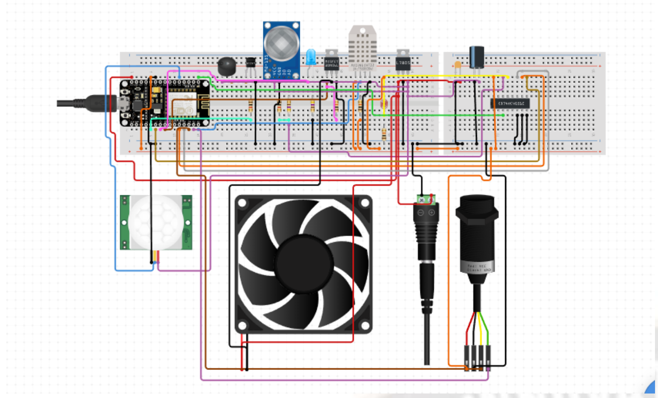

Figure 4. Circuit Diagram of the System

This circuit diagram of the system showcasing a comprehensive representation of all devices seamlessly governed by the NodeMCU microprocessor. This microprocessor, which is actively online, serves as the central control unit, enabling efficient management of the Node-Red dashboard through its designated IP address. This diagram is shown in Fig. 4. Sensors and Microcontroller provides a detailed visual overview of the interconnection and functionality of sensors and the microcontroller within the system, elucidating the intricate orchestration of components that contribute to the seamless operation of the entire smart poultry farming infrastructure.

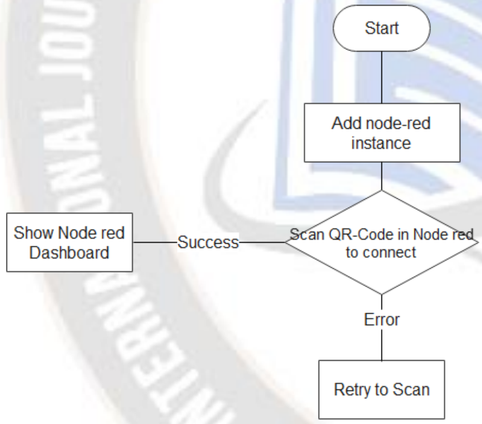

Figure 5. The flowchart in Mobile Software

This comprehensive flowchart embedded within the Mobile Software, showcasing the seamless process of connecting a mobile device to the Node-RED dashboard. This intuitive method, depicted in detail, not only facilitates the integration of mobile devices but also possesses the advanced capability to promptly notify the owner if any sensor exceeds predefined threshold values. This dual functionality enhances the system's accessibility and responsiveness, ensuring timely alerts for effective monitoring and control.

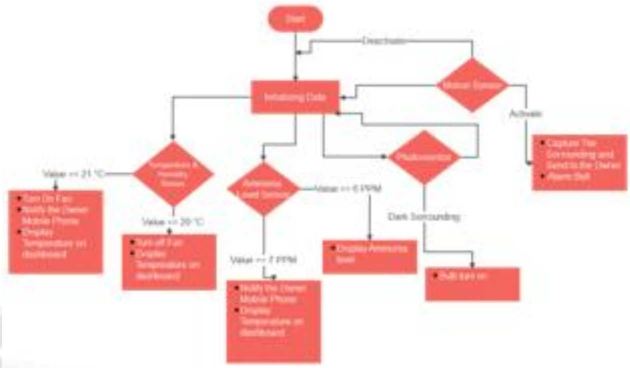

Figure 6. The flowchart in System Process

A comprehensive system process flowchart for the chicken farm is illustrated in Fig. 5. This intricate flowchart delineates the seamless operation of the entire system, offering a detailed overview of the processes involved in managing a poultry farm. An integral aspect of this system is the development of a specialized smartphone app designed to promptly alert farm owners. The system operates in real time, with the server diligently monitoring the collected data. If the data persists beyond predefined threshold values for a specified duration, the server triggers an immediate notification to the user's smartphone app. This alert mechanism ensures timely responsiveness to critical situations, allowing farm owners to take swift and informed actions, thereby optimizing the efficiency and well-being of the poultry farm.

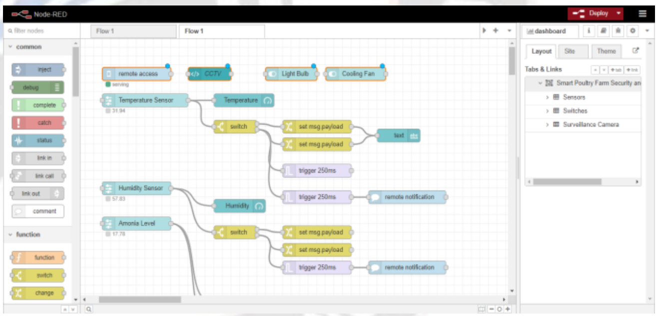

Figure 7. Node-Red Mobile Dashboard

Node-Red Mobile Dashboard, providing a glimpse into the backend node-red dashboard system. This study employs a remote access node that enables users to seamlessly navigate the node dashboard using their mobile devices. Upon app connection, secure certificates are seamlessly transferred to facilitate access to the local site, ensuring a protected and authenticated interaction. This configuration transfer encompasses crucial settings. However, for subsequent modifications to these fields, a user-friendly process is in place—instances in the app must be deleted and reconnected. This streamlined approach ensures continuous and secure operation of the node dashboard on mobile devices, thereby enhancing the accessibility and functionality of the entire system.

III. METHODOLOGY

This section delineates the comprehensive methodology employed to gather the requisite data for system development. The primary approach involved conducting interviews with

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poultry farmers situated in Camarines Norte to gain insights into the practical challenges faced in poultry farming.

A. *Interview Process*

In Camarines Norte, the researchers collected information about poultry farmers through structured interviews. For instance, what are the main problems, how good was safety, and what factors in the environment affect chickens? During the entire questioning process, the participants were requested to provide informed consent, stressing the strictly voluntary nature of their participation and that all information they provided would be handled confidentially.

B. *System Architecture Design*

The system architecture in this study was meticulously crafted using the Feature-Driven Development (FDD) methodology—a customer-centric, iterative, and incremental agile approach aimed at efficiently delivering tangible software solutions.

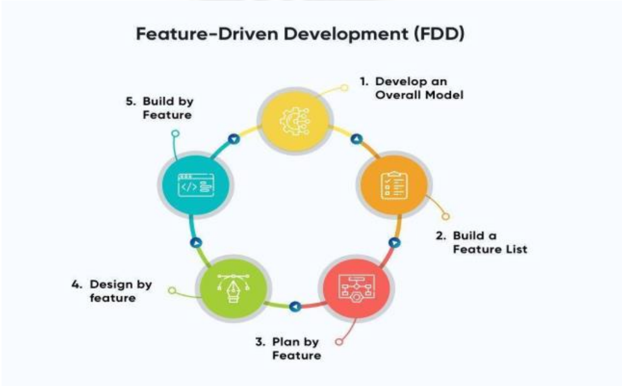

Figure 8. Feature-Driven Development

C. *Feature-Driven Development (FDD):*

FDD, as illustrated in Fig. 8, comprises five integral phases, ensuring a systematic and efficient development process.

- *Develop a Model:* In this initial phase, the chief architect or project lead created a comprehensive model by delineating the scope and context of the proposed poultry farm monitoring and security system.
- *Build a List of Features:* Developers engaged in brainstorming sessions to compile a detailed list of potential features essential for users. These features were envisioned to be completed within manageable 2-week timelines.
- *Plan Out Each Feature:* Features were meticulously organized based on their estimated development time and client priority. Ownership of each feature was explicitly assigned to ensure accountability.
- *Design Each Feature:* Detailed designs for each feature were developed, scrutinized, and finalized, emphasizing precision in implementation.
- *Build Each Feature:* Following the refinement of designs, each feature was systematically integrated into the official build for subsequent delivery to the client.

D. *Iterative Feedback Loop*

Throughout the FDD process, an iterative feedback loop was maintained, fostering continuous collaboration between the development team and stakeholders. This iterative approach facilitated flexibility in adapting to evolving requirements and ensured the alignment of the developed features with the clients' expectations.

E. *Ethical Considerations*

The research adhered to ethical standards, and the methodology was designed to respect participant privacy and ensure the confidentiality of collected data.

IV. FINDINGS AND DISCUSSION

The data in figure 7 depicts the simulation's outcomes. The humidity and temperature sensor's maximum thresholds are set to 35°C; if the threshold is surpassed, the microcontroller will activate the switch of exhausted fans to reduce the heat level. However, if the temperature and humidity levels fall below a certain threshold, the microcontroller will turn off the exhaust fan in the poultry house.

Sensors	**Maximum Value**	**Node MCU Response**
Temperature & Humidity	Val <=20 °C	Automatically Turning off the fan
	Val >= 35 °C	Automatically Turn on the fan
	Manually	Control through Node-RED Dashboard
Gas Sensor	Val <= 7 PPM	Notify the owner to clean the poultry farm
Motion Sensor	Detection	Capture surroundings, send to the owner, and activate alarm
Photoresistor	Light Detection	Automatically turn on/off the bulb based on the light conditions
	Manually	Control through Node-RED Dashboard

TABLE II. TABLE FOR SENSORS

The gas sensor has a maximum threshold of 7 ppm; if the value exceeds this threshold, the microcontroller will transmit a

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notification to the owner or personnel. This figure indicates that the ammonia level in the poultry house is already beyond the maximum threshold, and they must clean out the chicken pot, which creates ammonia and is damaging to the bird's health.

That means you can use it only when its owner has done so. Once turned on by this sequence of instructions, ESP32-CAM will catch any motion detected in your vicinity and send an alert directly to the owner.

These photoresist sensors, or LDRs (light-dependent resistors), are used in poultry farms to determine whether the ambient environment is bright or dark. Once the poultry house becomes dark, the LDR will automatically light the bulb. However, if it detects illumination from the environment, the LDR will simply turn off the bulb.

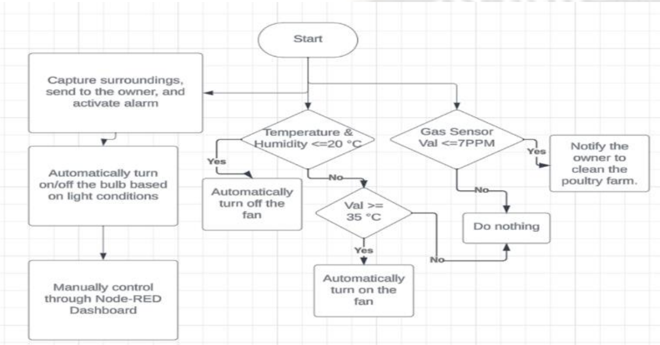

Figure 9. Flowchart Process of Micro Controllers

The dynamic sequence of actions taken by the poultry farm monitoring and security system in response to environmental conditions and sensor inputs. Beginning with the assessment of temperature and humidity, the system navigates through decision points, where it checks specific criteria such as whether the temperature is below 20 °C or exceeds 35 °C. Based on these conditions, the system autonomously controls the fan's operation. In addition, manual control via the Node-RED Dashboard is available for user intervention. The flowchart seamlessly progresses to other critical sensors, including the gas sensor, motion sensor, and photoresist. Each sensor triggers specific actions, such as notifying the owner, capturing surroundings, activating alarms, and controlling the poultry farm's lighting. This visual representation offers a clear understanding of the system's logic, ensuring efficient and responsive operations in poultry farm management.

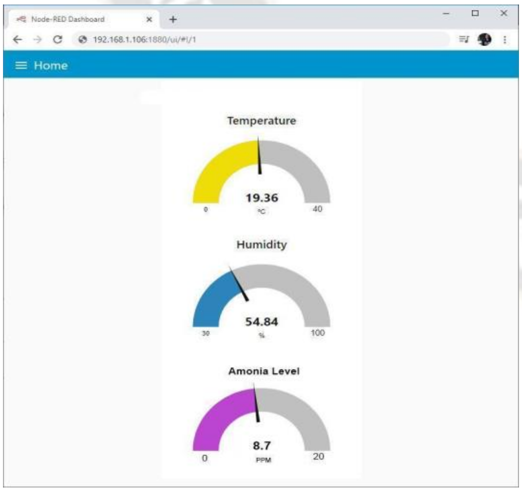

Figure 10. Node-Red Dashboard User Interface

Node Red Dashboard. It gives you data on the temperature, humidity, and gas levels so you can monitor the entire farm. The smooth, user-friendly interface now makes it more convenient to know where many of the country's worst troubles gather—from agriculture to health. Often called 'smart farming," this system teaches us something that we ourselves do not understand. This picture is worth a thousand words. You can see the growth environment for chickens and so on with all domestic fowl production! Everything you need to run your poultry farm is at the click of a mouse in this software. Its user-friendly features make quick judgment possible at any time, allowing the farmer to judge the climate data.

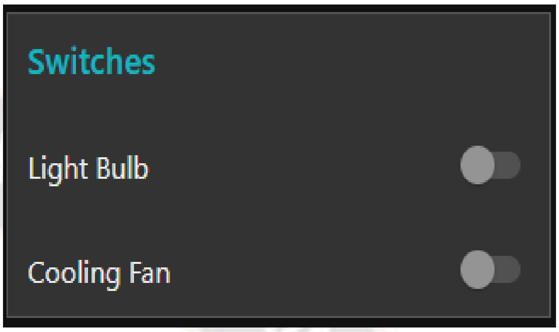

Figure 11. Node-Red Switch User Interface

Shows the fan and lightbulb manual switches, giving consumers the ability to operate these appliances without relying on sensor input. When an emergency arises and quick action is needed, this capability is priceless. Users can quickly and easily turn on or off the fan and lightbulb using the manual switches, which provide responsive control over the environment of the chicken farm. This feature gives the system an extra degree of adaptability by enabling users to override automated processes as needed. The addition of manual controls makes the system more flexible and responsive to unanticipated events, making it a more reliable and approachable solution for security and monitoring of poultry farms.

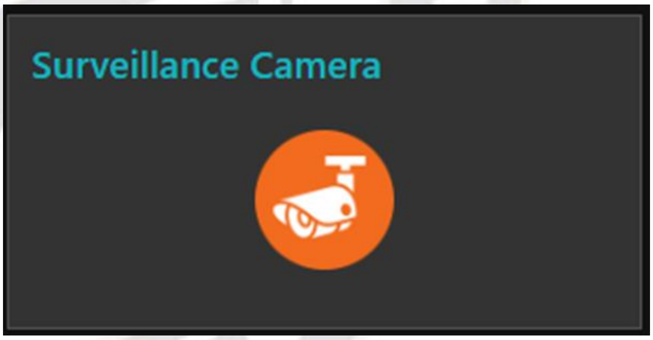

Figure 12. Node-Red Surveillance Camera User Interface

The Node-Red Dashboard features a surveillance camera icon, providing the owner with the capability to capture the surroundings of the poultry farm. In addition, the dashboard is equipped with a motion detection controller, enabling the system to automatically capture and record footage in the event of any detected intruder activity within the poultry farm premises. This multifaceted functionality enhances the security measures implemented in the poultry farm, offering not only real-time monitoring of the environment but also proactive surveillance against potential threats. The integration of these features ensures comprehensive and responsive security management, empowering the owner to maintain a vigilant eye on the poultry farm's activities and promptly address any security concerns.

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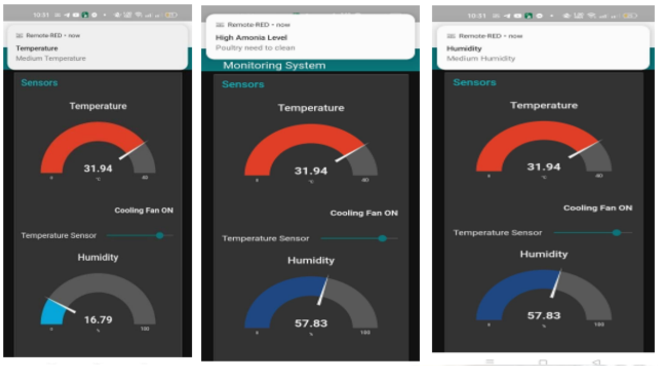

Figure 13. Node-Red Mobile Dashboard

The mobile dashboard provides comprehensive monitoring capabilities for temperature, humidity, and ammonia levels within the poultry farm. This visualization is facilitated through the integration of the Remote-RED software, seamlessly connecting to the Node-Red dashboard. Notably, the mobile dashboard not only presents real-time data on environmental parameters but also incorporates a sophisticated alert system. This alert mechanism proactively notifies users of critical events such as deviations from optimal temperature, humidity fluctuations, or elevated ammonia levels, ensuring swift and informed decision-making. The upper section of Figure 11 showcases these alert notifications, offering poultry farmers valuable insights into the status of their farm. By leveraging Remote-RED and implementing a robust alert system, this research contributes to the advancement of precision monitoring in poultry farming, thereby enhancing overall farm management and productivity.

V. CONCLUSION AND RECOMMENDATION

In conclusion, the primary purpose of poultry farming is to prevent the shortage of chicken meat and eggs. In its current form, poultry farming has already broken through into a different type, a qualitative change and segmentation. There is now feeder breeding, layer breeding, feed production, and processing. Farmers can achieve substantial benefits in poultry farming by using new technologies such as the Internet of Things (IoT). For Monitoring and Scenes "Monitor", the smart systems based on IoT are used in coordination with one another.

Environmental factors such as temperature, humidity, and ammonia concentrations greatly affect the growth and health of chickens and their fertilized eggs. With challenges such as ammonia production, heat stress, and disease outbreaks obstructing optimal production, the proposed study attempts to overcome these problems by creating a modern poultry farm monitoring system using the Internet of Things technology. The system's ability to track such crucial parameters as effectively employing various sensors and microcontrollers, predict potential problems, and instigate appropriate countermeasures guarantees optimal production conditions. Such a technology-driven approach is not designed only to produce more healthful, higher-quality, low-price poultry; it also serves in other ways against environmental pollution and resource wastage.

To make full use of IoT in the poultry farming Industry, several strategic measures should be taken. First, encourage widespread use by providing training and incentives. Second, the IoT sensor data must be mined constantly for decision making to inform. Third, you can create IoT solutions that are very flexible and can work on farms of different sizes. Fourth, AI-driven disease detection must be integrated for early intervention. Fifth, efforts to encourage them to harness natural energy sources for their IoT devices. Sixth, put in place regulatory frameworks that ensure ethical data practices are enforced. Seventh, to make IoT applications promote a robust and productive sector of poultry that will meet changing global needs throughout its development.

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