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# Application of Internet of Things (IoT) Technology in the Sound Monitoring System for Swiftlets in Kendari City

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## Abstract

*This research implements Internet of Things (IoT) technology in a sound monitoring system for swiftlets in Kendari City. This approach addresses the inefficiencies of the manual system currently utilised by farmers. This study focuses on the inefficiencies in operating swiftlet sound devices, which requires farmers' presence to control the audio system. This research uses a prototyping approach which involves the steps of needs identification, system design, prototype construction, and testing, which consists of black-box testing and evaluation of the Blynk interface. The system designed comprises a NodeMCU ESP32 as the main controller, a DFPlayer Mini as the audio player, a speaker for audio output, and the Blynk application designed as the interface. The tested system met all the operational and design requirements and allows for remote control of the playback of the recorded swiftlet sounds with an average control response time of one second. The system designed demonstrates that operational costs, inefficiencies, and on-site monitoring are remote; presence control of sound playback is possible. IoT technology incorporates operational efficiency and monitoring systems in real time. This research has the practical outcomes of developing an effective, uncomplicated, and inexpensive system that improves productivity of swiftlet farms and provides a prototype for incorporating digital technology into agriculture and farming. In summation, the use of IoT technology for monitoring and managing swiftlet sounds is effective and has opportunities for advancement into smart, real-time, data-based systems.*

## Keywords

*Internet of Things (IoT); NodeMCU ESP32; Blynk Application; Sound Monitoring; Swiftlet Farming.*

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## 1. Introduction

The rising international interest in swiftlet nests has opened up swiftlet farming in Kendari City, Indonesia. Swiftlet nests are valuable because of their nutritional and medicinal value, and are comprised of the birds' hardened saliva, (Damayanti 2023). However, the economic potential these nests bring has not persuaded local

farmers to move beyond traditional methods in controlling sound systems for attracting and managing swiftlets. These manual methods are especially inefficient, forcing farmers to make costly trips to the nesting sites as sound devices need to be activated and deactivated for nesting site and flock management. Productivity is further limited, in this and other sectors, because real-time automated systems for monitoring and control are absent (Fatih Muhana and Fuad 2024).

This study aims to develop an automated sound control system for swiftlets integrated with an IoT-based monitoring system. The system will utilize a NodeMCU ESP32 microcontroller and Blynk application for automation and remote control. It will reduce manual control and provide system dependability for automation. The study was prompted by the insufficiency of research incorporating IoT within bioacoustic environment control for small-scale agribusiness sectors like swiftlet farming. Previous literature has been primarily focused on the biological aspects of control, such as nutrition and habitat ecology, thereby lacking research on automated environmental control technologies, as noted by Sahrul, et al, 2023. (Sahrul, Candra, and Nur 2023)

Research capitalized on a prototyping approach that incorporated system design, hardware and software interfaces, and functionalities evaluated through black-box and interface testing. Regarding findings, the IoT system maintained efficient and convenient operation by controlling sound activation and deactivation with a mean time of close to one second in response to user commands. Moving on, as a response to the need for more practical and affordable IoT tools, this study also addresses the more general construction of smart farming and digital livestock systems to the extent that it can. Overall, the rapid incorporation of automation suggested in this study improves the productivity of swiftlet farming but more importantly, modernizes a segment of Indonesia's agriculture, i.e. swiftlet farming automation, and demonstrates the use of automation in agriculture for other developing nations (Rinaldi, Hidayat, and Suryanto 2022) (Imran and Rasul 2020).

## **1.1 Literature Review**

The rapid development of digital technology has significantly transformed various industrial sectors, including agriculture and animal husbandry. One of the most impactful innovations is the Internet of Things (IoT), a system that enables interconnected devices to communicate, monitor, and execute commands through the Internet (Ashton 2009). In the context of smart agriculture, IoT facilitates remote control, environmental monitoring, and automation, which improve productivity and efficiency (Fatih Muhana and Fuad 2024). The application of IoT in swiftlet farming a niche yet lucrative industry in Indonesia offers new possibilities for improving sound management systems that play a crucial role in attracting and maintaining swiftlets. According to Stevenson (2018), implementation refers to the process of transforming a planned concept into operational practice, emphasizing coordination, communication, and control to ensure success. In IoT-based systems, implementation requires integration between hardware and software to create seamless data flow and control. Similarly, (Usman 2019) argues that implementation is not merely executing activities but a planned and measured effort to achieve specific goals through system mechanisms. These perspectives underline that IoT implementation in swiftlet farming must go beyond connectivity it must involve measurable performance outcomes and user-oriented design.

The core concept of IoT involves the integration of physical objects equipped with sensors, software, and communication technologies that can collect and exchange data autonomously (Ashton 2009). NodeMCU ESP32, as introduced by (Imran and Rasul 2020), is a microcontroller that supports Wi-Fi connectivity and is widely adopted in IoT applications for its versatility and low power consumption. This device serves as the central controller that connects various hardware components in a smart system. In the context of this research, NodeMCU ESP32 connects with DFPlayer Mini, a compact MP3 module capable of processing and playing sound files from a microSD card, controlled via serial communication (Ratna 2019). The Blynk platform further enhances the system's accessibility by providing a mobile-based graphical interface that allows users to control and monitor devices remotely (Rinaldi, Hidayat, and Suryanto 2022). Through its three main components application, server, and libraries Blynk facilitates data transmission between hardware and smartphones, enabling real-time control and status visualization. Prior studies have successfully implemented

Blynk-based systems in environmental monitoring and smart home applications, demonstrating its reliability and user-friendliness (Amalia et al. 2022).

In the field of swiftlet farming, several researchers have explored IoT applications for automation and monitoring. (Damanik 2024) developed an IoT-based monitoring system for swiftlet houses and reported significant improvement in operational efficiency and bird attraction rates. (Sahrul, Candra, and Nur 2023) extended this research by designing a prototype capable of monitoring sound, temperature, and humidity. Their study confirmed that automated control systems could maintain optimal environmental conditions for swiftlets, reducing manual workload. (Gunawan, Akbar, and Ilham 2020) applied IoT for water-level monitoring using NodeMCU ESP8266, emphasizing that IoT integration improves system precision and reliability in continuous monitoring scenarios. Building upon these findings, the present study advances prior research by focusing specifically on IoT-based sound monitoring systems rather than environmental or multi-variable control. Unlike previous works, this study integrates NodeMCU ESP32, DFPlayer Mini, and Blynk to create a cost-effective, portable, and remotely accessible system tailored for small-scale swiftlet farms. The design leverages a prototyping methodology, allowing iterative testing and refinement to achieve optimal functionality.

In summary, the reviewed literature collectively highlights that the convergence of IoT technology, microcontroller-based automation, and mobile applications provides a transformative approach to enhancing traditional farming systems. The gap identified in earlier studies lack of real-time, user-friendly sound monitoring tools for swiftlet farming serves as the foundation for this research. By addressing this gap, the study not only contributes to technological innovation in local industries but also aligns with broader global trends in smart agriculture and digital transformation.

## **2. Research Methods**

This research employs an applied and experimental approach using the prototyping methodology, aimed at designing and implementing an Internet of Things (IoT)-based sound monitoring system for swiftlets in Kendari City. The study emphasizes the integration of hardware, software, and cloud-based applications to solve the inefficiency and operational challenges faced by traditional swiftlet farming systems. The method was selected because it allows iterative development, continuous testing, and user-oriented improvement until a functional and reliable prototype is achieved (Perry, Riege, and Brown 2003).

### **2.1 Sampling**

The target population in this study includes swiftlet farmers in Kendari City, particularly those operating along Jalan Pasar Baruga, an area known for active swiftlet nest cultivation. The selected site represents a typical local farming context where traditional sound monitoring systems are still predominantly used. Therefore, it provides an ideal setting for evaluating the applicability and efficiency of IoT-based automation. The unit of analysis focuses on a single swiftlet house owned by a local farmer, which serves as the test environment for implementing and observing the developed system. Sampling is purposive, meaning it was chosen based on its relevance to the research objective specifically, the availability of infrastructure for system installation and farmer willingness to collaborate.

The respondent profile includes:

- a. One swiftlet house owner (end user and system operator)
- b. Two technical assistants who support installation and testing
- c. The researcher, who acts as system designer, developer, and evaluator.

### **2.2 Data Collection**

Data collection was carried out through observation, interviews, and documentation.

- a. Observation was conducted to study the behavior of swiftlets toward sound frequency and timing, as well as to assess the environmental factors affecting sound propagation within the nesting structure.

- b. Interviews with the swiftlet house owner provided qualitative insights into existing operational challenges, expectations of automation, and usability requirements.
- c. Documentation involved collecting technical references, system schematics, and software code details for replication and verification purposes.

These methods allowed for a comprehensive understanding of both the technical and practical dimensions of IoT system implementation, ensuring that the proposed solution addresses real-world constraints faced by farmers (Creswell and Creswell 2018).

## **2.3 Measures**

The study focuses on measuring system performance, user responsiveness, and functional reliability. To achieve this, the following instruments and procedures were employed :

### **a. Hardware Configuration**

The hardware configuration formed the physical foundation of the IoT-based monitoring system. At its core, the NodeMCU ESP32 functioned as the central microcontroller, managing communication between components and connecting the system to the Internet via Wi-Fi. The DFPlayer Mini module served as the MP3 audio player, processing sound files stored on a microSD card and transmitting them to the speaker, which acted as the sound output device. A power bank was selected as a portable power supply to ensure mobility and continuous operation. All components were assembled on a breadboard, with resistors integrated to regulate voltage and maintain electrical stability throughout the circuit.

### **b. Software Configuration**

The Blynk mobile application functioned as the Internet of Things (IoT) interface that allowed users to remotely control the swiftlet sound system through simple ON and OFF commands. It provided a real-time graphical dashboard displaying the device's operational status and connectivity indicators. Meanwhile, the Arduino Integrated Development Environment (IDE) was employed to program and upload logic scripts to the NodeMCU ESP32 microcontroller. Within this environment, specific libraries such as BlynkSimpleEsp32.h and DFPlayer\_Mini\_Mp3.h were utilized to establish stable communication between the application, microcontroller, and DFPlayer Mini module, ensuring synchronized control and accurate response during system execution.

### **c. Testing Procedures**

The testing phase played a crucial role in ensuring that the IoT-based sound monitoring system functioned according to its design objectives. The black-box testing method was employed, focusing exclusively on the system's external behavior rather than its internal code structure. This approach allowed the evaluation of how well the system responded to user commands through the Blynk interface. Each function particularly the activation and deactivation of sound playback was executed repeatedly to verify consistency, reliability, and responsiveness. The expected response time for each command was set at less than or equal to two seconds, serving as a benchmark for system performance. During the evaluation, latency and connectivity were tested under varying network conditions, including both stable and weak Wi-Fi connections, to assess real-world performance. The results showed that the system maintained operational stability with an average delay of approximately one second, confirming its suitability for remote monitoring and control in practical swiftlet farming environments.

#### d. Flow of the Proposed Solution

The following diagram illustrates the system workflow :

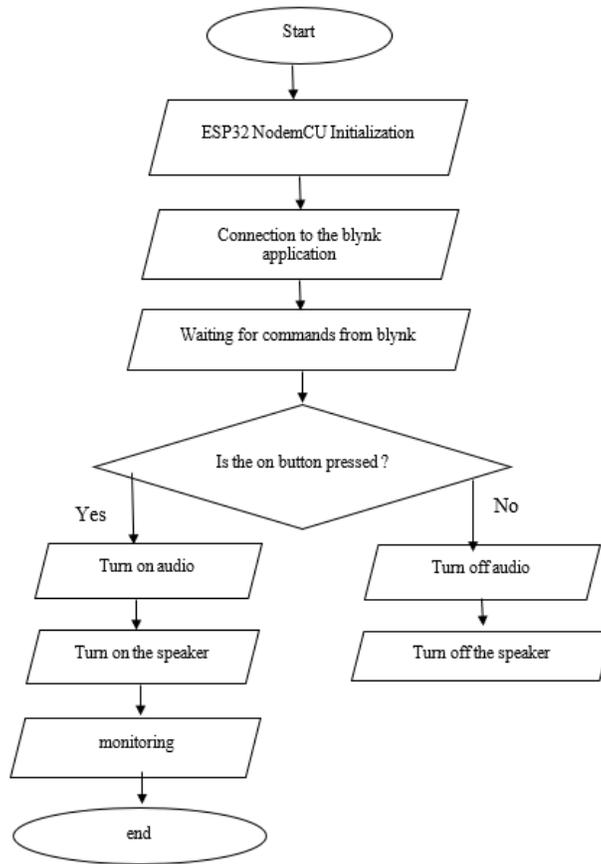


Figure. 1 : Flowchart of Swiftlet Sound Monitoring System

This flow demonstrates the continuous communication loop between the hardware and mobile interface, allowing real-time user control and feedback monitoring.

#### e. Justification and Reliability

The prototyping method was selected due to its iterative nature, which enables developers to refine the system based on direct user feedback. This approach increases construct validity by aligning the system's design with the actual operational needs of the farmers (Perry, Riege, and Brown 2003). Reliability was ensured through repeated testing under various environmental conditions, while internal consistency was verified by monitoring stable system performance across multiple trials.

### 3. Result and Discussion

The implementation of the Internet of Things (IoT)-based sound monitoring system for swiftlets in Kendari City successfully achieved its main objective developing a remote-controlled, energy-efficient, and user-friendly system that allows farmers to manage the playback of swiftlet calls from a distance using the Blynk mobile application. This section presents the results of the system development, testing, and evaluation phases, accompanied by an analysis of their practical implications and alignment with previous research findings.

### 3.1 System Prototype Design

The system was designed based on the integration of hardware and software components that communicate wirelessly through a Wi-Fi connection. The hardware configuration includes the NodeMCU ESP32 microcontroller as the central controller, DFPlayer Mini as the MP3 playback module, resistors to stabilize current flow, a speaker for audio output, and a power bank as a portable power source. The system was assembled on a breadboard for flexibility and modular testing.

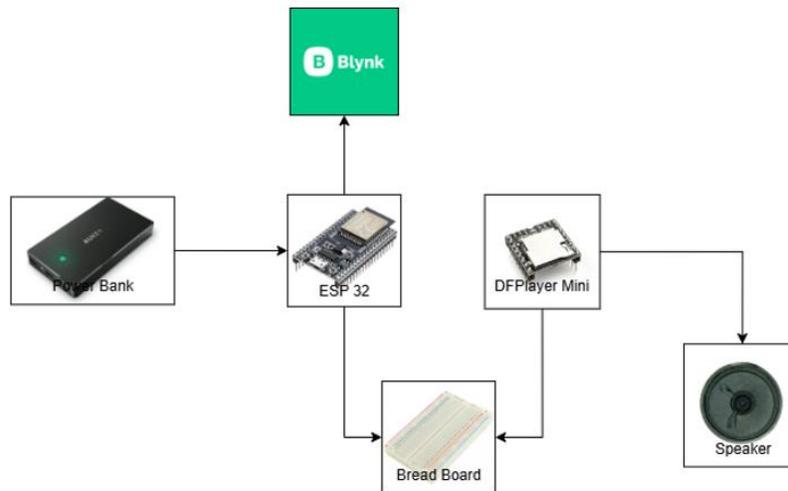


Figure 2. Prototype System Design for IoT-Based Swiftlet Sound Monitoring

The prototype was connected to the Blynk cloud server via Wi-Fi, enabling users to activate or deactivate the sound system through a mobile dashboard interface. The control logic was programmed using Arduino IDE, while data transmission occurred through the Blynk API library.

This modular design ensures scalability, meaning additional sensors such as temperature or humidity detectors can be easily integrated into the system in future iterations, following best practices in IoT system development (Imran and Rasul 2020).

### 3.2 System Interface Design

The design of the system interface represents the final stage of the IoT-based prototype development for the swiftlet sound monitoring system. After completing the hardware assembly and functional testing phases, a digital control interface was created to ensure that users could operate the device conveniently via the Blynk application on their smartphones. The interface design focuses on simplicity, accessibility, and real-time feedback, ensuring that the user experience remains intuitive even for farmers with minimal technological background. The primary function of this interface is to enable the remote activation and deactivation of the swiftlet sound system through an ON/OFF control button, while also displaying the system's operational status (active or inactive) in real time. The dashboard was developed using the Blynk platform, which connects directly to the NodeMCU ESP32 microcontroller through cloud synchronization. Once the system is online, users can send control commands from their mobile devices, which are instantly transmitted to the microcontroller to trigger the DFPlayer Mini module and play or stop the sound output.

In addition to functionality, the interface also incorporates several user indicators to enhance usability. The online status indicator (green dot) confirms active connectivity between the device and the server, while

textual notifications provide feedback for every command executed. To facilitate further development and scalability, the interface design remains modular, allowing for future integration of additional sensors such as temperature, humidity, or light detectors. The following is a picture of the system interface design.

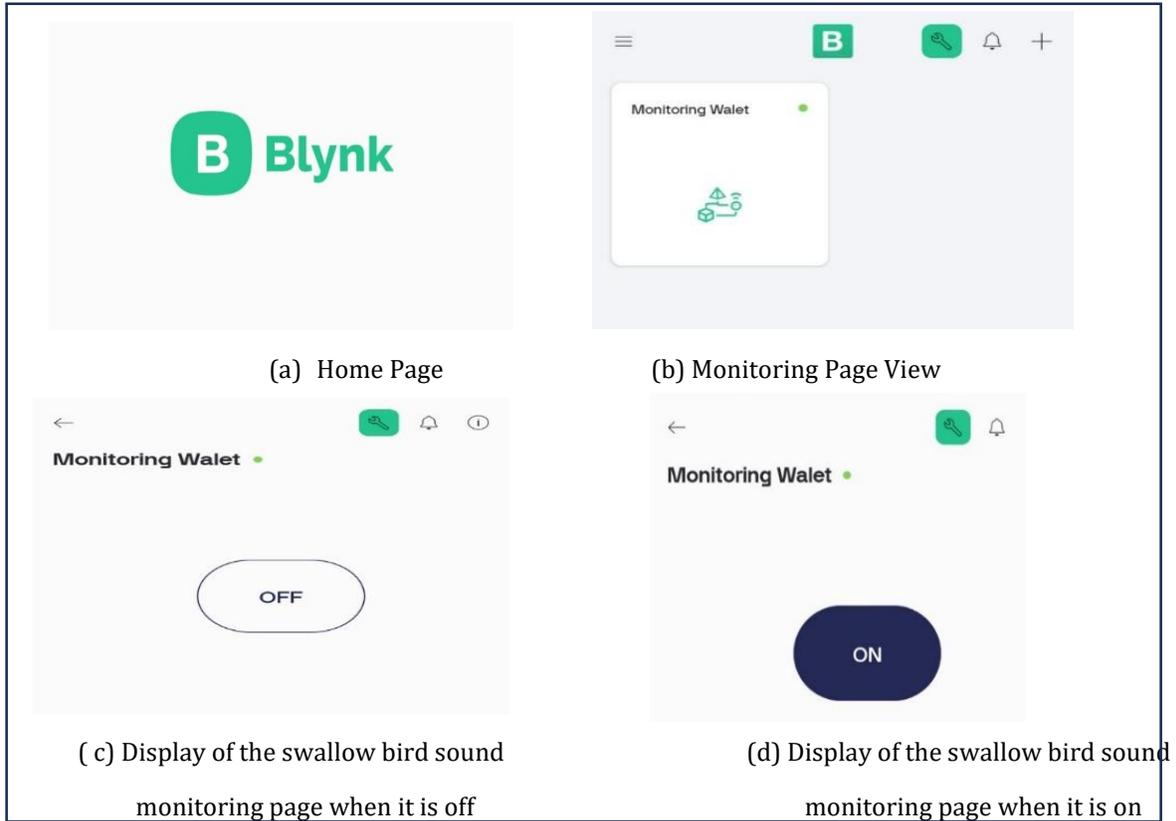


Figure 3. System Interface Design

### 3.3 Prototype Implementation and Field Testing

The system was implemented and tested at a swiftlet house located on Jalan Pasar Baruga, Kendari City. The testing process included assembling the components, uploading the program to the ESP32 microcontroller, and establishing connectivity with the Blynk application.



Figure 4. Assembled IoT-Based Swiftlet Sound Monitoring Prototype

The assembled prototype (see Figure 4) demonstrates a compact and portable configuration suitable for small-scale swiftlet farmers. All components were enclosed in a protective electronic box to prevent damage from humidity and dust common environmental factors in swiftlet nesting houses. The device was powered by a 10,000 mAh power bank, providing operational autonomy for up to 12 hours without external electricity.

### 3.4 Testing Results

Testing was conducted through two primary validation methods : black-box testing and Blynk interface testing, in alignment with established IoT evaluation frameworks (Perry, Riege, and Brown 2003).

Table 1. Results of Black-Box Testing

| No | Test Scenario       | Input                         | Expected Output  | Result  | Description                     |
|----|---------------------|-------------------------------|------------------|---------|---------------------------------|
| 1  | Turn ON sound       | Press ON button               | Sound activates  | Success | System responds correctly       |
| 2  | Turn OFF sound      | Press OFF button              | Sound stops      | Success | Immediate stop                  |
| 3  | Offline mode        | Press ON/OFF without internet | No change        | Success | System ignores offline commands |
| 4  | Status check        | Reopen app                    | Last state shown | Success | Retains previous state          |
| 5  | Unauthorized access | Use unregistered account      | Access denied    | Success | System secure                   |

The black-box results show 100% functional accuracy, with an average response time of  $\pm 1$  second, confirming that the system performs efficiently under normal network conditions.

Additionally, interface testing on the Blynk dashboard verified that user commands and feedback were synchronized correctly, displaying real-time updates of device status (ON/OFF).

### 3.5 System Performance and User Experience

The results indicate that the system achieved all design expectations, including remote accessibility, energy efficiency, and ease of use. Farmers could operate the system using a smartphone connected to the internet, eliminating the need for daily on-site visits. This aligns with the findings of (Damanik 2024) and (Sahrul, Candra, and Nur 2023), who observed similar improvements in automation efficiency through IoT-based solutions in swiftlet farming.

Moreover, the energy efficiency of the system supported by a rechargeable power source offers sustainable use in rural areas with limited electricity access. This aspect reflects a significant contribution to local innovation in agritech, supporting Indonesia’s broader digital transformation in agriculture agenda (Fatih Muhana and Fuad 2024).

### 3.6 Discussion

The study demonstrates that integrating IoT technology into swiftlet farming yields substantial operational benefits. The system’s remote-control capability using the Blynk application represents a shift from manual labor to smart automation, reducing workload and human error. From a technical standpoint, the NodeMCU ESP32 provided stable connectivity and processing power adequate for controlling the DFPlayer Mini, validating its suitability for lightweight IoT applications. The modular nature of the design allows scalability future research may integrate sensors for temperature, humidity, and light intensity, further enhancing environmental optimization for swiftlet breeding.

From an economic and social perspective, the innovation empowers local farmers to adopt affordable digital tools without requiring advanced technical knowledge. This system bridges the gap between traditional

practices and Industry 4.0 technology, positioning local farmers as active participants in digital innovation (Stevenson, 2018).

### 3.7 Summary of Findings

Before presenting the Summary of Findings, it is essential to highlight that the results obtained from testing and implementation demonstrate the system’s ability to operate efficiently, reliably, and in real time. The integration between hardware and software components specifically the NodeMCU ESP32, DFPlayer Mini, and Blynk application proved highly effective in enabling seamless communication and remote control. These outcomes validate the research objective of creating a practical and low-cost IoT-based solution for swiftlet farmers. The following table provides a concise comparison between the traditional manual system and the newly developed IoT-based monitoring system.

Table 2. Summary of Findings

| No | Aspect        | Traditional System    | IoT-Based System        |
|----|---------------|-----------------------|-------------------------|
| 1  | Control       | Manual (on-site)      | Remote (via smartphone) |
| 2  | Efficiency    | Time-consuming        | Time-efficient          |
| 3  | Energy Source | Fixed electricity     | Portable power bank     |
| 4  | Monitoring    | No feedback           | Real-time ON/OFF status |
| 5  | Cost          | High operational cost | Low maintenance cost    |

The results confirm that the IoT-based system significantly enhances operational efficiency and reliability. It validates the research hypothesis that automation through IoT can improve the management of swiftlet sound systems, leading to increased productivity and sustainability in local agribusiness.

## 4 Conclusions

This research concludes that the implementation of an Internet of Things (IoT)-based sound monitoring system for swiftlets in Kendari City successfully provides an efficient, reliable, and user-friendly solution to overcome the limitations of conventional manual systems. By integrating the NodeMCU ESP32 microcontroller, DFPlayer Mini, and Blynk mobile application, the system enables real-time remote control of sound playback with a response time of approximately one second. The findings demonstrate significant improvements in operational efficiency, energy usage, and monitoring flexibility, allowing swiftlet farmers to manage their operations without being physically present on-site.

The study also affirms that IoT technology can be effectively adapted to local-scale agribusinesses, such as swiftlet farming, where automation contributes not only to convenience but also to productivity and cost reduction. Moreover, the use of affordable components and open-source platforms enhances accessibility for small-scale users, promoting the digital transformation of traditional industries.

For future researchers, it is recommended to expand this prototype by integrating additional environmental sensors (temperature, humidity, and light intensity) and implementing automated scheduling systems to optimize sound duration and frequency. Further studies may also explore data analytics and machine learning approaches to predict optimal operating patterns and improve decision-making for farmers. Ultimately, this research underscores that the adoption of IoT-based systems can transform traditional farming practices into smart, data-driven operations that align with the goals of sustainable and intelligent agriculture.

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