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Implementation of the Threshold Method in an IoT-Based Monitoring System for Temperature, Humidity and Feed in Broiler Chicken Houses

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ABSTRACT

Broiler chickens require optimal house management to maintain productivity, particularly in terms of temperature, humidity, and feed availability. Monitoring that is still done manually can potentially cause delays in detecting changes in environmental conditions and feed stock, which can hinder the chickens' growth. This study aims to implement a threshold method in an Internet of Things (IoT)-based monitoring system for temperature, humidity, and feed levels in broiler chicken houses. The study employed the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model, utilizing an ESP32 microcontroller, a DHT22 sensor to measure temperature and humidity, an HC-SR04 sensor to detect feed levels, a 4-channel relay module to control fans and incandescent lights, and a web dashboard connected to a Supabase database for real-time monitoring. The system applies threshold values adjusted to the broiler chickens' growth phases so that the actuators can operate automatically to maintain optimal coop conditions. Test results show that the system is capable of monitoring temperature, humidity, and feed levels in real time, transmitting data to the web dashboard, and controlling lights and fans according to threshold values specifically, lights turn on when the temperature is below 31°C and fans turn on when the temperature is above 31°C. The implementation of this system improves the effectiveness of monitoring and controlling coop conditions and has the potential to support poultry farm productivity. The system applies threshold values adjusted to the growth phase of the broiler chickens so that the actuators can operate automatically to maintain optimal conditions in the coop. Test results show that the system is capable of monitoring temperature, humidity, and feed levels in real time, transmitting data to a web dashboard, and controlling lights and fans according to threshold values specifically, lights turn on when the temperature is below 31°C and fans turn on when the temperature is above 31°C. The implementation of this system improves the effectiveness of monitoring and controlling coop conditions and has the potential to support broiler farm productivity. Further development can be pursued by adding automatic notification features, improving sensor accuracy, and integrating an automatic feeding system.

Keywords: : *Broiler chickens; poultry house monitoring*; *Internet of Things (IoT); ESP32; threshold.*

INTRODUCTION

Broiler chicken farming is one of the livestock subsectors that plays a crucial role in supporting national food security, particularly as a source of affordable animal protein for the public. The global poultry industry continues to show significant year-over-year growth, reflecting high demand that drives farmers to continually improve production efficiency (Maharjan, et al., 2021). The productivity of broiler chickens is highly dependent on the environmental conditions in the coop, particularly during the brooding phase at 8–15 days of age, when the chicks' thermoregulatory system is not yet fully developed. Research shows that an optimal temperature ranging from 30°C to 33°C during the early rearing phase has been shown to increase weight gain while significantly reducing mortality rates (Hakim Fattah et al., 2023). Conversely, exposure to temperatures outside the thermoneutral zone for poultry carries the risk of triggering heat stress, which can lead to reduced growth rates and even sudden death (Nadhila Rosa et al., 2024).

Most small-scale family farms including those found in large numbers in the Manyaran area of

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Wonogiri, Central Java still rely on manual monitoring, which has a fundamental weakness: limited oversight, especially at night. This conventional approach is considered inefficient and prone to errors, given the many aspects that must be monitored simultaneously (Nur Ariefin, 2023). This situation is exacerbated by structural challenges in Indonesia's poultry industry, including limitations in biosecurity systems and weak monitoring capacity at the farm level. On the other hand, feed availability that is not monitored in real time can disrupt feeding schedules, which are critical for the optimal growth of chicks in the early stages.

Advances in Internet of Things (IoT) technology offer a practical solution to these problems through the ability to automatically and continuously monitor environmental parameters within the poultry house. Systematic studies have shown that temperature sensors can be integrated with actuators such as fans and heaters via relays, while ultrasonic sensors are capable of accurately detecting feed levels (Terence et al., 2024). The implementation of the ESP32 with a DHT22 sensor has also proven effective in displaying real-time temperature and humidity data on remote monitoring platforms, and the integration of ultrasonic sensors for monitoring feed and water levels has also shown promising results in smart poultry farming scenarios (Nalendra & Waspada, 2025).

A number of limitations have been identified in previous studies. Some of the systems that have been developed lack data logging and multi-zone monitoring capabilities, while others rely on proprietary platforms that are difficult to further develop. More fundamentally, most of these systems have not been tested under real-world field conditions on smallholder farms in Indonesia, so their relevance to the local context remains limited.

This study addresses this gap by developing and testing an IoT-based automated monitoring and control system implemented directly at Yuwono Broiler Farm in Punduhsari Village, Manyaran Subdistrict, Wonogiri Regency, which serves as a broiler farm. The system integrates a DHT22 sensor for temperature and humidity monitoring, an HC-SR04 sensor for feed level detection, and heating lamp and fan actuators controlled via relay-based threshold logic. Data is transmitted via HTTPS to the Vercel backend and stored in Supabase, then displayed through a real-time web dashboard. The novelty of this research lies in the simultaneous integration of feed monitoring and climate control within a single lightweight ESP32 architecture, which was validated directly in an operational farm environment during the critical 8–15-day age phase.

LITERATURE REVIEW

There are several previous studies that the researcher has used as a basis for consideration and as reference sources related to the title of this study, including the following:

Based on research conducted by (Trinaldi, 2022). Titled "*IoT-Based Mamdani Fuzzy Logic System for Controlling and Monitoring Temperature and Humidity in Broiler Chicken Coops*," the study found that the system is capable of remotely monitoring and controlling coop temperature and humidity. The difference from the proposed research lies in the method used; this study employs a threshold method and adds a feature for monitoring feed availability.

Research conducted by (Agus Setyanigsih et al., 2022). Titled "*Internet of Things (IoT)-Based Control and Monitoring System for Broiler Chicken Houses*," the study shows that the system is capable of monitoring temperature, humidity, feed, and water, as well as controlling devices via a website. The proposed research uses a threshold method and focuses primarily on the integration of web-based monitoring of temperature, humidity, and feed.

Next, the research (Hadyanto & Amrullah, 2022) Titled "*Internet of Things-Based Temperature and Humidity Monitoring System for Broiler Chicks*," this study developed a system capable of monitoring temperature and humidity in real time. What sets this proposed research apart is that it adds feed monitoring

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as a parameter and implements an automatic temperature control function.

Research conducted by (De Jesus Martins Corbafo et al., 2023). Titled "*Design and Development of an Internet of Things (IoT)-Based Security, Temperature Monitoring, and Lighting Control System for Broiler Chicken Coops,*" the study shows that the system is capable of monitoring temperature and controlling the coop lighting. However, the proposed research does not focus on security aspects, but rather on monitoring temperature, humidity, and feed using a *threshold* method.

In addition, research (Aspari et al., 2024). The study titled "*Internet of Things-Based Temperature and Humidity Monitoring System for Broiler Chicken Coops to Improve Production*" demonstrates that the system is capable of monitoring temperature and humidity in real time using the ESP32. The proposed research, however, adds feed availability monitoring, website integration, and the application of threshold methods as a decision-making mechanism.Berdasarkan beberapa penelitian terdahulu tersebut, dapat disimpulkan bahwa penelitian yang diusulkan memiliki perbedaan pada penggunaan metode *threshold*, integrasi website sebagai media monitoring, serta penggabungan fungsi kontrol suhu dan monitoring kelembaban serta ketersediaan pakan dalam satu sistem berbasis Internet of Things (IoT).

Tabel 1 Researcher

No	Researcher	Research Title	Method	Research Findings	Research Gaps
1	Trinaldi (2022)	IoT-Based Mamdani Fuzzy Logic System for Controlling and Monitoring Temperature and Humidity in Broiler Chicken Coops	Mamdani Fuzzy Logic	The system is capable of remotely monitoring and controlling the temperature and humidity in the coop.	Previous research used the Mamdani fuzzy method and monitored only temperature and humidity. The proposed study applies a threshold method and adds feed monitoring to the IoT system.
2	Agus Setyanigsih et al., (2022)	Internet of Things (IoT)-Based Control and Monitoring System for Broiler Chicken Coops	Web-based IoT	The system is capable of monitoring temperature, humidity, feed, and water, as well as controlling devices via a website.	Previous studies have not applied the threshold method as the basis for automated decision-making. The proposed study focuses on the implementation of thresholds for IoT-based monitoring of temperature, humidity, and feed.

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3	Hadyanto & Amrullah, (2022)	An Internet of Things-Based Temperature and Humidity Monitoring System for Broiler Chicks' Cages	IoT	Temperature and humidity monitoring can be performed in real time.	Previous studies have only monitored temperature and humidity without applying threshold methods and have not monitored feed intake. The proposed study integrates these three parameters into an IoT system.
4	De Jesus Martins Corbafo et al., (2023)	Design and Development of an Internet of Things (IoT)-Based Security, Temperature Monitoring, and Lighting Control System for Broiler Chicken Coops	IoT	The system is capable of monitoring the temperature and controlling the lights in the coop.	Previous research has focused more on the safety and control aspects of lighting. The proposed research focuses on the implementation of a threshold method for monitoring temperature, humidity, and feed in an IoT-based broiler chicken coop.
5	Aspari et al., (2024)	An Internet of Things-Based Temperature and Humidity Monitoring System for Broiler Chicken Coops to Improve Production	Prototype IoT	The system is capable of monitoring temperature and humidity in real time using the ESP32.	Previous studies have not integrated feed monitoring and threshold methods as a basis for determining housing conditions. The proposed study implements thresholds in IoT-based monitoring of temperature, humidity, and feed.

METHOD

This study employs the Analysis, Design, Development, Implementation, Evaluation (ADDIE) model-based system development approach, which is systematic and iterative. The analysis phase was conducted to identify the requirements for an automated monitoring and control system for temperature, humidity, and feed in broiler chicken coops, which have thus far been managed manually and conventionally. Based on the results of this analysis, it was determined that the system must be capable of operating in real time, automatically, and remotely via an easily accessible interface. The system was also designed to be efficient, cost-effective, and suitable for implementation on small- to medium-scale farms.

During the design phase, the system was designed using an ESP32 microcontroller as the main control unit, which features built in Wi-Fi and Bluetooth connectivity. A DHT22 sensor is used to measure the temperature and humidity inside the cage, while an HC-SR04 ultrasonic sensor is used to measure the feed level in the feeder without physical contact. Two actuators are integrated into the system: an exhaust fan for cooling and an incandescent lamp for heating. All actuators are controlled via a 4-channel relay module connected to the ESP32's GPIO pins. For remote monitoring, the system uses a web-based dashboard that

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allows users to monitor sensor data and actuator status in real time via a smartphone. The system employs a threshold method as the basis for automatic control based on the optimal temperature for broiler chickens. In this study, testing focused on 8–15 day old broiler chickens with a threshold value of 31°C; thus, the incandescent lamp is activated when the temperature falls below 31°C, and the fan is activated when the temperature exceeds 31°C to maintain coop conditions suitable for the chickens' growth.

During the Development phase, the components were assembled and programmed using the Arduino IDE to read sensor data, process threshold logic, control actuators, and transmit data to a web dashboard via Wi-Fi, with local testing conducted prior to implementation. During the Implementation phase, the system is tested in small- to medium-scale broiler chicken coops to ensure that actuator response, reading accuracy, and notifications align with the design. During the Evaluation phase, system performance is evaluated by measuring sensor accuracy, actuator response time, and notification accuracy, followed by quantitative and qualitative analysis to assess whether the system meets the initial research objectives.

RESULT

Table 2 System Testing

No	Time	DHT 22 (Temperature / Humidity)	HC-SR04	Feed level	Lights	Fan
1	23.40	30,8°C / 72,1%	1 cm	100%	ON	OFF
2	23.50	31,0°C / 72,2%	2 cm	80%	OFF	OFF
3	00.00	31,2°C / 72,3%	3 cm	60%	OFF	ON
4	00.10	31,5°C / 72,4%	4 cm	20%	OFF	ON
5	00.20	32,0°C / 72,5%	5 cm	0%	OFF	ON

System testing was conducted during the night from 11:40 p.m. to 12:20 a.m. WIB, with data recorded every 10 minutes. The purpose of this test was to validate the system's ability to read environmental data in real time and automatically respond to changing conditions through the installed actuators.

Based on data obtained from the DHT22 sensor, the coop temperature showed a gradual upward trend from 30.8°C at the first observation to 32.0°C at the fifth observation. Relative humidity remained relatively stable in the range of 72.1%–72.5%, indicating consistent air conditions inside the coop throughout the testing period. The recorded temperature range remained within the system's threshold limits set for 8–15-day-old broiler chickens, with a critical point at 31°C.

The HC-SR04 sensor successfully detected gradual changes in feed level, from a distance of 1 cm at the start of the test to 5 cm at the end of the test. As the measured ultrasonic distance increased, the feed level percentage decreased from 100% to 0%, indicating that feed consumption occurred during the observation period. This proves that the system is capable of accurately and continuously monitoring feed availability without requiring manual observation by the farmer.

The system's actuator response reflects the designed threshold-based control logic. During the first observation (temperature 30.8°C, below the 31°C threshold), the heating lamp was active (ON) to maintain the warmth of the coop, while the fan was off. Once the temperature exceeded the threshold value during the second through fifth observations, the heating lamp was automatically turned off. The fan began

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operating during the third observation when the temperature reached 31.2°C and remained on until the end of the test as the temperature continued to rise, serving to dissipate excess heat inside the coop.
he test results show that the system operates in accordance with the programmed control logic, which is to maintain the coop temperature within the optimal range through a combination of automatic heating and cooling. With its IoT-based real-time monitoring capabilities for temperature, humidity, and feed levels, this system has the potential to assist broiler chicken farmers particularly during the critical 8–15-day phase in maintaining ideal coop environmental conditions, reducing the risk of early mortality due to temperature fluctuations, and improving feed management efficiency, which can ultimately contribute to increased productivity and the overall success of broiler chicken farming.

DISCUSSIONS

The development of an IoT-based monitoring and control system for broiler chicken coops in this study was carried out using the ADDIE model, which consists of five structured phases: *Analysis, Design, Development, Implementation, and Evaluation*. This approach was chosen because of its systematic and iterative nature, making it suitable for the development of hardware and software based systems that require phased validation in a real-world environment.

Analysis

The main issue underlying this research is the lack of an integrated system that combines Internet of Things (IoT)-based monitoring of temperature, humidity, and feed availability in broiler chicken coops at a cost that is affordable for small- to medium-scale farmers. Until now, coop environmental management has largely relied on manual observations and the farmers' instincts, often resulting in delayed responses, misinterpretations of conditions, and environmental conditions that do not meet the physiological needs of broiler chickens. (Rohman & Isnaini, 2025).

House temperature control should be adjusted gradually according to the growth stage of the broiler chickens. During the early rearing period from 1 to 7 days of age the recommended house temperature is 34°C.

As the chickens age, the required temperature decreases to 31°C at 8–15 days of age, 28°C at 16–23 days of age, and approximately 26.6°C at 24–30 days of age. Therefore, a temperature monitoring system is needed that can provide real-time information on housing conditions so that temperature changes can be immediately detected and addressed according to the chickens' needs during each rearing period.

Based on the identified issues, it is evident that a monitoring system is needed that can provide real-time information on temperature, humidity, and feed levels in the poultry house. The system is also designed to automatically control fans and incandescent lights based on preset threshold values to maintain optimal environmental conditions in the coop. To make the monitoring process more effective, the monitoring data is displayed via a smartphone app that can be accessed remotely. To meet these requirements, the system was built using an ESP32 microcontroller integrated with a DHT22 sensor and an ultrasonic sensor as data acquisition devices(Andini et al., 2024).

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CONCLUSION

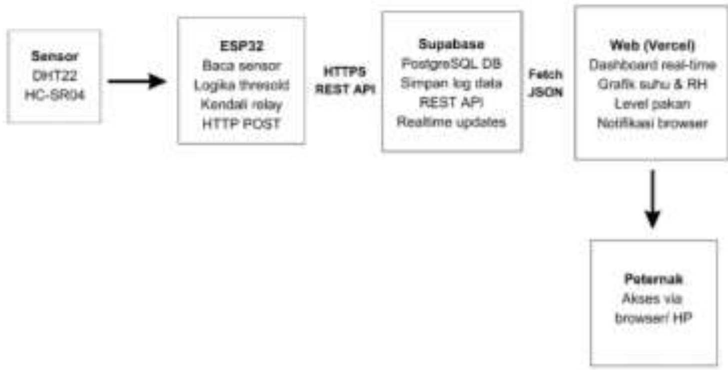

Figure 1: System Flowchart

Figure 1 shows the results of the design, implementation, and testing that have been conducted; an Internet of Things (IoT)-based monitoring and control system for broiler chicken coops was successfully developed using an ESP32 microcontroller, a DHT22 sensor, and an HC-SR04 sensor. The system is capable of monitoring temperature, humidity, and feed levels in real time via a web dashboard connected to a Supabase database. Test results show that the DHT22 sensor can accurately measure the environmental conditions inside the coop, while the HC-SR04 sensor is capable of detecting changes in feed levels based on the measured distance. Additionally, the automated control system operates according to preset threshold values: the incandescent light turns on when the temperature drops below 31°C, and the fan activates when the temperature exceeds 31°C. Sensor readings are successfully transmitted and displayed on the website, making it easier for farmers to monitor coop conditions remotely.

Although the system has functioned as intended for this study, there are still several aspects that can be further developed in future research, such as adding an automatic notification feature when temperature, humidity, or feed levels fall outside the specified limits, using sensors with higher accuracy, and developing an automatic feeding system integrated with the monitoring results. Testing on a larger-scale farm and over a longer period is also necessary to determine the system's reliability under actual operational conditions.

Design

The system design was developed by integrating hardware, software, and an Internet of Things (IoT)-based monitoring interface. The ESP32 microcontroller serves as the control center to read data from the DHT22 and HC-SR04 sensors, process the information, and control actuators such as fans and incandescent lights via a relay module based on predetermined threshold values. The DHT22 sensor is used to monitor the temperature and humidity of the cage, while the HC-SR04 sensor is used to detect the feed level in the feed container.

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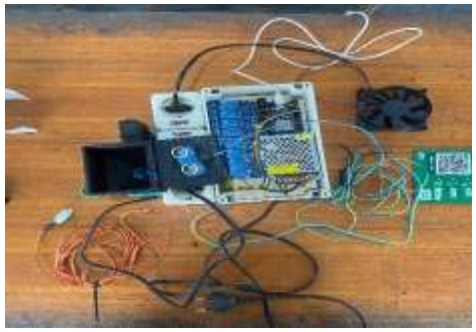

Figure 2: Component Circuit

Tabel 3 Component Circuit

No	Components	Functions	Pin ESP32
1.	DHT22 Sensor	Measuring the temperature and humidity of the coop	GPIO 4
2.	HC-SR04 Sensor	Measuring the distance to the feed surface to determine feed levels	GPIO 14
3.	Light Relay	Controlling incandescent bulbs for heating	GPIO 18
4.	Fan Relay	Controlling fans for cooling	GPIO 17
5.	Feeding Relay	Measuring the temperature and humidity of the coop	GPIO 5

Sensor readings are sent to the Supabase database via the internet and displayed on a web dashboard in real time, allowing farmers to monitor coop conditions remotely. In addition to serving as a monitoring tool, the system can also automatically control the coop's temperature using fans and incandescent lights to maintain environmental conditions that meet the needs of broiler chickens. With this design, the system is expected to improve monitoring effectiveness and help ensure a sustainable supply of feed and a comfortable coop environment.

Devploment

During the development phase, all system components were integrated and programmed in stages. The hardware was assembled with careful attention to cable neatness and connection security to prevent system malfunctions, including the connections between the ESP32, the DHT22 sensor, the HC-SR04 sensor, the relay module, the fan, and the incandescent light bulb. Meanwhile, the software was developed using the Arduino IDE with the C++ programming language, which includes the processes of reading sensor data, processing data, sending data to a database via a Wi-Fi network, and controlling actuators via relays. The system employs threshold logic as the basis for automatic control, which turns on the incandescent light when the temperature falls below a specified threshold and activates the fan when the temperature exceeds a predetermined threshold. Additionally, data on temperature, humidity, and feed levels are transmitted and displayed on the website dashboard in real time, allowing farmers to remotely monitor the conditions inside the coop.

System testing was conducted in stages to ensure that all components functioned as designed. Testing included reading data from the DHT22 and HC-SR04 sensors, actuator responses (*fans and incandescent lights*) based on threshold values, connecting the ESP32 to a Wi-Fi network, sending data to the Supabase database, and displaying data on the website dashboard in real time. The test results were used to evaluate the system's stability and accuracy, after which several adjustments were made such as sensor calibration, improvements to the feed level reading logic, and optimization of data transmission to ensure the

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monitoring and control system operates more stably, accurately, and in line with the needs of broiler chicken farming.

Implementation

The system was implemented by integrating hardware and software components, including an ESP32 microcontroller, a DHT22 sensor, an HC-SR04 sensor, a relay module, a fan, an incandescent light bulb, a Supabase database, and a website dashboard. The ESP32 serves as the control center to read temperature, humidity, and feed level data, then transmits it via Wi-Fi to the Supabase database so it can be displayed on the website in real time. In addition to monitoring, the system also implements automatic control by activating fans or incandescent lights based on predetermined threshold values to maintain optimal coop conditions. All sensor data and actuator statuses can be monitored via the web dashboard, making it easier for farmers to oversee coop conditions remotely.

To ensure the system functions as designed, all hardware components were implemented and assembled into a single integrated system. This setup connects the ESP32 microcontroller to the DHT22 sensor, the HC-SR04 sensor, the relay module, fans, and incandescent lights the key components in the monitoring and control of the broiler chicken coop.

Figure 3: Complete Component

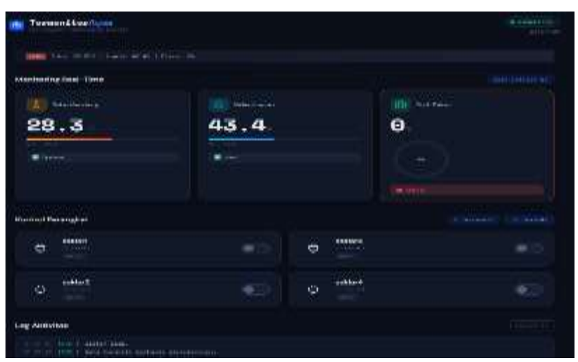

Figure 4: Web Monitoring

As shown in Figures 3 and 4, the success of this implementation demonstrates that the developed system not only functions in a controlled testing environment but can also operate stably under actual broiler house conditions, including when faced with variations in temperature, humidity, and dynamic physical conditions within the broiler house throughout the rearing period.

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CONCLUSION

This study successfully developed and validated an IoT-based automated monitoring and control system for broiler chicken coops using the ADDIE model, which was directly implemented at Yuwono Broiler Farm in Punduhsari Village, Manyaran Subdistrict, Wonogiri Regency an active smallholder farm. The integration of DHT22 and HC-SR04 sensors and a relay actuator on an ESP32 microcontroller with a Vercel serverless backend and a Supabase database proved capable of operating reliably under real-world coop conditions, where a 31°C threshold successfully triggered the automatic activation of heating lamps and ventilation fans to prevent cold stress and heat stress in 8–15-day-old broiler chickens, while real-time feed level monitoring ensures a consistent supply of nutrients without relying on manual nighttime supervision conditions that directly contribute to a reduced risk of early mortality, improved Feed Conversion Ratio (FCR), and increased overall livestock productivity. For future research, it is recommended to include air quality sensors such as those for ammonia and CO_2 and automatic mobile notification features, as well as to conduct trials with longer durations and a greater number of rearing cycles to strengthen the statistical validity of the data.

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