Implementing a Smart Farm Layer Management System Using Microcontrollers and Android

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***Abstract*— Cage management has long been considered one of the most important influences on poultry health and productivity. As well as the comfort of the cage, it is important to focus on safety and maintain all conditions in, around, and through equipment and supplies that have been used, implementing a preset condition or an overall system. Nevertheless, the closed-house layer cage system is said to be associated with some disadvantages. For example: There is no real-time capture and recording of temperature and humidity values detected by sensors. Furthermore, although the system includes some real-time values and notifications about egg collections, it does not have any daily recording data or performance dashboard for the cage, for example, indicating eggs laid per day versus the predicted number of chickens in cages, so production efficiency can be calculated on a weekly basis. It is also clear that such attributes will be a requirement for breeders to make continued performance evaluations simpler. Further, there is no layered security system in place to operate the instruments or appliances installed. The existing control system can only be operated within the enclosure on a control panel and does not support remote operation with mobile devices.**

Keywords— Smart Farm, IoT, Poultry, Closed house farm, hen day production

I. Introduction

The Indonesian People's Poultry Association (Pinsar) stated that the consumption of meat and chicken eggs by the Indonesian population is still lower compared to the consumption per capita of neighboring countries such as Malaysia and Thailand [1]. In contrast, according to the Central Statistics Agency (BPS), the average consumption rate of local chicken or free-range eggs in the country in 2022 was 2,336 kilograms per capita per week. An increase occurred in egg consumption by 2.45% compared to the previous year (year-on-year/yoy), which was only 2.28 kg per capita per week in 2021 [2]. The increasing demands for nutritional needs, in this case eggs, have made the livestock industry post-pandemic start to rise and grow.

Management of poultry health and production levels in the livestock business cannot be separated from cage management, where cage comfort is critical since it affects productivity [3]. Layer breeders often employ either open or closed cages. However, breeders are beginning to transition from open cages to closed-house farms. The closed cage is outfitted with cage equipment such as humidity sensors, temperature sensors, an exhaust fan, a cooling pad as a cooling system, curtains, and a cage controller equipped with a security alert that will sound if there is a mismatch in the equipment's operating system. pen. The fan control system is separated into two systems: direct fans, in which a number of fans run constantly for 24 hours, and fan control systems, which are dependent on panel settings, temperature position, or humidity. If the direct fan abruptly switches off owing to the motor burning out or the electrical command failing, an alert will ring on the panel. As a precaution, the closed cage has a drop curtain and a limit switch. If an off position occurs on one or more direct fans, the curtain will open automatically. If the limit switch sensor encounters the curtain or when the curtain is closed, an alert will ring.

The current system lacks data recording for temperature and humidity values obtained by sensors, among other flaws. Data can only be acquired by connecting a port connection between the computer and the mainboard on the control panel; therefore, it cannot be accessed in real time. Currently, there is no daily data recording or cage performance dashboard linked to the system to let farmers monitor the performance of hens in cages. Data that may be recorded include the number of eggs produced, the number of the number of chickens that die, the quantity of feed consumed, the amount of water drunk, and the productivity of chickens in generating eggs. There is also no security mechanism to guarantee that the equipment or instruments deployed work properly. Security or security alerts caused by system failure in the cage may not work if the alarm siren is switched off by cage staff. The existing control system can only be operated from a control panel within the enclosure and cannot be controlled remotely using a mobile device. The aim of this research is to develop a closed-house chicken coop system with an alarm system and notifications that are documented and connected through Android. Furthermore, to implement a double security system on the existing system, where alarms not only sound on the control panel inside the coop but also on mobile devices, developing a mobile device application as a tool or remote controlling system as well as facilitating analysis and coop performance monitoring through dashboard analysis of existing recorded data.

Raising laying hens in a closed house system remains ineffective; thus, internet-based smart apps are required to improve the efficacy and efficiency of business in the laying hen farming sector [4]. Pribandanu et al. [3] designed coop automation utilizing the Omron Sysmac CPM1A20-CDR-A-VI PLC to manage temperature, humidity, lighting, and conveyors for transferring feed; however, this application is utilized in boiler chicken coops. Adinegoro et al. [5] also developed an Internet of Things (IoT)-based enclosure control system that utilized an Arduino Nano ESP8266 microcontroller and data fed into a web server. Cage monitoring is based on a wireless sensor network and IoT, using an Arduino Uno 3.

This research aims to assist layer chicken farmers in obtaining a smart application utilizing digital technology and internet-based information. This will streamline coop monitoring for farmers in real-time through a smart application on mobile devices or smartphones. It will also enhance production outcomes in layer chicken farming.

II. Methods

This section outlines a detailed explanation of the methodologies used in this research. The closed-house farm is the first topic of discussion, followed by a control system and programmable logic controller. In addition, we describe the hardware specifications and dashboard.

A. Closed House Farm

Poultry housing is an important part of poultry management. For farmers using intensive systems, the coop is critical to the success of their cattle. Construction of coops is necessary to protect chickens from midday heat, rain, wind, cold air, and predators. Furthermore, coops help to monitor poultry activities, such as ensuring hens are properly fed and watered, as well as keeping track of their health state [6] [7].

A closed-house farming system is a concept in which the agricultural environment is modeled like a facility where animals are housed that is entirely regulated and secluded from the outside world [8]. This system is intended to provide the best circumstances for animal care by managing temperature, humidity, light, air circulation, and safety. Closed-house cages may also manage the appropriate air temperature using internal technology to ensure comfortable air circulation [9].

Kim et al. [10] stated that the harmful effects of heat stress are the same whether laying hens are subjected to temperatures of 32°C or 27°C. Meanwhile, Barrett et al. [11] reported that laying hens subjected to heat stress may reduce feed intake, reduce heat generation, and alter blood flow from organs to body surface regions to dissipate heat (Fig. 1). In addition to temperature, humidity can have an impact on egg production performance [12]. Relative humidity is the ratio of the actual water vapor content in the air to the quantity of saturated water vapor at the same temperature, stated in percentage form [13].

B. A Control System and Programmable Logic Controller

A control system is a system where its output is controlled to a certain value or to change some predetermined conditions from input to the system. To design a system that can respond to voltage changes and execute commands based on the situation, an understanding of control systems is required. A control system is a condition in which a device can be controlled according to changes in the situation [3].

Programmable Logic Controller (PLC) is an electronic device that operates digitally and has programmable memory, storing commands to perform specific functions such as logic, sequencing, timing, counting, and arithmetic to control various types of motors or processes through analog or digital input/output modules. Inside the PLC, there is electronic circuitry that can function like contact relays (both normally open and normally closed), which can be used repeatedly for all basic instructions besides output instructions. Therefore, it can be said that in a PLC program, using output with the same contact number is not allowed. According to Efendi (2019) [14], PLC offers several advantages:

1. Easier maintenance as only input and output wiring into the PLC is required, while the control circuitry is programmed via a computer.

2. Control relays do not have physical forms since they are controlled within the PLC program itself, and the auxiliary contacts of each virtual relay can be numerous, unlike real control relays in conventional control systems that are limited.

3. More reliable in operation and maintenance.

4. Easier troubleshooting due to PLC's self-diagnostic facilities.

5. If the control flow of the system changes, the modification is only made to the program on the computer relatively quickly, as its name suggests, it's a programmable logic controller.

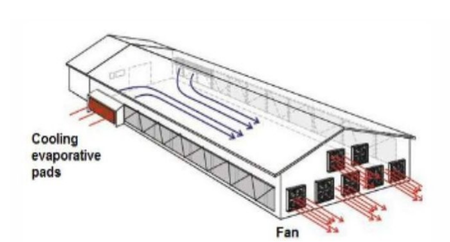

Fig.1 A closed-house farm illustration [15]

C. Hardware Specifications

There are several hardware specifications used in this research. It can be seen in the Fig.2

Fig.2 Hardware Specifications

D. Dashboard

A dashboard is a visual presentation of the most relevant information required to fulfill one or more goals, which is integrated and organized on a single screen for easy monitoring [16]. A dashboard is an information system application that displays information about the key indicators of organizational activity on a single screen. Making the model takes into mind three major features of the dashboard: data and information display, customization, and user collaboration [17]. One tool for building dashboards is Microsoft Power Business Intelligence.

III. Results and Discussion

Before installing a smart farm layer management system, various steps must be completed. The first stage is to produce a block diagram schematic design that shows what equipment is utilized to build a smart farm layer. Figure 3 shows the block diagram schematic design.

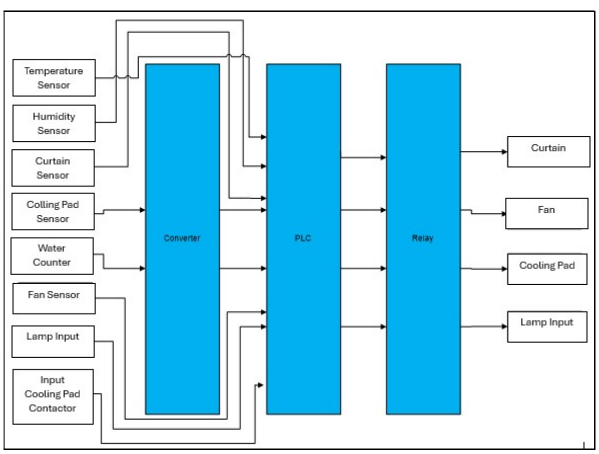

Fig.3 Schematic Block Diagram of a Smart Farm Layer Management System

In designing this equipment, several tools will be used, such as:

1. the Arduino Mega 2560 microcontroller, where the Arduino is classified as having a larger memory than the Arduino UNO series or type, namely having 8KB SRAM (Static Random Access Memory) memory. Meanwhile, the EEPROM (Electrically Erasable Programmable Read Only Memory) is 4KB and has Flash memory that can be filled with programs of 256KB and has a larger number of pins, namely 54 pin.
2. For temperature and humidity sensors, use the AM2302 (Wired DHT22) sensor, where this tool has the following advantageous features:
   - High level of temperature and humidity measurement accuracy
   - Humidity: 0 to 99.9% RH with 2% accuracy
   - Temperature: -40 to 80 ℃ with a tolerance of around 0.5℃
   - Various temperature and humidity measurements
   - Very low power consumption
   - Signal transmission distance 20 meters
   - Already calibrated, can be used straight away
   - Dimensions: 40 x20 x11mm
3. The ME-8108 limit switch is employed as a fan shutter limit switch, and it serves as an additional security feature that overlays fan performance in the program. By installing this restriction, you can ensure that the fan's electrical output is functioning properly, i.e., that the fan is turned on. This limit is also set on the curtain or drop curtain, which is very necessary as a safety measure when there is a problem with the fan or when the fan fails to run, therefore the curtain must be in an open position to provide sufficient air and oxygen circulation in the cage.
4. The Cooling Pad Water Sensor is used to detect the flow of cooling water as one of the tools for controlling the temperature of the air in the room.
5. Wi-Fi Module: ESP-01 ESP8 266 is a highly integrated chip developed to meet the demands of the future connected world. It provides a comprehensive, stand-alone Wi-Fi networking solution, with the ability to host applications or offload all Wi-Fi networking functions to other application processors.
6. The ESP8266's robust on-board processing and storage capabilities enable it to be integrated with sensors and other application-specific devices via GPIOs with minimal upfront work and runtime loading. The high level of on-chip integration allows for minimum external circuitry, and the complete solution, including front-end modules, is designed to take up minimal PCB space.
7. LCD touch screen. The NT35510 LCD is a touch screen device that is installed on the panel to obtain information that has been set to be displayed and operated via this touch screen.

The next step is testing the prototypes that have been made. This design and system are applied to the cage (Fig. 4). The following is a visualization of the prototype that has been created and simulated into the Android APK on a mobile device.

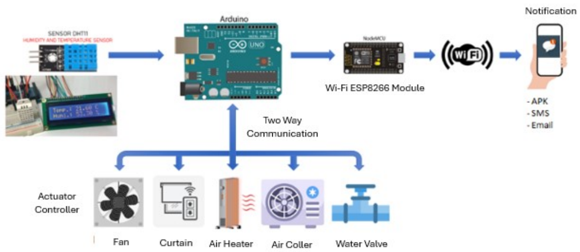

Fig.4 Equipment communication schemes and flows

Fig.5 Closed House Farm Cage System Prototype

Fig.6 Installed Microcontroller Illustration

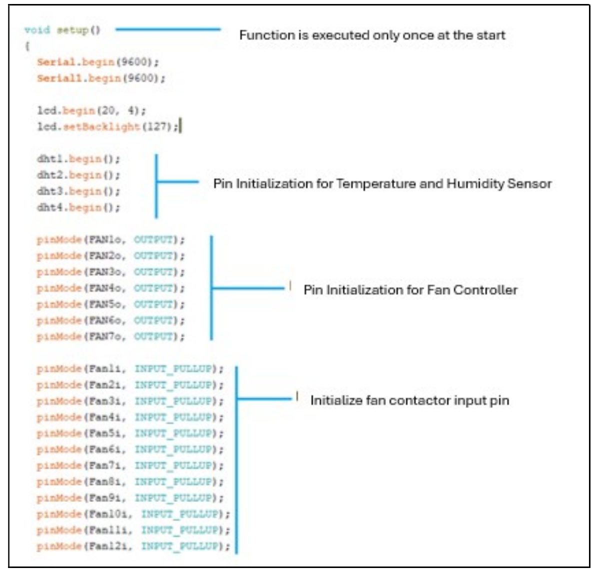

Fig. 7 Script code used

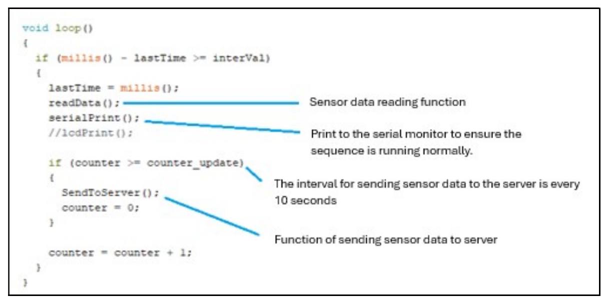

Fig. 8 Function of The Script Used

All data readings from sensors (Figs. 5 and 6) are received and stored in the database, and the data will be sent to the Android application, with the results displayed as follows: Each sensor point of the 5 sensor points, both temperature and humidity sensors, can be monitored according to the display above. From the 5 sensor points, the average data is taken, either temperature or humidity data (Fig. 7). The average data will later be refreshed every 30 seconds (Fig. 8), and the data can be retrieved in the form of numerical data or graphs. Apart from that, in this farm application there is a menu for monitoring the fan (on or off position), and you can intervene to start or turn it off by remote control using this application (Fig. 9). The condition of lighting, cooling pads, and curtain sensors can also be controlled and monitored remotely using this application (Fig. 10).

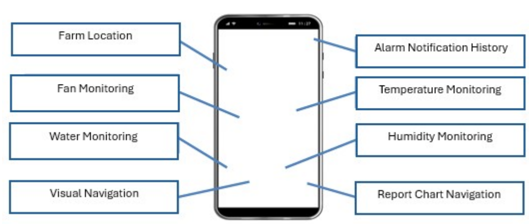

Fig.9 Application view in Android

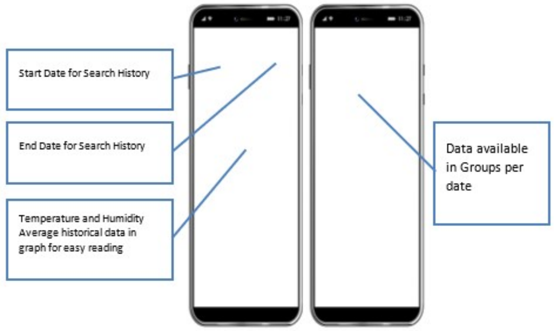

Fig.10 Data Visualization Graphs in Android Applications

By entering the data collection start date range and the end date for the data collection cut-off, the desired data can come out immediately. The data menu is available to display data in the form of daily figures or in the form of data graphs. For daily recording, the cage can also be monitored, namely: egg production performance, average egg weight, number of eggs produced, amount of feed consumed, position of drinking water consumption, number of chicken deaths, and so on. All daily recording data can also be seen on the dashboard to make it easier for the owner to analyze and make subsequent decisions.

The farm performance dashboard display menu can be seen in Fig. 11.

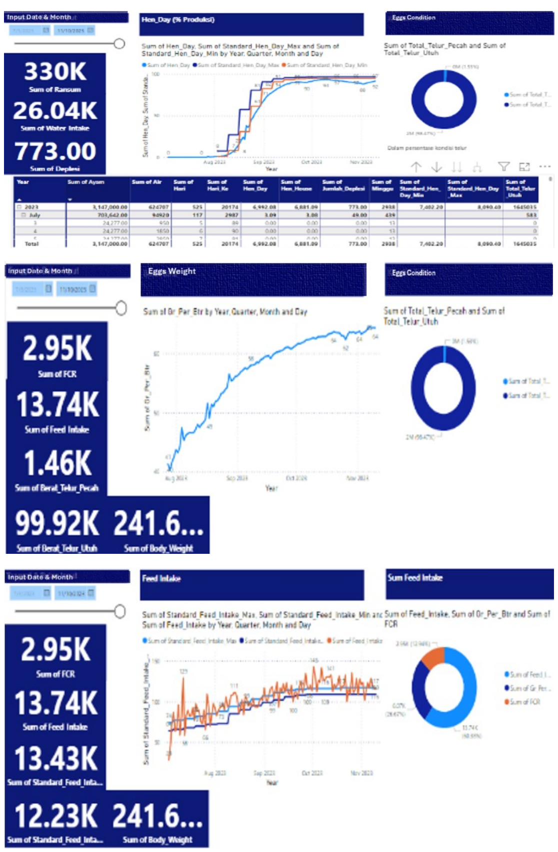

Fig.11 Farm Performance Dashboard Display

The prototype that has been created has been demonstrated to chicken farmers, who have a chicken population of around 3000 to 5000 chickens. The feedback provided by the farmers is very valuable for the further development of the system (Table 1). In general, farmers feel that this system is very helpful in farming work, especially in terms of monitoring the condition of the cage. It is easy to use and interesting because it can be monitored remotely through the application. Farmers mentioned that they can see basic data such as the amount of feed given and the temperature of the cage, which is very helpful in daily decision-making.

However, because the system is still in the prototype stage, some features have not been fully integrated, which causes some challenges in navigation and operation. Farmers who tried this prototype suggested that the user interface be made simpler and a step-by-step guide be added to make the process of use easier. Although still in the early stages, this prototype has shown significant potential in helping farmers monitor chicken conditions in real time. Farmers also highlighted the need for additional features to provide automatic notifications or warnings when certain conditions occur, such as a drastic drop in temperature or changes in the chicken diet. In terms of impact on farming efficiency, because the scale of the demo is still small, significant changes in egg production or operational efficiency cannot be measured precisely. However, farmers believe that if the system is further developed and fully utilized, there is potential for time savings and increased productivity.

TABLE 1. FEEDBACK FROM CHICKEN FARMERS

Aspect	Feedback Description	Assessment (1 to 5 scale)	Recommendation
Usability	The prototype is easy to use, but some features are not fully integrated, causing challenges in navigation.	3.5/5	Simplify the user interface and add usage guides.
Effectiveness	The prototype helps in monitoring basic conditions such as cage temperature and feed amount, but needs to add automatic notification features..	4/5	Add automated alert features and further data integration.
Farm Efficiency	The impact on efficiency is not yet significant at this demo scale, but there is potential for time savings and increased productivity.	3.5/5	Develop a mobile version for easier access in the field.

IV. Conclusion

After creating and designing a closed-house chicken coop system with a system for monitoring temperature, humidity, lights, curtain sensors, a cooling pad, a fan, and daily recording, it can be concluded that making a closed-house chicken coop can increase livestock efficiency, where farmers can monitor performance. enclosure via the existing dashboard on the mobile device. Apart from that, sound alarms and notifications recorded on a mobile device or database can make it easier to carry out reviews and take action when there are problems with cage equipment.

Based on the results of the prototype demonstration conducted on chicken farmers, it was found that the system created showed significant potential in helping to monitor chicken conditions and make daily decisions. In terms of usability, the system obtained an average value of 3.5 on a scale of 1 to 5, indicating that the system is quite easy to use, although there are some improvements needed in navigation and feature integration. In terms of effectiveness, the prototype obtained a value of 4 on a scale of 1 to 5 because it succeeded in providing monitoring of basic conditions such as cage temperature and feed amount, although the automatic notification feature still needs to be added. The impact on agricultural efficiency obtained a value of 3.5 on a scale of 1 to 5, and farmers saw the potential for time savings and increased productivity in the future. This feedback shows that with further development, including simplifying the interface, adding automatic notification features, and developing a mobile version, this system has the potential to substantially improve the operational efficiency and productivity of chicken farms.

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