Smart Poultry Farming: Enhancing Chicken Welfare and Productivity with IoT-based Monitoring Temperature Humudity

Muya Is Nabil
Informatics
University of Technology Yogyakarta
Yogyakarta, Indonesia

Anna Dina Kalifia
Master Program of Information
University of Technology Yogyakarta
Yogyakarta, Indonesia

Anita Fira Waluyo
Master Program of Information
University of Technology Yogyakarta
Yogyakarta, Indonesia

ABSTRACT
Monitoring temperature and humidity on chicken farms using Internet of Things (IoT) technology aims to improve the welfare and productivity of laying hens. In this research, a monitoring system using DHT11 and ESP8266 sensors connected to a mobile application was developed. This system allows real-time monitoring of cage conditions to maintain optimal temperature and humidity, thereby improving the health and productivity of chickens. The research methods used include observation, interviews, and literature studies for data collection. The test results show that the monitoring device functions as expected with an average temperature measurement error rate of 1.59% and humidity of 0.58%. The implementation of IoT in chicken farming provides significant benefits in terms of efficiency and animal welfare.

General Terms
Internet of Things

Keywords
Internet of Things, Temperature Monitoring, Humidity Monitoring, Chicken Farm, Mobile Apps

1. INTRODUCTION
Chicken farming plays a crucial role in providing poultry meat, but controlling temperature and humidity in cages is a key factor in ensuring the success of this industry. Climate change, which causes temperature fluctuations, can negatively impact on the health of laying hens and reduce egg production. Therefore, an IoT-based temperature and humidity monitoring system has been developed to assist farmers in maintaining optimal environmental conditions.

The system enables real-time monitoring via smartphones using DHT11 and NodeMCU sensors to measure temperature and humidity. This technology allows farmers to respond quickly to changes in cage conditions, thereby improving chicken welfare and optimizing egg production. The primary objective of this research is to support farmers in overcoming challenges posed by climate change in the poultry industry.

Livestock is the main source of food after agriculture. Efforts made by farmers to improve the quality of livestock include genetic selection, good nutrition, health services, effective cage management, and the use of modern technology and education. This aims to meet the demand for high-quality animal products in the global market as well as maintaining the welfare and environment of livestock farms [1]. The chicken industry has experienced significant growth in Indonesia, especially chicken meat production. This increase is due to the efficiency of chicken production. Chicken grows rapidly and can reach a live weight that meets consumer needs in a relatively short time, making chicken meat an effective source of protein to meet human needs [2].

Temperature and humidity monitoring using DHT11 sensors and NodeMCU ESP8266 connected to a mobile application is essential in chicken farming. It allows for quick monitoring to maintain the welfare, productivity, and safety of the chickens [3]. This installation allows a direct or remote control of the temperature and humidity inside the chicken house, providing flexible monitoring without having to worry about distance and time. This ensures optimal conditions and promotes effective farm management [4].

Accuracy in measuring weather parameters is important because accurate weather observations have a major impact on the understanding of current weather and the ability to predict weather changes. This is especially true in the fields of meteorology and environmental science. Regulations set by the World Meteorological Organization (WMO) set standards that must be followed in weather measurements to ensure accurate and reliable results [5].

Internet of Things (IoT) is a technology that connects physical devices through the Internet [6]. The use of microcontrollers such as the NodeMCU ESP8266 in many applications, including agriculture and animal husbandry [7]. The application of IoT in monitoring chicken flocks with temperature and humidity sensors provides benefits in the form of real-time monitoring, automatic control, and early warning to improve animal welfare [8]. The concept of IoT was introduced by Kevin Ashton in 1999 [9] and uses devices such as Arduino and the Android operating system. Cloud networking platforms are used to connect and manage IoT devices [10], with wide applications in various sectors, including smart homes, industry, healthcare, and agriculture. Technology IoT continues to evolve along with advances in technology and connectivity [11].

2. RESEARCH METHODS
This research uses descriptive qualitative research methods, focusing on understanding and describing phenomena using words and natural language. Data is obtained in the form of descriptions of observed behavior. This qualitative research aims to understand the phenomenon from the subject's point of view, including aspects such as perception, behavior, action,

motivation, and others. The data obtained in this study is original data that has not been manipulated or created. This research method also includes observation, interviews, and document research to collect in-depth information about the phenomena observed on chicken farms [12]. This research employs descriptive qualitative methods, focusing on understanding and describing phenomena using natural language. Data collection includes direct observation, structured interviews, and literature studies. The study follows several stages, including data collection, system analysis, system and physical design.

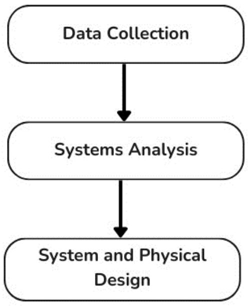

Figure 1 Stages of Research

2.1 Data Collection

a. Observation

Observation was conducted to understand user needs for the software to be developed [13], particularly in the context of monitoring chicken farms. This process involved direct examination of farm conditions and ongoing activities.[14]. When observing, system analysts can choose to participate in the activity or simply observe. The goal is to collect general data by means of direct observation of events in the field. This involves visiting the research site to observe and understand various aspects related to software development [15].

b. Interview

Structured interviews were conducted with farm owners and poultry experts in Suradadi, Tegal to gain insight into the challenges and specific requirements of a temperature and humidity monitoring system [16]. The interview questions focused on the efficiency of existing manual monitoring methods, potential benefits of automation, and user preferences for the mobile app interface. Interviews were also conducted with IoT developers to assess the feasibility and technical requirements of integrating sensors with cloud-based storage and real-time mobile apps [17].

c. Literature Study

Comprehensive literature study was conducted to analyze various academic references, including peer-reviewed journals, conference papers, and books related to IoT-based environmental monitoring in poultry farming. This method provided insights into existing technologies, methodologies, and best practices in temperature and humidity monitoring systems. The study also examined previous research findings to identify gaps and areas for improvement in the current monitoring approach. Additionally, regulatory standards and guidelines were reviewed to ensure compliance with industry's best practices and scientific rigor.[18].

2.2 System Analysis

Flowchart was designed to illustrate the process of storing temperature and humidity data in the cloud database. The system's workflow begins with the initialization of the DHT11 sensor, which reads temperature and humidity data via ESP8266. The data is then sent to the cloud database and displayed on a mobile application. The system also provides notifications and recommendations regarding optimal temperature and humidity levels.

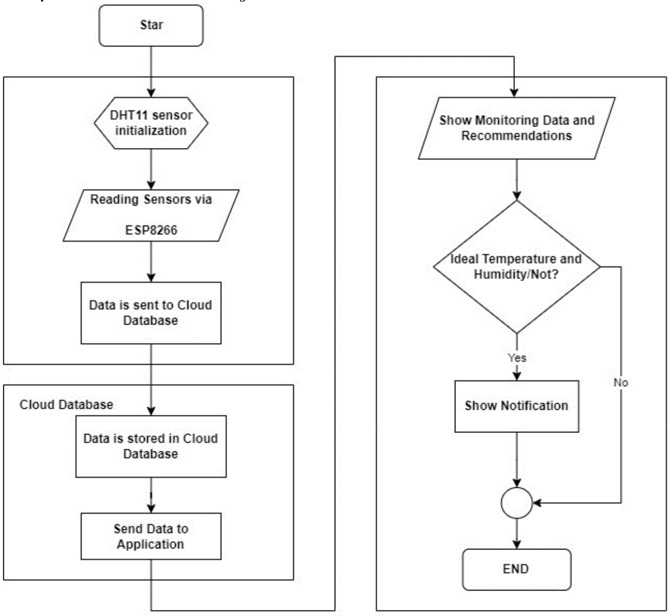

Figure 2 Flowchart

In Figure 2 flowchart, is the process flow of storing temperature and humidity data into the Cloud database. The initial stage carried out is DHT11 initialization. After initialization is complete, the DHT11 sensor then reads the sensor via ESP8266 which will be sent to the Cloud database, then the data is stored in the Cloud database, then the data is sent to the codular, then display monitoring data and recommendations, is the temperature and humidity ideal / not? then display notifications.

2.2.1 Functional Requirements

Functional requirements define the essential features and capabilities that the system must have to fulfill its intended purpose.

a. The system must allow users to access it via the internet.
b. Real-time monitoring of environmental conditions such as temperature and humidity must be enabled.
c. DHT11 sensor must detect temperature levels and send data values to Firebase.
d. Firebase must process and store the data received data for further use.

2.2.2 Non-Functional Requirements

A. Software

The software used must support hardware components, specifically the Arduino Uno to program, configure, and update its functionality.

a. Windows 8.1 64-bit on a laptop
b. Arduino IDE
c. Google Chrome
d. Kodular
e. Firebase
f. Draw Io

B. Hardware

The components used must align with their respective types and functions to effectively support the development of a mobile-based temperature and humidity monitoring system.

a. laptop
b. ESP8266
c. DHT11 Sensor
d. Jumper cable
e. USB serial cable
f. LCD 12C

2.3 System and Physical Design

a. System Design

The use of the prototype method to monitor temperature and humidity in chickens allows for rapid and incremental system development. This facilitates interaction between developers and users during the development process [19], so that developers can easily model the software and hardware to be used [20]. After being evaluated, the application prototype becomes the basis for creating a final application that is more complete and ready to be used to monitor temperature and humidity in chickens [21]. The following is the design of the temperature and humidity monitoring system in the chicken coop.

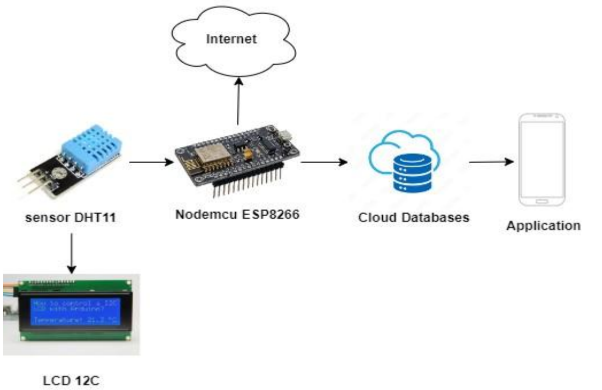

Figure 3 System Design

In the cage there are hardware components consisting of Arduino Uno, DHT11 sensor, ESP8266. These hardware components will be connected to the mobile application via a web server. Users (breeders) will be able to monitor the temperature and humidity in the cage through the mobile application.

Table 1 Temperature and Humudity

No.	Age (Days)	Temperature (°C)	Humidity (%)
1.	1-7	32-35 °C	50-60 %
2.	8-21	29-31 °C	40-50 %
3.	22-25	21-24 °C	40-60 %

The temperature must be kept stable. The difference between day and night is also regulated so that it is not too extreme. This is because differences above 40 C can cause chickens to experience stress. The temperature of the layer cage must be maintained in such a way that the chickens remain comfortable, and the production is high and has good egg quality. Different cage models also affect the ideal temperature. For relatively closed house cages, the comfortable temperature ranges from 21 - 24°C.

b. Physical Design

Physical design is the process of implementing the results of conceptual design into a more detailed design model, so that it can be used to compile code and test programs.

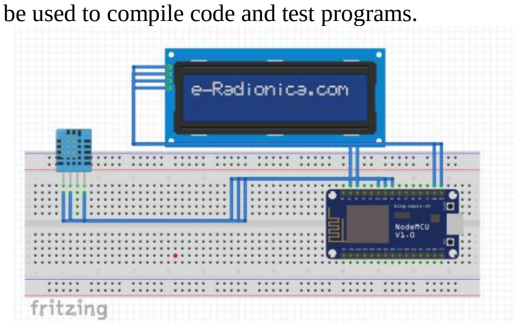

Figure 4 Physical Design

The DHT11 sensor as a temperature and humidity sensor will measure the temperature and humidity conditions in the chicken coop. The data will be processed as well as controlling the entire system by the ESP 8266 MCU Node which functions as a link between the module and the internet / by using a WiFi network to be sent to the cloud database. LCD will display temperature and humidity data.

3. RESULT AND DISCUSSION

The developed IoT-based monitoring system was implemented and tested to evaluate its performance in a real poultry farm environment. The hardware components were successfully integrated, and the system provided real-time data transmission to the cloud. Farmers could monitor environmental conditions remotely via the mobile application, ensuring that corrective actions were taken promptly to maintain optimal conditions [22].

3.1 Result

In this study, a temperature and humidity monitoring system on a chicken farm was successfully tested. The system includes a DHT11 sensor and a Node MCU microcontroller. The DHT11 sensor is used to measure air temperature and humidity, while the Node MCU collects data from the sensor, processes it, and sends it to the application, enabling real-time monitoring. The test results show that the temperature and humidity monitoring device work as expected, helping chicken farmers maintain suitable environmental conditions for their chickens [23].

a. Sensor Result

Testing demonstrated that the DHT11 sensor effectively captured temperature and humidity levels with a high degree of accuracy. The system recorded data every 5 seconds, and the results were validated against standard measuring instruments. The average error rate for temperature measurement was found to be 1.59%, while humidity measurements had an average error of 0.58% [24]. The entire temperature and humidity monitoring circuit in chicken livestock can be seen in Figure 5.

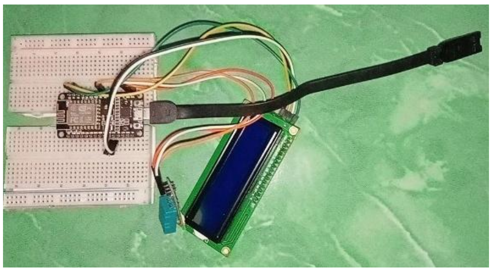

Figure 5 Hardware Sensor

The temperature and humidity data generated by the sensors will be uploaded to the cloud database and displayed in real time through the app. The sensor sends data every 5 seconds, although sometimes there is a time lag that varies. By viewing the sensor data for approximately 60 seconds.

b. Application Result

The mobile application provided farmers with a user-friendly interface to access real-time environmental data. Notifications were implemented to alert users whenever temperature or humidity levels deviated from optimal ranges. This feature enabled immediate corrective action, reducing the risk of poultry stress and improving overall farm productivity. Additionally, the application allowed users to review historical data trends, enabling better decision-making for farm management. The integration of Firebase ensured secure storage and quick data retrieval, enhancing the application's reliability and usability. Users reported improved efficiency and ease of use compared to manual monitoring methods. The application screen can be seen in Figure 6 Login, and Figure 7 Monitoring.

Figure 6 Login **Figure 7 Monitoring**

Figure 6 shows the login page on the application platform which is the application interface before users can access the monitoring page. Users are asked to enter their "Username" and "Password" and after clicking the "Login" button, they will be directed to the dashboard page.

Figure 7 is a screen displaying the in-app monitoring page showing real-time temperature and humidity values. The app allows farmers to monitor the current temperature and humidity and provides information on the most comfortable temperature and humidity values for laying hens. This provides useful tips for farmers to maintain optimal environmental conditions for laying hens.

3.2 Discussion

In this discussion, the temperature and humidity were changed by raising the temperature by heating, lowering the humidity by using a dryer, and lowering the temperature and humidity by spraying water. Tests were conducted indoors at night to observe the response of the monitoring system to changes in environmental conditions that may occur in the chicken coop.

The ideal temperature for chickens varies depending on their growth stage. In the early stages, the ideal temperature is between 32 and 35°C, then gradually lowered to around 27°C by theend of the first week. During the later growth stages, the temperature is maintained at around 27°C and gradually decreases as the chickens grow. When the chickens reach the production stage, the recommended temperature is 18°C to 24°C, with mature chickens being more tolerant of lower temperatures than young chickens. Monitoring and regulating these temperatures are important to ensure optimal health and development of the chickens.

The ideal humidity for raising chickens varies depending on their growth stage. In the early stages, a humidity level of around 50-60% is important as it helps prevent dehydration in very young chickens. In the later stages, humidity can be kept at 50-60% to allow the chickens to grow and develop feathers. At the production stage, the recommended humidity ranges from 40 to 70%, with an optimum range of around 50 to 60%. Appropriate adjustment of humidity at each growth stage is an important factor in maintaining chicken welfare and health. In table 2 there are sensor tests compared to thermometer measurements.

Table 2 Sensor Testing

No	*Sensor*	*DHT11*	*Measurement*	*Thermometer*	*Presentation*
	Temperature	Humidity	Temperature	Humidity	Error
1.	28.50 °C	82.00 %	29.00 °C	83.00 %	0,51
2.	28.90 °C	79.00 %	30.00 °C	80.20 %	1,11
3.	29.10 °C	78.00 %	30.10 °C	79.10 %	1,50

4.	29.80 °C	78.80 %	30.80 °C	79.80 %	0,70
5.	30.20 °C	77.00 %	31.40 °C	78.00 %	0,90

Table 2 contains the results of sensor testing compared to thermometer measurements, as well as an overview of the differences between the two measurements. This table can contain data from DHT11 sensor measurements and thermometer measurements, as well as the difference between the two data. This difference can be used to evaluate the accuracy of the DHT11 sensor in measuring temperature and whether there are biases or errors that need to be considered when using it. This is important for evaluating the quality and performance of air temperature monitoring sensors in chicken farms.

The test is carried out by heating the tool until it reaches a temperature of about 20ºC, then the measurement starts and the temperature around the sensor is raised slowly with a lighter until it reaches 35ºC. From the results in the table above, it is found that the difference between sensor readings and the average measuring instrument is 0.5ºC or an average error of 1.59%.

The test begins with the humidity sensor sensing the humidity of the room, then the measurement begins and the humidity around the sensor is slowly increased by spraying water points in the air with a spray so that an increase in humidity value is obtained. From the results in the table above, it is found that the difference between sensor reading, and the average measuring instrument is 0.2% or an average error of 0.58%.

4. CONCLUSION

The use of Internet of Things (IoT) technology to monitor temperature and humidity on chicken farms offers significant benefits. The monitoring system developed using sensors and hardware connected with a mobile app allows farmers to maintain real-time temperature and humidity conditions. This helps in maintaining the health and productivity of laying hens by ensuring optimal environmental conditions.

The research method used was qualitative, including observation, interviews, and document research, which helped understand the needs and challenges in temperature and humidity monitoring in chicken farms. Temperature and humidity monitoring of chickens should be maintained at optimal conditions, with ideal temperatures ranging from 20 to 24°C in the early and late stages, and 18 to 21°C in the production stage. The ideal humidity in the production stage ranges from 50 to 70%.

The test results show that the average error of the DHT11 sensor in measuring temperature is 1.59%, while for humidity it is 0.58%. In conclusion, the use of IoT technology in temperature and humidity monitoring in chicken farms can improve efficiency and animal welfare and provide benefits for farm owners.

5. ACKNOWLEDGMENTS

Praise be to Allah SWT who has given the author permission to complete the research paper entitled “Internet of Things for Temperature and Humidity Monitoring in Poultry Farms”. The author is grateful for the support of Yogyakarta University of Technology and the contributions of family supervisors (Anna Dina Kalifia and Anita Fira Waluyo), classmates, and other stakeholders involved in this research process. I close with the hope that all your efforts and kindness will be rewarded in the same way.

6. REFERENCES

[1] I. Gunawan, H. Ahmadi, and M. R. Said, “Rancang Bangun Sistem Monitoring Dan Pemberi Pakan Otomatis Ayam Anakan Berbasis Internet Of Things (IoT),” Jurnal Informatika dan Teknologi, vol. 4, no. 2, 2021, doi: 10.29408/jit.v4i2.3562.

[2] R. F. Hadi, W. P. S. Suprayogi, E. Handayanta, S. Sudiyono, A. Hanifa, and S. D. Widyawati, “Peningkatan Produktivitas Usaha Budidaya Ayam Kampung UKM Putra Budi Kecamatan Mojolaban Kabupaten Sukoharjo,” PRIMA: Journal of Community Empowering and Services, vol. 5, no. 2, p. 118, Dec. 2021, doi: 10.20961/prima.v5i2.44687.

[3] Silalahi F.D, Dian J, and Nuris, “Implementasi Internet Of Things (Iot) Dalam Pemantauan Suhu Dan Kelembaban Ruang Produksi Obat Non Steril Menggunakan Arduino Berbasis Web,” JUPITER (Jurnal Penilitian Ilmu dan Teknologi Komputer), vol. 13, no. 2, pp. 62–68, Oct. 2021.

[4] Fauziah YQ Ontowirjo, Vecky C.Poekoel, Pinrolinvic DK Manembu, and Reynold F, “Implementasi Internet of Things Pada Sistem Monitoring Suhu dan Kelembaban Pada Ruangan Pengering Berbasis Web,” Jurnal Teknik Elektro dan Komputer, vol. 7, no. 3, pp. 331–338, Dec. 2018, doi: https://doi.org/10.35793/jtek.v7i3.23638.

[5] Handini I.T, Yulkifli Y, and Darvina Y, “Rancang Bangun Sistem pengukuran Tekanan Udara Menggunakan DT-Sense Barometric Pressure Berbasis Internet of Things dengan Display Smartphone,” JTAF (Jurnal Teori dan Aplikasi Fisika), vol. 8, no. 1, pp. 1–10, Jan. 2020.

[6] Agus Junaedi I.N, Ngurah Amrita A.A, and Setiawan I.N, “IMPLEMENTASI SISTEM PEMANTAUAN SUHU DAN KELEMBABAN UDARA BERBASIS IOT PADA PLANT FACTORY KEBUN PERCOBAAN FAKULTAS PERTANIAN UNIVERSITAS UDAYANA,” Jurnal SPEKTRUM, vol. 9, no. 2, pp. 8–19, Jul. 2022, doi: https://doi.org/10.24843/SPEKTRUM.2022.v09.i02.p2.

[7] I. M. R. A. Anantajaya, I. N. S. Kumara, and Y. Divayana, “REVIEW APLIKASI SENSOR PADA SISTEM MONITORING DAN KONTROL BERBASIS MIKROKONTROLER ARDUINO,” Jurnal SPEKTRUM, vol. 8, no. 4, p. 171, Jan. 2022, doi: 10.24843/SPEKTRUM.2021.v08.i04.p20.

[8] Purwania Ida Bagus Gede, Satya Kumara I Nyoman, and Sudarma Made, “Application of IoT-Based System for Monitoring Energy Consumption,” INTERNATIONAL JOURNAL OF ENGINEERING AND EMERGING TECHNOLOGY, vol. 5, no. 2, pp. 81–93, Dec. 2020, doi: https://doi.org/10.24843/IJEET.2020.v05.i02.p014.

[9] T. Alam, “A Middleware Framework between Mobility and IoT Using IEEE 802.15.4e Sensor Networks,” Jurnal Online Informatika, vol. 4, no. 2, p. 90, Feb. 2020, doi: 10.15575/join.v4i2.487.

[10] Praisye E. A. Kaunang, Sherwin R.U.A. Sompie, and Arie S.M. Lumenta, "Implementasi Google Internet Of Things Core pada Monitoring Volume Ban Angin Mobil," Jurnal Teknik Elektro dan Komputer, vol. 9, no. 3, pp. 163–170, Nov. 2020, doi: https://doi.org/10.35793/jtek.v9i3.30131.

[11] I. Setiawan, J. Junaidi, F. Fadjryani, and F. R. Amaliah, "Internet of Things (IoT) for Soil Moisture Detection Using Time Series Model," Jurnal Online Informatika, vol. 7, no. 2, pp. 236–243, Dec. 2022, doi: 10.15575/join.v7i2.951.

[12] Khobariah N.F, Sahara Hermawan P.D, and Kusumadiarti R.S, "Sistem Monitoring Suhu dan Kelembapan Ruang Server Berbasis Wemos D1," JIPI (Junal Ilmiah Penilitian dan Pembelajaran Informatika, vol. 7, no. 1, pp. 32–42, Mar. 2022, doi: https://doi.org/10.29100/jipi.v7i1.2134.

[13] M. A. T. Luqmana, F. W. Putro, and M. Sholik, "Desain Dan Implementasi Aplikasi Penghafal Al-Quran Android Di Rumah Tahfidz Rabbunalloh Surabaya," Jurnal Teknologi Dan Sistem Informasi Bisnis, vol. 5, no. 2, pp. 84–89, Apr. 2023, doi: 10.47233/jteksis.v5i2.777.

[14] Sjafrina F, Chandra Y.I, and Arnesia P.D, "Rancang Bangun Purwarupa Alat Monitoring Kelembaban dan Suhu Tanaman Bunga Mawar Menggunakan Model Big Bang Berbasis IoT," Jurnal Penerapan Sistem Informasi (Komputer dan Manajemen), vol. 4, no. 1, pp. 157–169, Jan. 2023, doi: https://doi.org/10.30645/kesatria.v4i1.126.

[15] F. Ariani, R. Y. Endra, E. Erlangga, Y. Aprilinda, and A. R. Bahan, "Sistem Monitoring Suhu dan Pencahayaan Berbasis Internet of Thing (IoT) untuk Penetasan Telur Ayam," EXPERT: Jurnal Manajemen Sistem Informasi dan Teknologi, vol. 10, no. 2, p. 36, Dec. 2020, doi: 10.36448/jmsit.v10i2.1602.

[16] R. F. Gumelar, A. Anshari, D. Ardiansyah, A. Kusuma, and M. Fauzi, "PENGELOLAAN PENYIMPANAN AIR BEKAS PENCUCIAN MESIN DI GUDANG PT ASR," Jurnal Ilmiah Teknologi Infomasi Terapan, vol. 6, no. 2, pp. 74–78, Apr. 2020, doi: 10.33197/jitter.vol6.iss2.2020.349.

[17] A. A. Islami and S. Ramadhani, "Rancang Bangun Sistem Pendataan Hardware," Jurnal Teknologi Dan Sistem Informasi Bisnis, vol. 3, no. 2, pp. 412–418, Jul. 2021, doi: 10.47233/jteksis.v3i2.300.

[18] R. Santosa, P. A. Sari, and A. T. Sasongko, "Sistem Monitoring Suhu dan Kelembaban Berbasis IoT (Internet of Thing) pada Gudang Penyimpanan PT Sakafarma Laboratories," Jurnal Teknologi Dan Sistem Informasi Bisnis, vol. 5, no. 4, pp. 391–400, Oct. 2023, doi: 10.47233/jteksis.v5i4.943.

[19] Michael D and Gustina D, "RANCANG BANGUN PROTOTYPE MONITORING KAPASITAS AIR PADA KOLAM IKAN SECARA OTOMATIS DENGAN MENGGUNAKAN MIKROKONTROLLER ARDUINO," ikraith-informatika, vol. 3, no. 2, pp. 59–66, Nov. 2018.

[20] Wahyu Wijaya Widiyanto, "ANALISA METODOLOGI PENGEMBANGAN SISTEM DENGAN PERBANDINGAN MODEL PERANGKAT LUNAK SISTEM INFORMASI KEPEGAWAIAN MENGGUNAKAN WATERFALL DEVELOPMENT MODEL, MODEL PROTOTYPE, DAN MODEL RAPID APPLICATION DEVELOPMENT (RAD)," Jurnal INFORMA Politeknik Indonusa Surakarta, vol. 4, no. 1, pp. 34–40, Aug. 2018, doi: https://doi.org/10.46808/informa.v4i1.34.

[21] W. Nugraha and M. Syarif, "PENERAPAN METODE PROTOTYPE DALAM PERANCANGAN SISTEM INFORMASI PENGHITUNGAN VOLUME DAN COST PENJUALAN MINUMAN BERBASIS WEBSITE," JUSIM (Jurnal Sistem Informasi Musirawas), vol. 3, no. 2, pp. 94–101, Dec. 2018, doi: 10.32767/jusim.v3i2.331.

[22] F. Hardyanti and P. Utomo, "Perancangan Sistem Pemantauan Suhu dan Kelembaban pada Proses Dekomposisi Pupuk Kompos berbasis IoT," Elinvo (Electronics, Informatics, and Vocational Education), vol. 4, no. 2, pp. 193–201, Nov. 2019, doi: 10.21831/elinvo.v4i2.28324.

[23] Anugraha N and Angriawan R, "PERANCANGAN SISTEM PEMANTAUAN SUHU UDARA DAN KELEMBABAN UDARA STASIUN METEOROLOGI SULTAN HASANUDDIN MAROS," TESLISKA, vol. 16, no. 1, pp. 5–10, Apr. 2023, doi: https://doi.org/10.5281/zenodo.7820993.

[24] Shofari Z.I, Margana D.B, and Saefudin D, "SISTEM PEMANTAUAN PENGENDALIAN SUHU UDARA DAN KELEMBABAN TANAH PADA LAHAN PERTANIAN BERBASIS SCADA," Prosiding Industrial Research Workshop and National Seminar, vol. 10, no. 1, pp. 170–175, Aug. 2019, doi: https://doi.org/10.35313/irwns.v10i1.1386.