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Cage Environment Monitoring System in Modern Livestock: A Literature Review

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ABSTRACT

Livestock in Indonesia is one of the sectors that can have a considerable economic impact. However, livestock in Indonesia still implements conventional livestock models so that livestock in Indonesia can still be developed into modern livestock, one of the things that can improve the Indonesian livestock system is through a monitoring system or cage monitoring. Therefore, the author conducted a literature review to find out how the cage monitoring system on the livestock can work. Based on the study conducted by the author, the author can conclude that temperature, humidity, air quality, water quality and livestock movement are the parameters controlled by most researchers. These various parameters can be monitored so that the system can control gas levels, temperature & humidity. With this monitoring system, researchers believe that it can increase the level of effectiveness in terms of cost and time so that it can also indirectly increase the economic value of the livestock sector.

1. Introduction

Livestock plays an important role in meeting the largest food needs apart from the agricultural sector and as a form of global food security. Livestock acts as a provider of animal protein food sources to fulfill nutritional value for the community, livestock also supports the economy of a country [1]. A good livestock sector can certainly improve the economy [2].

Based on data from the Coordinating Ministry for Economic Affairs in 2022, the livestock sector

experienced an increase in investment value of approximately IDR 541.000.000.000 compared to 2021. This shows that the livestock sector has a very positive impact on the Indonesian economy. If we look at the geographical aspects of Indonesia, Indonesia has the potential that can still be developed more widely [3]. Indonesian livestock tends to still use conventional livestock, if this is enhanced to modern livestock, it can certainly increase production capacity which will certainly have an impact on increasing the economy [4], [5].

Based on these conditions, Indonesia's livestock sector needs to improve in terms of modernization. Maintaining the state of the cage environment is a very settling condition in maintaining the health and production levels of livestock [6]. The process of monitoring cage conditions can be integrated with existing technology. Therefore, monitoring cage conditions must be considered so that livestock are always in an ideal state [7], [8].

With this significant technological development, we must be educated to utilize internet technology, for example monitoring and regulating the stability of the cage environment remotely with high mobility and using existing devices with the help of the internet of things [9]. One of the things that becomes a benchmark in measuring the condition of the cage environment integrated in this IoT [10] is a small part of the temperature, humidity and gas levels in the cage which get output input values that change in real time and can be monitored remotely [1]. This can make modernization in this field develop quite significantly. Therefore, we conducted research and questioned what are the challenges and problems in the field of livestock and the development of modernization in this field of livestock, especially in Indonesia [11].

Some literature on IoT technology and cage monitoring has been published over the past few years. So far, Baehaqi [12] explains that the common indicators observed are temperature, humidity and ammonia gas levels or air conditions in the cage [12], [13]. There are other articles that only discuss the same thing but more in-depth such as Mulia [14] explaining about a closed house system that regulates temperature [14]. So far, a review article that comprehensively discusses monitors in livestock cages has never been published.

Based on this background, the author hopes to write a review article that comprehensively discusses the cage environment monitoring system in modern livestock with the following research questions (RQs):

- RQ1: What parameters are measured in the system?
- RQ2: What sensors are used in the system?
- RQ3: What is the effectiveness of this system compared to conventional farming?

- RQ4: Apart from the system itself, what are the factors that affect the effectiveness of the system?

Based on this, this article utilizes a Systematic Literature Review (SLR) to gather data related to the research question (RQ) mentioned earlier. The purpose of this review is to provide researchers with an understanding of the advances in research on environmental monitoring systems in modern livestock, so that they can find elements of novelty and originality in their future research.

By reading and analyzing various previous articles, we realize that the livestock sector has significant benefits for people's lives both from the nutrition fulfilment sector and from the economic sector which of course has a direct and indirect impact on the community environment [15], [16]. And one of the important things is that this field of livestock, especially in developing countries, is sometimes still seen as underdeveloped, therefore one of the objectives of this research is to be able to make this sector or field which is seen by the people of developing countries, especially Indonesia, can increase significantly and not be underdeveloped anymore by modifying and modernizing this field [17], [18].

With the example of combining this field with current technology precisely in the era of the industrial revolution 4.0, namely the integration of everything with the internet remotely or regularly called the internet of things [19], it makes breeders in developing countries, especially in Indonesia, easier and more efficient for young breeders and their successors [19]. In addition, it can trigger young scholars who are interested in this field but have ideas or backgrounds in technology to work with scholars who have a background in animal husbandry to create a collaboration that can create an integration and answer in order to make discoveries that make it easier for farmers in developing countries, especially in Indonesia.

Then the ultimate goal is to provide insight or views to current and future generations so that they do not focus on developing things in the usual fields in technology alone but in sectors that are arguably underdeveloped among the current generation and then can create inventions that can be useful in the future and so on [20], [11].

2. Methods

This article is a literature review with a similar approach to the article [21], method described in detail as follows:

2.1. Article Selection

Using Google Scholar, Science Direct and Research Gate, relevant articles were selected. Google Scholar, Science Direct and Research Gate was chosen because it is one of the largest, most comprehensive and most cited data sources worldwide [22]. The search keywords used were based on

("monitoring" AND "livestock" AND "modern"). The search was conducted on September 25, 2023 with the following details (table 1):

Table 1: The process of selecting articles from the google scholar database

No	Process	Numbers of Articles
1	Entering keywords in the Google Scholar search bar based on article publications in the last 5 years (2019-2023) and the authors only selected 100 articles	100 Articles
2	Excluding inaccessible articles	84 Articles
3	Exclude thesis/final project/service repository	38 Articles
4	Excluding duplicate articles	36 Articles
5	Excluding irrelevant articles	20 Articles
Number of Articles to use		**20 Articles**

Based on table 1, the documents obtained from Google Scholar based on the keywords monitoring, animal husbandry, and modern are 100 articles. After selecting the exclusion criteria and reviewing the articles, we used 20 (20%) of the total 100 articles.

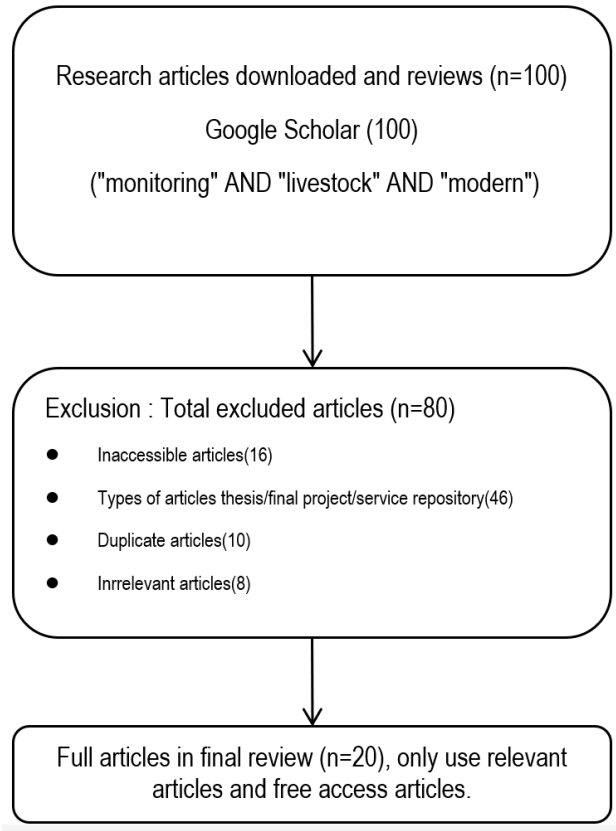

Figure 1 Paper Selection

Based on **Figure 1,** we only used 20 articles from 100 articles(20%). We only use relevant articles and free access articles from Google Scholar.

2.2. Article Review Process

After the article selection process is complete, then the author downloads 20 articles and reviews the articles and reviews the articles by answering four predetermined research questions (RQs), providing discussion and providing conclusions that have been discussed based on the research findings.

3. Results and Discussion

3.1. Article Metadata

The metadata of the 20 articles used can be seen in Table 2:

Table 1: Metadata of articles used

No	Author (s)	Year	Paper Title	Conference / Journal Source
1	Ariyanto et al [23]	2020	Sistem monitoring berbasis internet pada otomatisasi suhu kandang ayam broiler menggunakan raspberry pi	Prosiding seminar informatika aplikatif polinema
2	Supriyono et al [24]	2021	Sistem monitoring suhu dan gas amonia untuk kandang ayam skala kecil	ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika
3	Masriwilaga et al [25]	2019	Monitoring system for broiler chicken farms based on internet of things (IoT)	Telekontran : Jurnal Ilmiah Telekomunikasi, Kendali dan Elektronika Terapan
4	Afiah et al [26]	2021	Prototipe Otomasi Dan Monitoring Suhu Dan Kelembaban Pada Peternakan Ayam Broiler Berbasis IoT	eProceedings of Applied Science
5	Tarigan et al [27]	2019	Implementasi Internet Of Things (IOT) Pada Sistem Monitoring Suhu Kandang Ternak Ayam Broiler Berbasis Node Mcu Menggunakan Teknik Simplex	Jurnal Cyber Tech
6	Tampubolon et al [28]	2023	Pembuatan Aplikasi Sistem Pemantauan Suhu Kandang Ayam Tipe *Close-House* Berbasis *Internet of Things*	eProceedigs of Engineering
7	Ali et al [29]	2020	*Smart Chicken Farm Monitoring System*	Evolution in Electrical and Electronic Engineering
8	Mulia et al [14]	2022	Rancang bangun miniatur sistem kontrol dan monitoring suhu kandang close house berbasis arduino uno	Jurnal TEDC
9	Salensehe et al [30]	2021	System Pengontrol Kandang Ayam Otomatis Menggunakan Smartphone	-

10	Rini et al [31]	2020	Perancangan alat makan dan minum pada peternakan ayam petelur secara otomatis berbasis mikrokontroler	Jurnal Teknik Elektro Uniba (JTE UNIBA)
11	Aini et al [1]	2022	Rancang bangun smart system pada kandang ayam menggunakan mikrokontroler	Jurnal Teknologi Pertanian Gorontalo (JTPG)
12	Harsono et al [32]	2022	Perancangan Sistem Informasi Monitoring Pertumbuhan Ayam Broiler Berbasis Web	Prosiding Seminar Nasional Universitas Borobudur Publikasi Hasil-Hasil Penelitian dan Pengabdian Masyarakat
13	Bagus et al [33]	2023	Internet of things (IoT) based temperature and humidity monitoring in chicken cages: Monitoring suhu dan kelembaban berbasis internet of things (iot) pada kandang ayam	Jurnal Pendidikan, Elektro dan Informatika (EDUKASI ELEKTROMATIKA)
14	N. Li et al [34]	2019	Review: Automated techniques for monitoring the behavior and welfare of broilers and laying hens: towards the goal of precision livestock farming	Animal
15	Salah Uddin et al [35]	2020	Freshwater shrimp farm monitoring system for Bangladesh based on internet of things	Engineering Reports
16	Ling et al [36]	2023	*Smart System for Poultry Farming*	Borneo Engineering & Advanced Multidisciplinary International Journal
17	Baehaqi et al [12]	2022	Design Monitoring and Automatic Control System for Modern Chicken Cage	Mestro: Jurnal Teknik Mesin dan Elektro
18	Sarif et al [37]	2019	Implementasi Arsitektur Publish And Subscribe Pada Alat Monitoring Suhu Dan Kelembaban Kandang Ular Python Regius Menggunakan NodeMCU (ESP8266)	Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer
19	Rusito et al [38]	2023	Sistem Monitoring Hasil Pemanenan Madu Berbasis IoT	Elkom: Jurnal Elektronika dan Komputer
20	Fauzan and Arafat[39]	2023	Perancangan Internet Of Things Smart Farm Untuk Pengaturan Suhu Pada Day Old Chicken (DOC) Berbasis Arduino	OKTAL: Jurnal Ilmu Komputer dan Sains

3.2. Article Review Summary

Furthermore, the summary of the results of the article review that has been carried out is as in Table 3:

Table 2: Results of article review

No	Reference	RQ 1	RQ 2	RQ 3	RQ 4
1	Ariyanto et al [23]	Temperature and Humidity	DHT 11	By testing a cage containing five chickens with each chicken aged four days, it is found that when the ideal temperature is in the range of 32 ° C, the lights will turn on and	Age differences in chickens that can cause the ideal temperature for chickens to change

				the fan will turn off, then when the cage temperature is too hot, namely in the range of 35 ° C the lights will be turned off and the fan will turn on, then if the cage temperature is too cold, namely in the temperature range of 25 ° C, the lights will be turned on and the fan will be turned off. With an automation system that can adjust the temperature depending on this situation, of course, the cage will be more effective than ordinary cages in conventional farms.	also affect the effectiveness of the system.
2	Supriyono et al [24]	Temperature, Humidity, and Ammonia gas levels.	DHT11, MQ-135	By testing the prototype system with the help of matches as a temperature and humidity enhancer/changer and parfume as ammonia gas reading, it is discovered that this system works 100% effectively without any errors.	The temperature around the cage substantially affects the effectiveness of the system.
3	Masriwilaga et al [25]	temperature, humidity and gas levels dangerous	DHT11, MQ-135	By detecting temperature, ammonia gas and RFID data is sent wirelessly to the web system (Firebase) and the error rate of the sensor can be tolerated.	Temperature (outside cage, ideal chicken) and nitrogen (NH3) levels
4	Afiah et al [26]	Temperature and Humidity	DHT22	By comparing the DHT22 sensor and thermometer, the average percent error of temperature is 1.30% with the highest error value of 0.6°C where the figure is still within the error tolerance limit of DHT22, while in humidity the percent error is 0.86% with the highest error value obtained is 2%. As for the test on broiler chickens that require an ideal temperature of 26 °C - 28 °C with humidity of 60% - 70%, data is collected every 4 hours for seven days, it is establish that the average temperature obtained by the system is 26.5 °C and the average humidity acquire is 66%, indicating that the system is quite effective.	Weather and climate around the cage
5	Tarigan et al [27]	Temperature	LM35	Based on the test results and statements from the author, it is found that the system works effectively where the test obtained when the temperature is below 29 °C, the incandescent lamp turns on then the fan turns off, as well as when the temperature is above 33 °C, the incandescent lamp turns off and the fan turns on so that the	Temperature around the cage environment

				temperature of the cage can be ideal for chickens.	
6	Tampubolon et al [28]	Temperature, Humidity	DHT11	After testing by taking data from temperature and humidity on the serial monitor and also the application and then comparing, it was found this data i serial monitor and application found no difference, so this monitoring system can be said to be effective.	-
7	Ali et al [29]	Temperature and Humidity	DHT11	After testing with normal temperature settings at 33°C and humidity in the range of 60% - 70%, it is found that when the temperature is less than 33°C, the lights will turn on to increase the temperature until the temperature reaches, then when the temperature is above 33°C, the lights will turn off and the fan will turn on to reduce the temperature so that the system can be said to be quite effective.	-
8	Mulia et al [14]	Air velocity/airflow & temperature	Anemometer, LM35	Based on the results of the tests carried out on the miniature closed-house cage system, several conclusions can be drawn as follows: 1. Miniature closed-house chicken coop based on Arduino UNO works according to the system that has been designed. this tool works to control the temperature according to the desired setpoint. 2. The LM35 temperature sensor secondhand has an average error value of 0.658994%. The accuracy obtained is quite good but has a resolution level that is not too high. 3. The temperature can be controlled properly and stable using PID control. 4. PID tuning can be done using MATLAB software and the output response can be adjusted as desired.5. Visual Basic can display the temperature conditions that have been sent by the Arduino as a result of reading from the sensor. 6. The LM35 sensor has reading noise when the actuator working this because the sensor has an output voltage with a small range so that the sensitivity level is high.	Human

9	Salensehe et al [30]	Temperature	DHT22	Based on the author's statement and the results of the trials carried out, the following are the results: The designed system has been able to perform the stage of reading the temperature value in the chicken coop and egg holder 2. the application made, namely blink, can connect with the system and display the temperature via a smartphone 3. feeding and drinking are carried out automatically according to a predetermined time 4. Users can reveal the temperature in the jug and can enter on a smartphone within a certain distance.	Feeding time
10	Rini et al [31]	Feeding time, Animal feed	LDR Light sensor	Based on the author's statement and the results of the trials carried out, the results of the design and testing of feeding and drinking equipment on laying hens haphazardly based on microcontrollers can be concluded as successful and in accordance with the author's expectations.	Hardware system design, feeder
11	Aini et al [1]	Temperature, Humidity, Gas content	DHT 11, MQ-02	Based on the author's statement and the results of the trials conducted, this monitoring system is able to run well. The designed system is able to minimize temperature (30°C) and humidity (70%) that are too high and low air quality (260 ppm). So that it can reduce the risk of environmental conditions that are not habitable for livestock.	Environmental conditions of the cage.
12	Harsono et al [32]	Broiler growth and production	Use Object-Oriented Analysis	Based on the results of the research conducted, the designed system can monitor the growth of livestock properly. So that with this system the monitoring process does not need to visit the cages one by one.	Operators who can ensure the fulfilment of cage needs and use the designed system
13	Bagus et al [33]	Humidity, Gas content, Camera	DHT 22, MQ-135, ESP 32 CAM	-	Support from those who operate the system that has been created.
14	N. Li et al [34]	Livestock movement, livestock weight	RFID, Camera	Based on the results of the research conducted, this system can improve the endurance and health of livestock. This system also increases the efficiency of raising livestock.	-

15	Salah Uddin et al [35]	Temperature, water, salt content of water, acidity of water, ammonia, nitrite and oxygen	Turbidity Sensor, PH sensor (PH-4502C), Sensor suhu (DS18B20), salinity sensor, dissolved oxygen sensor	This system has been successful in increasing shrimp production. This is due to reduced shrimp mortality, and reduced risk of waterborne diseases. Thus, production costs can be reduced and profits increased.	-
16	Ling et al [36]	Temperature and Humidity	DHT22	The system can maintain the temperature in the range of 26°C to 32°C which is ideal for chickens, so the system can be considered effective.	Ambient temperature and age of chickens
17	Baehaqi et al [12]	Temperature, Humidity, and Ammonia Gas	DHT11, MQ-135	Based on the findings of the above design and testing, a prototype device has been created that can be used for internet monitoring and automatic control of the blower and heater.	-
18	Sarif et al [37]	Temperature and Humidity	DHT11	This monitoring device successfully helps farm owners in keeping an eye on their snake farms. This is because, before using this system, owners had to check the temperature and humidity levels in the snake cages regularly. The owner only needs to examine the enclosure. As a result, the quality of the enclosure can enhance.	Implementation of automation system
19	Rusito et al [38]	Temperature and Humidity	DHT11, DS18B20	This system has benefited farmers in understanding the glodok humidity, frame temperature, and ready-to-harvest weight of each frame. To determine which honey frames are ready to harvest. And the user validation score is 3.4, which is very good.	Storage area
20	Fauzan and Arafat [39]	Temperature	DHT11	Users can more easily regulate the temperature conditions inside the chicken coop with this technology, and they no longer need to go down to check the coop directly.	The cage environment and the age of the chicken

3.3. Answering RQs

Monitoring systems in modern livestock cages use a variety of indicators in monitoring the cage environment. The main indicators that can be monitored and controlled are temperature, humidity, air

quality, water quality and livestock movement [25], [35], [37], [34]. To answer RQ 1, the following is a brief explanation of the monitored indicators:

- Temperature: The temperature in the barn should be stable, generally at 29-33℃. Fixed temperature conditions can reduce stress and dehydration in livestock.
- Humidity: The ideal humidity in the cage environment is 60%-70%. Ideal humidity levels can reduce the risk of livestock having difficulty breathing and reduce the risk of diseases caused by mold.
- Air quality: Air quality plays crucial role in the livability conditions of farm animals, the ideal air quality for farm animals is around 0.36-200 ppm. Most systems focus on monitoring and controlling ammonia gas.
- Water quality: The condition of livestock drinking water needs to be maintained so that livestock do not suffer from dehydration or disease due to dirty water.
- Livestock movement: The movement of livestock must also be observed so that farmers know the habits of their livestock and directly observe their livestock.

It should also be noted that each type of livestock has its own standards. Therefore, the data above are general indicators for various livestock. Maintaining ideal housing conditions will definitely increase livestock production [35].

By knowing the indicators used, RQ2 is related to the sensors used in this system. The sensors that the system uses are DHT, LM35, MQ, LDR, DS18B20, RFID, ESP 32 CAM, RFID, Water Level Sensor, Anemometer, Turbidity Sensor, Salinity Sensor, Dissolved Oxygen Sensor and PH Sensor [1], [24], [12], [14], [25], [27], [28], [29], [35], [37], [26], [29], [30], [31], [33], [39].

In answering RQ3, it can be seen that all researchers and reference articles claim that the system they designed can run effectively in maintaining the condition of the indicators that have been set [24], [27], [29], [23]. This cage monitoring system has a relatively small percentage error value [26]. With this system, cage monitoring can be done remotely [34].

Based on RQs 4, namely "Apart from this system itself, what factors affect the effectiveness of this system?" that there are many other factors that affect the system apart from sensor readings, including differences in chicken age, outside cage temperature, climate in the cage environment, humans, feeding time, feeding place, system hardware design [36], [39], [40].

4. Conclusion

This article reviews articles from the Google Scholar data source on Cage Environment Monitoring System in Modern Livestock. The search keywords used were built on ("monitoring" AND "peternakan" AND "modern"). The search was aimed on 25 September 2023 and obtained 20 articles related to the topic discussed. The subject matter of enclosure environment monitoring system in modern livestock can still be expanded comprehensively and is a fine opportunity for applicative steps in the world of modern livestock industry. After the review process is complete, it can be come to an end that temperature, humidity, air quality, water quality and livestock movement are the parameters controlled by most researchers . Environmental monitoring systems in cages use various sensors such as DHT, LM35, MQ, LDR, DS18B20, RFID, ESP 32 CAM, Water Level Sensor, Anemometer, Turbidity Sensor, Salinity Sensor, Dissolved Oxygen Sensor and PH Sensor. The majority of sensors used by researchers are DHT series sensors and MQ series anywhere aimed to monitor so that when passing definite parameters, the system can control gas levels, temperature and humidity. With each ideal state of 29-33 degrees Celsius for temperature, 60-70 % Relative Humidity (RH) and 0.36-200 ppm for air quality control, especially ammonia gas which has been recommended by researchers. With various positive results from studies conducted by researchers, the author believes that the implementation of a cage monitoring system can increase the level of effectiveness in terms of cost and time so that it can also indirectly increase the economic value of the livestock sector.

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