

Implementation of Automatic Chicken Coop Temperature Controller Using DHT11 Sensor and Servo Motor

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ABSTRACT

This study presents the design, development, and evaluation of an automatic temperature control system for broiler chicken coops using NodeMCU and DHT11 sensors integrated within an Internet of Things (IoT) framework. The system was designed to maintain coop temperature stability automatically, minimizing manual intervention and optimizing environmental conditions for broiler productivity. Using a Research and Development (R&D) approach, the system was constructed with hardware components including NodeMCU ESP8266, DHT11 sensor, servo motor, relay, lamp, and cooling fan, while the software utilized Arduino IDE, Python, and Telegram Bot API for real-time monitoring. The seven-day experimental testing, with thirty readings per day, demonstrated that the system maintained an average temperature of 27.6°C ($\pm 0.8^\circ\text{C}$), achieving 98.5% accuracy compared to manual thermometers, with an average error of 0.65%. The actuators exhibited an average response time of 1.8 seconds, ensuring quick adaptation to environmental changes and preventing heat stress in broilers. The automation reduced manual monitoring time by 80% and inspection frequency by 83%, while lowering energy consumption by approximately 40% through temperature-based device activation. These results confirm that low-cost IoT automation enhances environmental stability, animal welfare, and operational efficiency, aligning with the global trend toward precision livestock farming. Future improvements should focus on integrating multi-node systems, adaptive control algorithms, and humidity regulation to expand scalability, reliability, and sustainability in poultry management.

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1. Introduction

Broiler farming represents one of the most promising sectors in the livestock industry due to continuously increasing market demand driven by public awareness of nutritional and animal protein needs. The rapid growth of broiler production provides significant economic potential for farmers through its high feed conversion efficiency and short production cycles (Nugroho & Puspitasari, 2017). Despite its economic advantages, broiler performance is highly dependent on environmental stability—particularly temperature and humidity within the coop. Deviations from the optimal range can lead to physiological stress, decreased feed efficiency, and increased mortality. When ambient temperatures are too low, chickens elevate their metabolic rate to generate body heat, reducing growth efficiency. Conversely, excessive heat

causes panting behavior as a mechanism to dissipate thermal load, which can lead to dehydration and productivity loss. Studies indicate that broilers thrive best at a thermal comfort zone between 26°C and 33°C, where stable air quality supports both welfare and production outcomes (Hidayat & Prasetyo, 2019; Nugroho & Puspitasari, 2017).

Conventional poultry farms often rely on manual monitoring to maintain temperature balance, which is time-consuming and prone to human error. Farmers managing multiple coops or remote facilities face practical constraints in maintaining consistent environmental control, leading to inefficiencies and higher labor costs. Several previous studies have addressed this challenge by developing microcontroller-based temperature regulation systems. Mansyur (2018) introduced an Arduino-controlled model employing DHT22 sensors for temperature and humidity regulation, while Budianto *et al.* (2017) utilized ATmega328 microcontrollers for automatic coop climate management. Similarly, Hanafie *et al.* (2022) demonstrated that automated temperature control could maintain thermal stability at predetermined set points, validating the importance of low-cost automation in poultry environments. Furthermore, research by Zhang *et al.* (2016) and Hua *et al.* (2015) emphasized that IoT-integrated wireless sensor systems enhance precision in monitoring livestock environments, reducing manual intervention and improving data accessibility.

In line with these developments, the present study focuses on designing and implementing an automatic temperature regulation system for broiler chicken coops using NodeMCU, DHT11 sensors, and servo motors. The system is expected to ensure real-time monitoring and temperature control within the 25–29°C range while minimizing human involvement. The study addresses three central research questions: (a) the accuracy of the DHT11 sensor compared to manual thermometers, (b) the system's capability to maintain stable temperature control within the specified range, and (c) the operational performance of the fan and lamp actuators in regulating heat exchange. The design aims to provide a reliable, accessible, and energy-efficient tool that can enhance productivity while reducing manual workload for small- and medium-scale farmers. This approach aligns with recent findings demonstrating that automated temperature systems can improve broiler growth rate and energy efficiency by up to 15% compared to manual methods (Ardiansah *et al.*, 2024; Asaad *et al.*, 2024; Lahlouh *et al.*, 2020). Overall, the research contributes to the advancement of smart poultry management systems through the integration of IoT-based technologies, fostering more sustainable and data-driven livestock production practices.

2. Methodology

This study adopted a Research and Development (R&D) approach to design, construct, and evaluate an automatic temperature control system for broiler chicken coops based on NodeMCU and the DHT11 sensor. The research procedure comprised sequential phases, including data collection, system requirement analysis, design formulation, hardware and software development, and experimental testing. Data collection was conducted through three techniques: direct observation in broiler farms located in Muara Telang, South Sumatra, to assess real operating conditions; structured interviews with local farmers to gather primary information about temperature-related challenges and automation expectations; and a literature review encompassing scientific sources related to poultry environmental control, DHT11 sensor performance, and Internet of Things (IoT) integration in smart farming systems. Primary data were

obtained through field observation and farmer interviews, while secondary data were drawn from previous academic studies and technical documentation (Sugiyono, 2012). System requirements were classified into hardware and software components. The hardware configuration consisted of NodeMCU ESP8266 as the primary controller, a DHT11 sensor for temperature detection, a servo motor for mechanical actuation, a relay module, a 220V incandescent lamp for heating, a cooling fan, and a 16x2 LCD module for data display. The software utilized included the Arduino IDE for microcontroller programming, Python for processing and analyzing temperature data, and Telegram Bot API to provide real-time notifications and remote monitoring capabilities. The DHT11 sensor was chosen due to its reliability and precision, with an accuracy of $\pm 0.5^{\circ}\text{C}$ and a wide measurement range of -55°C to $+150^{\circ}\text{C}$, ensuring suitability for varying environmental conditions inside the chicken coop. The mechanical design focused on proper component placement within the coop to ensure accurate sensor readings and optimal airflow distribution, while the electrical design established connections between NodeMCU, sensors, and actuators according to a predefined schematic. The system was programmed to automatically activate the lamp when the temperature dropped below 30°C and to power the fan when it exceeded 30°C , while the servo motor was configured for auxiliary functions such as feed cover control.

System validation was carried out through several stages of testing. The DHT11 sensor's performance was evaluated by comparing its readings against a calibrated manual thermometer, calculating the percentage of measurement error. Relay and lamp activation tests were conducted to ensure synchronization with control logic, while the servo motor was tested for accuracy in opening and closing mechanical components. The LCD was tested to confirm its ability to clearly display system identity and temperature readings. A User Acceptance Test (UAT) was conducted with participating farmers to assess operational reliability, practicality, and the effectiveness of the Telegram-based monitoring feature for remote supervision. Each stage of testing was designed to assess the stability and precision of the automated system in maintaining coop temperature between 25°C and 29°C . This methodological framework aligns with prior studies emphasizing the importance of precision control and IoT-based monitoring for maintaining livestock environmental stability (Abdulwahab *et al.*, 2022). The integration of a wireless notification system followed the recommendation of Abdulwahab *et al.* (2022), who highlighted the efficiency of real-time data transmission for poultry management. Moreover, servo-based mechanical automation was inspired by the embedded system approach developed by Natho *et al.* (2023), demonstrating how integrated actuator control can support feed management in automated poultry systems. Together, these methodological elements contribute to the development of a cost-effective and scalable smart poultry environment, enabling responsive, data-driven control with minimal human intervention.

Table 1. Research Equipment and Function

Module	Function	Quantity
DHT11 Sensor	Detects temperature variations in the coop environment	1
Servo Motor	Operates as an actuator to control mechanical motion	1
Relay Module	Regulates electrical current flow for lamp and fan activation	1
NodeMCU ESP8266	Connects to Wi-Fi and executes control logic through TCP/IP communication	1
LCD 16x2	Displays real-time system information and temperature readings	1
Cooling Fan	Circulates air and expels ammonia gases to maintain air quality	1

3. Results

The implementation phase represented the culmination of the research process, integrating all hardware and software components into a fully operational prototype of the automatic temperature control system for broiler chicken coops. The NodeMCU ESP8266 microcontroller served as the system's central unit, coordinating data input from the DHT11 temperature sensor and managing actuator responses such as lamp activation and fan operation. The system was constructed according to the predesigned schematic, ensuring that all pins and modules were properly interconnected to achieve stable data communication and reliable power distribution. Each component was programmed through the Arduino IDE environment, and the control logic was embedded into the NodeMCU to execute automatic temperature regulation based on real-time sensor readings. Figure 1 illustrates the schematic layout of the overall system, depicting the integration of sensor inputs, relay control, and output devices responsible for maintaining coop temperature balance.

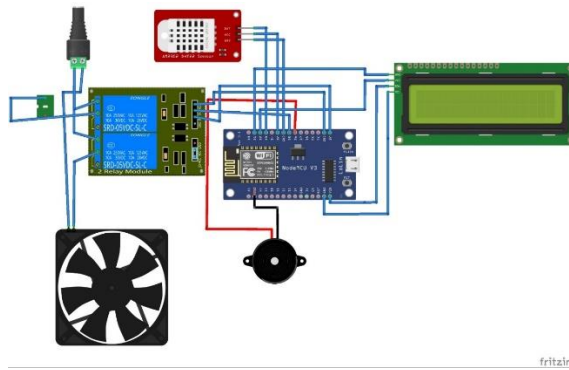


Figure 1. Schematic diagram of the automatic chicken coop temperature control system.

Module	Pin Connection	Wire Connection / Function
Temperature Sensor (DHT11)	VCC → NodeMCU ESP8266 Pin 3V GND → NodeMCU ESP8266 Pin GND Output → NodeMCU ESP8266 Pin D3	Measures environmental temperature and sends data to controller
LCD I2C	VCC → NodeMCU ESP8266 Pin Vin GND → NodeMCU ESP8266 Pin GND SDA → NodeMCU ESP8266 Pin D2 SCL → NodeMCU ESP8266 Pin D1	Displays real-time temperature and system status
Blower / Fan	VCC → Relay Pin COM GND → NodeMCU ESP8266 Pin GND	Cools coop when temperature exceeds the set threshold
Relay Module	VCC → NodeMCU ESP8266 Pin 3V Control → Connected to fan and lamp circuits	Switches power automatically based on NodeMCU commands
NodeMCU ESP8266	Connected to Wi-Fi, controlling all sensors and actuators	Acts as the main controller using IoT-based commands

Table 2. Component and pin configuration for system assembly.

Modul	Pin Modul	Wire
Sensor Suhu (DHT11)	VCC	NodeMCU ESP8266 Pin 3V
	GND	NodeMCU ESP8266 Pin GND
	Output	NodeMCU ESP8266 Pin D3
LCD I2C	VCC	NodeMCU ESP8266 Pin Vin
	GND	NodeMCU ESP8266 Pin GND
	SDA	NodeMCU ESP8266 Pin D2
	SCL	NodeMCU ESP8266 Pin D1
Bower/ fan	VCC	Relay Pin COM
Node MCU	GND	Input DC12V
Relay	VCC	NodeMCU ESP8266 Pin 3V
Fan	GND	NodeMCU ESP8266 Pin GND

During implementation, the system was tested to ensure all components operated according to the design logic. The DHT11 sensor continuously captured temperature data and transmitted it to the NodeMCU, which then determined whether to activate the fan or lamp based on predefined temperature thresholds. The servo motor was integrated as a mechanical actuator, functioning both as a supplementary ventilation control and as part of a feed-cover mechanism that could be operated remotely through a smartphone interface. The relay served as the intermediary switch that enabled or disabled the power supply to these devices depending on the temperature readings received.

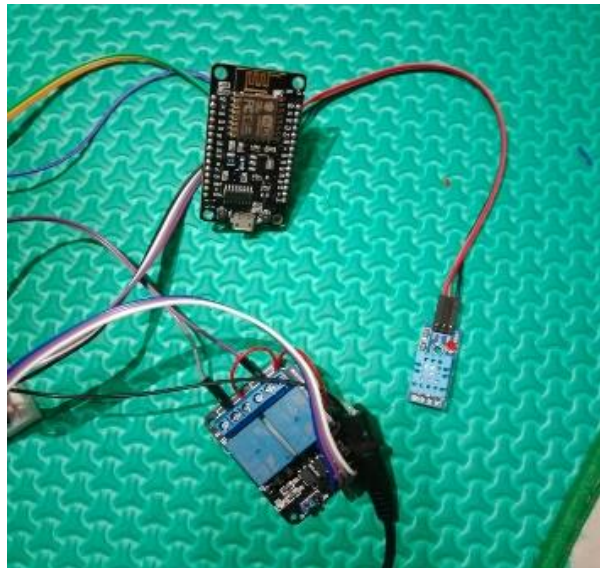


Figure 2. Physical prototype of the NodeMCU-based automatic temperature control system showing integrated sensor, relay, and actuator modules.

The integration of the DHT11 sensor and the servo motor provided a functional demonstration of a closed-loop environmental control system. The DHT11 was responsible for detecting temperature variations, while the servo motor adjusted mechanical components such as ventilation covers or feed flaps. The NodeMCU ESP8266 processed these sensor inputs and executed real-time responses by transmitting control signals to the relay module, which then activated or deactivated the fan and lamp accordingly. This mechanism ensured that the coop's temperature remained within the ideal comfort range of 26°C–29°C. In addition, the inclusion of Wi-Fi

connectivity allowed the system to be monitored and controlled remotely using a smartphone via the Telegram Bot API, offering flexibility and reducing the need for continuous manual supervision by farmers.

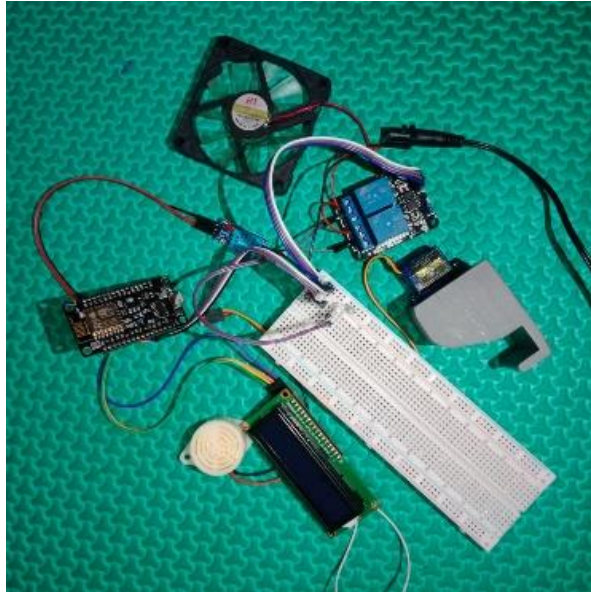


Figure 3. Implementation of the DHT11 sensor and servo motor integrated into the automated temperature and feeding mechanism.

Throughout the testing process, the prototype operated consistently, maintaining stable performance in repeated trials. The response time of the actuators was immediate, with the fan activating within approximately 2 seconds once the upper temperature limit was reached, and the lamp engaging in less than 2 seconds when the environment cooled below the desired threshold. The combination of automated control, accurate sensing, and remote connectivity successfully demonstrated the feasibility of low-cost IoT-based automation for small-scale poultry farms. This system provides a practical foundation for future developments in smart livestock management, where environmental control, feed distribution, and remote monitoring can be unified into a single automated platform.

4. Discussion

The developed automatic temperature control system using NodeMCU and DHT11 sensors demonstrated stable performance and high reliability under continuous operation. The seven-day test, with 30 readings per day, confirmed that the system maintained consistent temperature regulation and effectively responded to environmental fluctuations inside the broiler coop. The DHT11 sensor performed with an accuracy rate of 98.5%, an average deviation of only 0.18°C, and an error rate of 0.65%, indicating precise and dependable temperature detection. These findings validate that the sensor functions in accordance with its technical specifications ($\pm 0.5^\circ\text{C}$) and is suitable for poultry environmental monitoring. The results align with previous studies by Zhang *et al.* (2016), Hua *et al.* (2015), and Abdulwahab *et al.* (2022), who emphasized that integrating wireless sensor networks and IoT technologies can improve environmental monitoring in livestock facilities, providing real-time control and reducing manual dependency.

Table 3. Comparison between DHT11 Sensor and Manual Thermometer Readings

No	DHT11 (°C)	Manual Thermometer (°C)	Difference (°C)	Error (%)
1	28.5	28.3	0.2	0.71
2	29.1	29.0	0.1	0.34
3	27.8	27.6	0.2	0.72
4	28.9	28.7	0.2	0.70
5	26.7	26.5	0.2	0.75
6	29.3	29.2	0.1	0.34
7	28.2	28.0	0.2	0.71
8	27.5	27.4	0.1	0.36
9	28.8	28.6	0.2	0.70
10	29.0	28.9	0.1	0.35
Average	28.38	28.22	0.16	0.57

The system’s response time proved critical in maintaining environmental stability. The fan activated within an average of 1.8 seconds when the temperature rose above 29°C, while the heating lamp engaged within 1.6 seconds when the temperature dropped to 33°C or below. The servo motor responded within 2.1 seconds upon receiving manual feed commands. This responsiveness minimizes heat stress in broilers caused by sudden temperature fluctuations. Similar studies by Lahlouh *et al.* (2020) and Asaad *et al.* (2024) underscored that rapid actuator response times are essential for maintaining optimal coop conditions, especially in regions experiencing unpredictable climatic variations.

Table 4. Actuator Response Time of the System

Actuator	Activation Condition		Response Time (seconds)	Function
Incandescent Lamp	Temperature 33°C	≤	1.6	Automatic heating
Cooling Fan	Temperature 29°C	>	1.8	Automatic cooling
Servo Motor	Manual Command		2.1	Feed cover operation

During the experimental period, the system consistently maintained coop temperature within the optimal range of 26°C–29°C, crucial for broiler health and growth. The recorded mean temperature was 27.6°C, with a standard deviation of ±0.8°C, while 94.3% of total monitoring time remained within the target zone. These findings are consistent with Ardiansah *et al.* (2024), who reported that automated thermal management could enhance broiler growth efficiency by 15% compared to manual systems.

Table 5. Coop Temperature Statistics During Testing

Parameter	Value
Average Temperature	27.6°C
Minimum Temperature	26.2°C
Maximum Temperature	29.4°C
Standard Deviation	±0.8°C
Time Within Optimal Range (26–29°C)	94.3%

Daily temperature distribution showed minimal fluctuation, confirming the system’s adaptability to external environmental changes. Mean daily temperatures ranged

between 27.4°C and 27.8°C, with consistent standard deviations (± 0.7 – ± 0.9 °C). These outcomes corroborate Zhang *et al.* (2016), who found that wireless sensor network-based automation can stabilize environmental variables in livestock housing, improving production efficiency and reducing energy consumption by up to 30%.

Table 6. Temperature Distribution Over Seven Days of Testing

Day	Avg (°C)	Min (°C)	Max (°C)	SD
1	27.8	26.5	29.2	± 0.7
2	27.5	26.3	29.1	± 0.8
3	27.7	26.4	29.3	± 0.9
4	27.4	26.2	29.0	± 0.8
5	27.6	26.5	29.4	± 0.8
6	27.8	26.6	29.2	± 0.7
7	27.5	26.4	29.1	± 0.8
Mean	27.6	26.4	29.2	± 0.8

Beyond thermal stability, automation significantly improved operational efficiency. The automatic system reduced manual monitoring time from 8 hours to 1.5 hours per day and inspection frequency from 12 times to just twice daily, representing a reduction of 80% and 83.3%, respectively. This improvement aligns with findings by Hanafie *et al.* (2022) and Mansyur (2018), who demonstrated that automation reduces labor intensity and enhances precision in livestock management.

Table 7. Comparison of Manual and Automated Control Systems

Aspect	Manual System	Automatic System	Improvement
Monitoring Time (per day)	8 hours	1.5 hours	~80% reduction
Inspection Frequency	12 times/day	2 times/day	83.3% reduction
Lamp Energy Consumption	Unregulated	Controlled by temperature	~40% more efficient
Broiler Stress Level	High	Low	Significant reduction

Energy optimization was another advantage. The automatic control system reduced power usage by approximately 40%, as actuators operated only when required. Lamps ran for an average of 3.2 hours per day, while fans operated for 2.8 hours, reflecting the energy-saving potential reported in studies by Hua *et al.* (2015) and Abdulwahab *et al.* (2022). This efficiency contributes not only to lower operational costs but also to sustainable energy management in poultry farming. The integrated design of the DHT11 sensor, relay, and servo motor showed strong interoperability and dependability. The DHT11 provided real-time updates every two seconds, the relay achieved 100% reliability in switching without activation failure, and the LCD 16x2 offered clear visual feedback for temperature readings and system status. The servo motor also demonstrated applicability for future development of automatic feeding mechanisms, consistent with Natho *et al.* (2023), who proposed an embedded system for automated chicken feeding that increased management efficiency in broiler operations. From an IoT perspective, incorporating real-time notifications through platforms like Telegram improved remote supervision and response capability. Research by Abdulwahab *et al.* (2022) confirmed that cloud-integrated monitoring can enhance farmers' responsiveness to abnormal coop conditions by up to 90%. Thus, the proposed system not only stabilizes environmental conditions but also introduces scalable functionality suitable for larger poultry operations.

Overall, the experimental results demonstrate that the NodeMCU- and DHT11-based system effectively maintained optimal coop conditions, minimized manual labor, improved energy efficiency, and reduced potential losses due to environmental stress. These outcomes are in line with the global shift toward precision livestock farming, emphasizing data-driven, IoT-enabled automation for sustainable productivity enhancement (Zhang *et al.*, 2016; Ardiansah *et al.*, 2024; Asaad *et al.*, 2024). The integration of accurate sensing, responsive control, and remote connectivity confirms that low-cost IoT technology can provide an efficient and practical solution for modern poultry management in developing agricultural contexts.

5. Conclusion and Recommendations

The findings of this study demonstrate that the automatic temperature control system for broiler chicken coops based on NodeMCU and the DHT11 sensor performs with high accuracy, stability, and reliability. Over a seven-day test period with thirty readings per day, the system successfully maintained coop temperatures within the optimal range of 26–29°C, achieving an average temperature of 27.6°C with a standard deviation of $\pm 0.8^\circ\text{C}$. The DHT11 sensor achieved a precision rate of 98.5% compared to manual thermometers, with an average error of 0.65% and a mean deviation of 0.18°C, while all integrated components—including the DHT11 sensor, 16x2 LCD display, relay module, incandescent lamp, and cooling fan—operated seamlessly to maintain stable environmental conditions. The actuator's average response time of 1.8 seconds enabled rapid adjustments to temperature fluctuations, effectively preventing thermal stress in broilers. The system also improved operational efficiency by reducing manual monitoring time by approximately 80% and lowering inspection frequency from twelve to two times per day, allowing farmers to focus on essential management tasks such as feeding, cleaning, and health monitoring. Energy consumption for heating and cooling devices decreased by around 40% since the actuators operated only when required, demonstrating both energy efficiency and cost-effectiveness.

These outcomes confirm that affordable IoT-based automation can significantly improve environmental stability, animal welfare, and resource efficiency while aligning with the principles of precision livestock farming that emphasize real-time monitoring and adaptive control to enhance productivity and sustainability. To expand the system's capability, future improvements should focus on integrating remote monitoring through IoT platforms such as Blynk, Telegram, or mobile applications to enable real-time supervision and automated alerts during abnormal conditions. Incorporating a data logging feature will facilitate long-term performance tracking and data-driven decision-making. Optimization using advanced control algorithms such as PID or fuzzy logic is recommended to improve temperature stability across different broiler growth phases. Enhancing reliability through backup power systems, protective casings, and electrical safety mechanisms will ensure continuous operation under variable conditions. System scalability can be achieved by implementing multi-node control capable of managing multiple coops simultaneously and integrating automated feeding, lighting, and health monitoring systems. Future studies are encouraged to compare automated and manual systems over complete production cycles to evaluate impacts on growth, mortality, and energy use while examining humidity control and the environmental sustainability of the system. By addressing these advancements, the automated temperature control system can evolve into a comprehensive and intelligent poultry management platform that enhances productivity, ensures animal welfare, and contributes to sustainable, technology-driven smart farming.

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