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# Developing a Digital Scales System using Internet of Things Technology on Indonesia Digital Farm

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**Abstract.**
**Purpose:** This research aims to develop a digital scales system using internet of things technology on Indonesia digital farm.
**Methods:** The stages of the research were carried out starting from literature studies, system requirements analysis, digital scales system design, system testing, and analysis of system test results. This model consists of hardware and software. The hardware consists of sensors for data collection in the field or using cameras, data input devices, data senders to data centers, data centers, and data processors, and data output that can be accessed on a laptop or a smartphone in real-time.
**Result:** The results of the study show that IoT-based digital scales can be used to read goat weighing results based on RFID data input and camera image capture. The average body weight of a goat that has been weighed is 106.5 pounds, while the average body height of a goat is 150.7 cm.
**Novelty:** The IoT-based digital scales system (IoT-DSS) can be used to measure the weight and height of goats so that the weighing process is more efficient.

**Keywords**: Digital Farm, Digital Scales System, Livestock, Internet of Things
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## INTRODUCTION

Climate change greatly affects the management of agriculture and animal husbandry [1], [2]. Efforts to increase the productivity and quality of livestock products are based on several things [3], [4]. These include global climate change, the decline in agricultural or livestock land, and lifestyle demands for the consumption of quality livestock products [5], [6], [7]. As well as the population increases every year, it will automatically increase the demand for food for livestock products [8], [9]. Such as chicken, beef, milk, and eggs [10]. Livestock is a business that is growing very rapidly and has a fairly high demand, for example, goat farming. Currently, there are various types of goats that can be used for breeding. Lack of knowledge and insight can make goat farms run less than planned, which can affect the efficiency of the farm itself [11]. Entering the era of the industrial revolution 4.0, every country is starting to compete to advance the country and its nation in various fields so that they can face global challenges [12], [13], including in the field of animal husbandry [14].

Technological progress can also be felt by the existence of a system that can control an electronic system with a program [15]. One of them is technology based on the Internet of Things (IoT) [16]. IoT is now starting to be applied in the agricultural sector, one of which is in the field of animal husbandry [17]. The use of IoT allows farms to become smart farms or smart farming, namely a livestock monitoring system that can be carried out remotely using a semi-automatic microprocessor [18]. The composition of costs that are usually incurred in livestock companies is 67% of animal feed, 20% of veterinarians, 5% of manual

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labor, 2% of drugs and vitamins, and 6% others. Animal feed (feed) consumes 60-70% of production costs in livestock, therefore the use of feed needs to be maximized [19]. Feeding efficiency is one of the factors in determining the livestock productivity index [20]. IoT applications can measure goat's food levels to ensure an adequate food supply at all times and to record daily food consumption [21]. The implementation of IoT is expected to provide breakthroughs related to raising healthy goats, reducing workloads, reducing costs, increasing productivity, increasing resource use efficiency, improving data quality, and making decisions based on data [22].

On the other hand, this condition is a challenge that creates problems and obstacles for farmers and the livestock industry [2]. Namely the inability to achieve a financing balance between input costs, production operational costs, and the low selling price of the product [23]. Competition is so strong between independent farmers and livestock companies to maintain business by increasing efficiency [24]. Meanwhile, those who cannot afford it will lose money and go bankrupt. Therefore, it is necessary to implement IoT by utilizing internet systems and other devices in livestock business management [25].

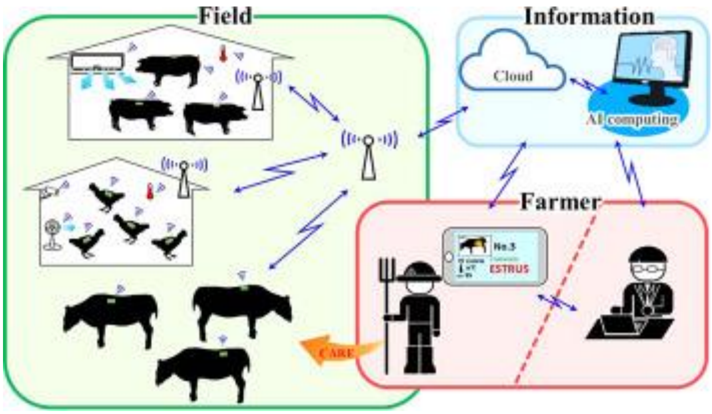


Figure 1. Digital Farm Illustration [26]

To improve business efficiency, avoid budget deficits, and be able to maintain managed businesses [27]. This model consists of hardware and software. The hardware consists of sensors for data collection in the field or using cameras, data input devices, sending data to the data center, data center and data processing, and data output that can be accessed on a PC, laptop, or mobile phone, as presented in Figure 1. The picture above illustrates the IoT working system in Digital Farm management. Goats are equipped with two kinds of devices, namely sensors that record the condition of cows and devices to identify cows (e.g. chips for cow numbers). The sensor is equipped with a data message sender and cow identity, which can be received by GPRS, then forwarded to the internet system (cloud) which can then be received by a laptop or cellphone online [28]. While the software is used to capture and process data with output according to needs [29], for example, number, average, ranking, time range, etc., so that decisions can be made quickly and accurately . Data is inputted into the system according to the needs and objectives of farm management [30]. For example, for a complete livestock management system [31], it is necessary to involve basic data : breed of livestock, sex, age, feed, and feed management [32]. While the data to be analyzed may include the nutritional status of livestock, body condition of livestock, reproductive status, marital success, birth weight, weaning weight, growth, body conformation, body color, and health status [33], [34].

Based on these studies, this research developed a digital farm system based on the Internet of Things (IoT), which is known as Indonesia Digital Farm (IDIFA). IDIFA's activities focus on developing digitalization processes in the livestock sector. IDIFA has several products developed in this sector such as automatic feeders, automatic sheep weight monitors, and several other products. IDIFA is also one of the IoT developers in the livestock sector which is carried out by a research team with students.

## METHODS

The location of the farm used in this study was on Jalan Bulu Raya, Bantul, Yogyakarta, with 10 goats as the research sample. Conducting research in September - November 2022, starting from system design, procurement of supporting hardware and software equipment, system implementation, testing and analysis of system test results.

Based on previous studies related to livestock management systems, we created a proposed method for developing digital farms. The development of the IDIFA platform includes Cage Management System, RFID Identify and Tracking, Auto Feed and Livestock Development Detection. The design for the development of the Indonesia Digital Farm (IDIFA) system as a proposed method is presented in Figure 2, and this research focuses on the development of the IoT-based Digital Scales System (IoT-DSS).

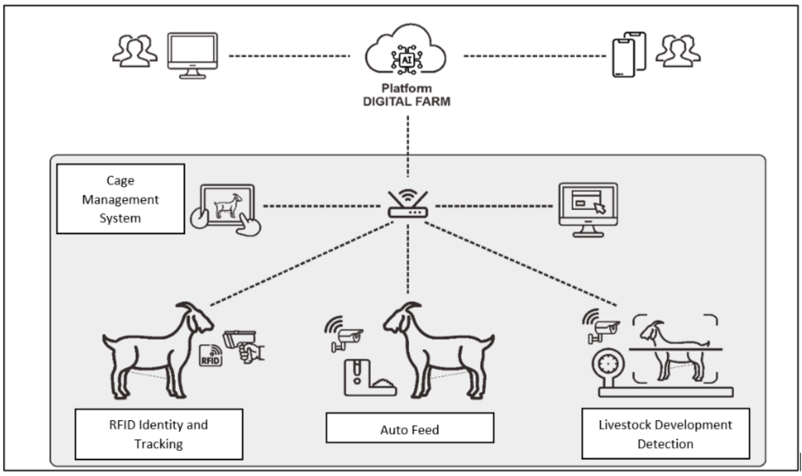

Figure 2. IDIFA Management System

Hardware components used for the development of IoT-DSS include Raspberry version 4, ESP 32 Microcontroller, HX711 Signal Conditioning System, Load Cell sensor, WebCam, Ultrasonic sensor, and RFID reader.

Raspberry serves as a place to process incoming data from sensors and will then be sent to the Indonesia Digital Farm server via the internet. The Microcontroller and Signal Conditioning System have the task of receiving data signals from the Load Cell to be processed in the microcontroller and sent to Raspberry via the USB port. The load cell sensor functions as a weight sensor that is used to weigh livestock. WebCam functions to take photos of farm animals from the top and side. Ultrasonic sensors will be used to measure the height of livestock.

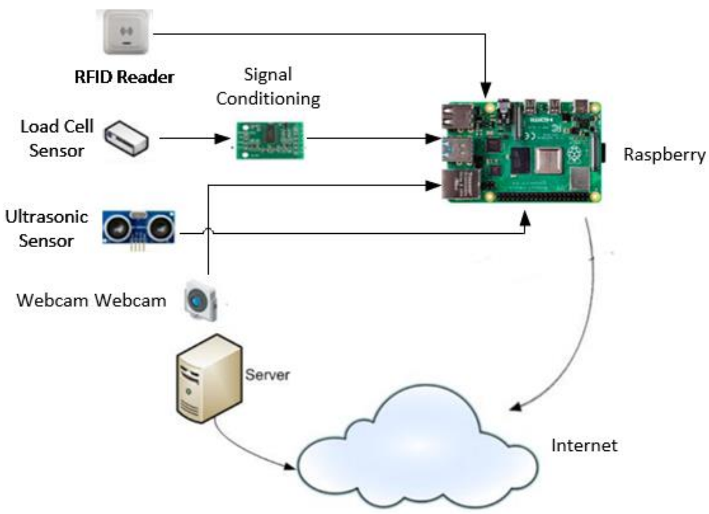

Figure 3. System Hardware

The explanation of the working system of IOT-based digital scales as presented in Figure 3 is as follows:

1) Data for measuring the weight of livestock that is read by the Loadcell sensor will be processed first in the HX711 signal conditioning system and then entered into the ESP32 microcontroller for parsing. After that, the parsed data will be sent to Raspberry to be forwarded to the internet and entered into the database.
2) ID tags from livestock are read by the RFID reader and the photos captured by the WebCam, then it sent to the raspberry via the USB port to be forwarded to the internet and entered into the database.
3) Ultrasonic sensors are directly connected to the ESP32 microcontroller to measure the height of livestock and then the data is sent to Raspberry to be forwarded to the internet and entered into the database.

Then, every livestock data, including ID tags, photos, weight, and height, will be entered into a database on the internet automatically when each livestock is weighed.

Goat weight measurement is carried out using specially designed scales, to facilitate the goat weighing process. The design of digital scales is presented in Figure 4 for the side view and front view of the cage, which makes it possible to weigh one goat.

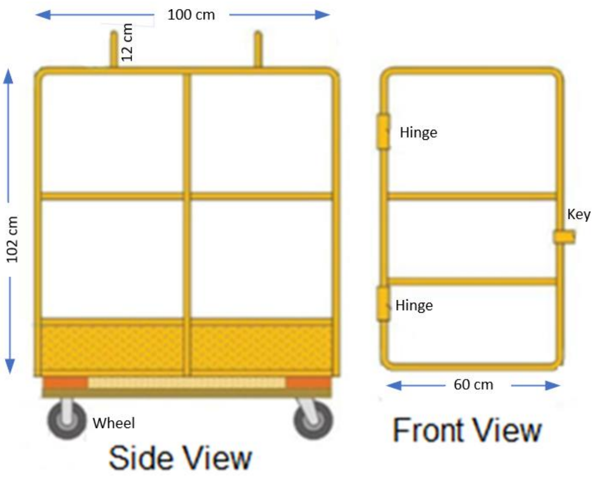


Figure 4. Side view and front of the cage

Then for the additional part design on the drum, which is a place for installing RFID and a camera presented in Figure 5, which consist of camera mount, telescopic pole and hinges to adjust the tilt. The camera mount is used to place a webcam, as a tool to capture images of goats, while the telescopic pole is used to adjust the length and short of the supporting pipe.

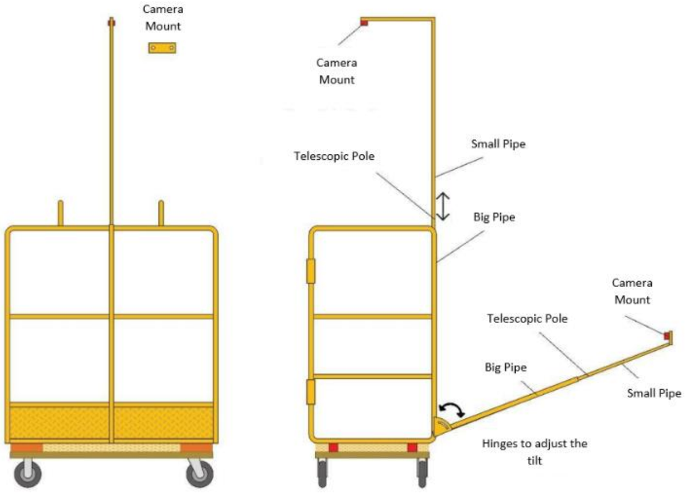


Figure 5. Additional part

The IoT-DSS flowchart is presented in Figure 6, from system initialization, read data from RFID tags and camera, goat weight measurement, data entered into database and monitoring system.

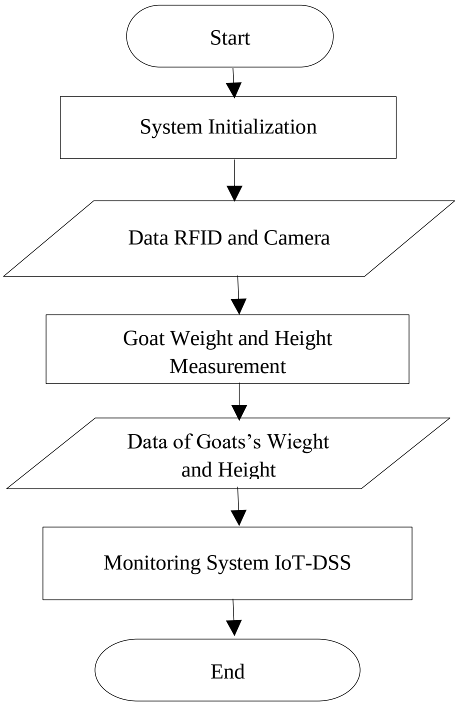


Figure 6. Flowchart of IoT-DSS

**RESULT AND DISCUSSION**

The research results that have been made include the IoT-DSS system, which consists of integrated hardware and software systems, a web-based IDIFA monitoring system application and goat pens used to weigh goats.

In the activity of monitoring goat scales, the research team conducted an experiment on how if a goat is placed on the tool it will automatically record the weight of the goat so that it can know the growth and development of the goat regularly. The results of making cages for digital weighing are presented in Figure 7.

Figure 7. IoT-DSS

ID tags from livestock that are read by the RFID reader and the photos captured by the WebCam, as presented in Figure 8. Then it is sent to the raspberry via the USB port to be forwarded to the internet and entered into the database.

Figure 8. RFID on the goat

The results of this reading could be accessed through the IDIFA Digital Scales monitoring system, as presented in Figure 9. Then, the display of the weighing results monitoring system is presented in Figure 10, which shows the RFID connection, body weight (in Pounds), and height (in cm), as well as screenshots from WebCam-1 and WebCam-2.


Figure 9. IDIFA Digital Scales


Figure 10. Monitoring IoT-DSS

Then, the next process is testing the IoT-DSS system, by testing the RFID connection, capturing the results of WebCam1 and WebCam2. Testing the IoT system connection was carried out by weighing 10 goats, and the results are presented in Table 1.

Table 1. Connection Testing Results

| Item | RFID | WebCam1 | WebCam2 |
|---|---|---|---|
| Goat 1 | Connected | Detected | Detected |
| Goat 2 | Connected | Detected | Detected |
| Goat 3 | Connected | Detected | Detected |
| Goat 4 | Connected | Detected | Detected |
| Goat 5 | Connected | Detected | Detected |
| Goat 6 | Connected | Detected | Detected |
| Goat 7 | Connected | Detected | Detected |
| Goat 8 | Connected | Detected | Detected |
| Goat 9 | Connected | Detected | Detected |
| Goat 10 | Connected | Detected | Detected |

In Table 1, it can be seen that when weighing, the RFID and WebCam-1 and WebCam-2 connections can be detected properly so that the weighing process can be carried out. Then, the weighing results in the form of the weight and height of the goat, are presented in Figure 11.

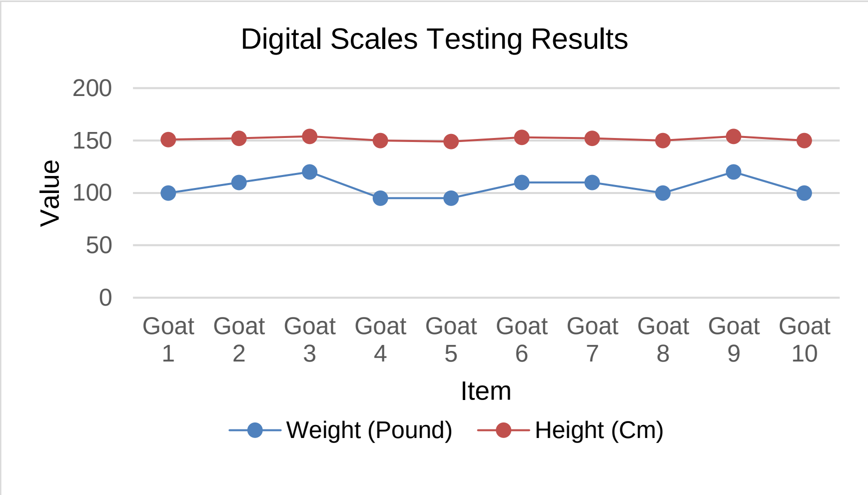


Figure 11. Digital Scales Testing Results

In Figure 12, digital scale results are presented for 10 goats, with body weight ranging from 90 – 120 pounds, and goat height ranging from 150 – 152. The average body weight of a goat that has been weighed is 106.5 pounds, while the average body height of a goat is 150.7 cm.

In the results of research conducted by [30] regarding real-time monitoring systems based on the Internet of Things and cloud messengers, it shows that the sensors used are well connected, resulting in accurate measurements. The use of cloud messenger is very good, and can then be implemented in a monitoring system for goat pens. In another study conducted by [35] regarding monitoring data collection in chicken coops using a camera, by comparing the resolution of image sizes, from 800x600 to 1024x768 resolution, but in this study did not weigh livestock at the same time. This research resulted in an IoT-DSS monitoring system application, which can monitor the development of goat weight and height online and in real-time using a webcam, with an image resolution of 1024x768, and combined with a load cell sensor to weigh goats. Then in a study conducted by [36], the goat pen was added with an automatic feeder that can be monitored online, making it easier to fill in the feed when it runs out. Therefore, the results of this study about IDIFA could be a recommendation for further research related to livestock monitoring systems.

## CONCLUSION

Digital farming in the field of animal husbandry is the application of all technologies or creations to improve business efficiency and effectiveness so that higher income and profits are obtained compared to without the application of new technology or creations. IoT is the main supporting technology in the application of smart farming in the livestock sector which is very helpful in monitoring, documentation, and data analysis. So, decisions and actions can be taken immediately without having to wait for data collection by officers, then tabulation and data analysis which takes a very long time and requires extra labor which is quite tiring. In the development of the IDIFA system, an IoT-DSS has been produced which functions to facilitate the process of weighing goats, by reading RFID data and capturing images on a camera placed on the scale. The results of the study show that IoT-based digital scales can be used to read goat-weighing results based on RFID data input and camera image capture. The average body weight of a goat that has been weighed is 106.5 pounds, while the average body height of a goat is 150.7 cm. This digital scale will make it easier for breeders to measure the body weight and height of goats so that the quality of livestock can be better. For further research, several studies can be carried out, for example adding more sensors to carry out health checks on livestock, as well as creating mobile-based applications to check and control livestock.

## REFERENCES


[1] C. M. Musafiri *et al.*, "Adoption of climate-smart agricultural practices among smallholder farmers in Western Kenya: do socioeconomic, institutional, and biophysical factors matter?," *Heliyon*, vol. 8, no. 1, 2022, doi: 10.1016/j.heliyon.2021.e08677.

[2] Y. Bai *et al.*, "Instability of decoupling livestock greenhouse gas emissions from economic growth in livestock products in the Tibetan highland," *J. Environ. Manage.*, vol. 287, no. December 2020, p. 112334, 2021, doi: 10.1016/j.jenvman.2021.112334.

[3] D. Devapal, "Smart Agro Farm Solar Powered Soil and Weather Monitoring System for Farmers," *Mater. Today Proc.*, vol. 24, pp. 1843–1854, 2019, doi: 10.1016/j.matpr.2020.03.609.

[4] A. M. Tadini *et al.*, "Evaluation of soil organic matter from integrated production systems using laser-induced fluorescence spectroscopy," *Soil Tillage Res.*, vol. 211, no. April, 2021, doi: 10.1016/j.still.2021.105001.

[5] L. Shang, T. Heckelei, M. K. Gerullis, J. Börner, and S. Rasch, "Adoption and diffusion of digital farming technologies - integrating farm-level evidence and system interaction," *Agric. Syst.*, vol. 190, 2021, doi: 10.1016/j.agsy.2021.103074.

[6] G. Branca, A. Braimoh, Y. Zhao, M. Ratii, and P. Likoetla, "Are there opportunities for climate-smart agriculture? Assessing costs and benefits of sustainability investments and planning policies in Southern Africa," *J. Clean. Prod.*, vol. 278, p. 123847, 2021, doi: 10.1016/j.jclepro.2020.123847.

[7] I. Pangapanga-Phiri and E. D. Mungatana, "Adoption of climate-smart agricultural practices and their influence on the technical efficiency of maize production under extreme weather events," *Int. J. Disaster Risk Reduct.*, vol. 61, no. June, p. 102322, 2021, doi: 10.1016/j.ijdrr.2021.102322.

[8] H. Park, S. Y. Choi, H. S. Kang, and N. ji Kwon, "Multi residue determination of 96 veterinary drug residues in domestic livestock and fishery products in South Korea," *Aquaculture*, vol. 553, no. February, p. 738064, 2022, doi: 10.1016/j.aquaculture.2022.738064.

[9] C. A. Josaputri, E. Sugiharti, and R. Arifudin, "Decision Support Systems with AHP and SAW Method for Determination of Cattle with Superior Seeds," *Sci. J. Informatics*, vol. 3, no. 2, pp. 119–128, Nov. 2016, doi: 10.15294/sji.v3i2.7908.

[10] T. Norton, C. Chen, M. L. V. Larsen, and D. Berckmans, "Review: Precision livestock farming: Building 'digital representations' to bring the animals closer to the farmer," *Animal*, vol. 13, no. 12, pp. 3009–3017, 2019, doi: 10.1017/S175173111900199X.

[11] S. SHIBUSAWA, "Digital Farming Approach Changes the Context," *IFAC-PapersOnLine*, vol. 51, no. 17, pp. 67–69, 2018, doi: 10.1016/j.ifacol.2018.08.062.

[12] C. Aquilani, A. Confessore, R. Bozzi, F. Sirtori, and C. Pugliese, "Review: Precision Livestock Farming technologies in pasture-based livestock systems," *Animal*, vol. 16, no. 1, p. 100429, 2022, doi: 10.1016/j.animal.2021.100429.

[13] D. A. A. Pertiwi, M. Yusuf, and D. A. Efrilianda, "Operational Supply Chain Risk Management on Apparel Industry Based on Supply Chain Operation Reference ( SCOR )," *J. Inf. Syst. Explor. Res.*, vol. 01, no. 01, pp. 17–24, 2023.

[14] T. Groher, K. Heitkämper, and C. Umstätter, "Digital technology adoption in livestock production with a special focus on ruminant farming," *Animal*, vol. 14, no. 11, pp. 2404–2413, 2020, doi: 10.1017/S1751731120001391.

[15] S. Neethirajan and B. Kemp, “Digital Livestock Farming,” *Sens. Bio-Sensing Res.*, vol. 32, no. December 2020, p. 100408, 2021, doi: 10.1016/j.sbsr.2021.100408.
[16] N. Kurniawan, “Electrical Energy Monitoring System and Automatic Transfer Switch (ATS) Controller with the Internet of Things for Solar Power Plants,” *J. Soft Comput. Explor.*, vol. 1, no. 1, Sep. 2020, doi: 10.52465/joscex.v1i1.2.
[17] P. Niloofar *et al.*, “Data-driven decision support in livestock farming for improved animal health, welfare and greenhouse gas emissions: Overview and challenges,” *Comput. Electron. Agric.*, vol. 190, no. September, p. 106406, 2021, doi: 10.1016/j.compag.2021.106406.
[18] L. S. Handigolkar, M. L. Kavya, and P. D. Veena, “Iot Based Smart Poultry Farming using Commodity Hardware and Software,” *Bonfring Int. J. Softw. Eng. Soft Comput.*, vol. 6, no. Special Issue, pp. 171–175, 2016, doi: 10.9756/bijsesc.8269.
[19] A. Prakash, V. K. Saxena, and M. K. Singh, “Genetic analysis of residual feed intake, feed conversion ratio and related growth parameters in broiler chicken: a review,” *Worlds. Poult. Sci. J.*, vol. 76, no. 2, pp. 304–317, 2020, doi: 10.1080/00439339.2020.1735978.
[20] N. Roux *et al.*, “Embodied HANPP of feed and animal products: Tracing pressure on ecosystems along trilateral livestock supply chains 1986–2013,” *Sci. Total Environ.*, vol. 851, no. December 2021, p. 158198, 2022, doi: 10.1016/j.scitotenv.2022.158198.
[21] S. Ingrand, “Opinion paper: ‘Monitoring te salutant:’ combining digital sciences and agro-ecology to design multi-performant livestock farming systems,” *Animal*, vol. 12, no. 1, pp. 2–3, 2018, doi: 10.1017/S1751731117001999.
[22] P. P. Ray, “A survey on Internet of Things architectures,” *J. King Saud Univ. - Comput. Inf. Sci.*, vol. 30, no. 3, pp. 291–319, 2018, doi: 10.1016/j.jksuci.2016.10.003.
[23] H. C. Lee, C. M. Chen, J. T. Wei, and H. Y. Chiu, “Analysis of veterinary drug residue monitoring results for commercial livestock products in Taiwan between 2011 and 2015,” *J. Food Drug Anal.*, vol. 26, no. 2, pp. 565–571, 2018, doi: 10.1016/j.jfda.2017.06.008.
[24] S. K. Awasthi *et al.*, “Multi-criteria research lines on livestock manure biorefinery development towards a circular economy: From the perspective of a life cycle assessment and business models strategies,” *J. Clean. Prod.*, vol. 341, no. January, p. 130862, 2022, doi: 10.1016/j.jclepro.2022.130862.
[25] L. F. Si, M. Y. Li, and L. He, “Farmland monitoring and livestock management based on internet of things,” *Internet of Things (Netherlands)*, vol. 19, no. July, p. 100581, 2022, doi: 10.1016/j.iot.2022.100581.
[26] W. Iwasaki, N. Morita, and M. P. B. Nagata, *IoT sensors for smart livestock management*. Elsevier Inc., 2019. doi: 10.1016/B978-0-12-815409-0.00015-2.
[27] F. N. Fote, A. Roukh, S. Mahmoudi, S. A. Mahmoudi, and O. Debauche, “Toward a big data knowledge-base management system for precision livestock farming,” *Procedia Comput. Sci.*, vol. 177, pp. 136–142, 2020, doi: 10.1016/j.procs.2020.10.021.
[28] M. W. Sari, B. Santoso, and M. N. A. Azman, “Implementing Geo Positioning System for Children Tracking Location Monitoring based on Android,” *Sci. J. Informatics*, vol. 8, no. 1, pp. 161–167, 2021, doi: 10.15294/sji.v8i1.27436.
[29] M. W. Sari, Herianto, I. G. B. B. Dharma, and A. E. Tontowi, “Design of Product Monitoring System Using Internet of Things Technology for Smart Manufacturing,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 835, pp. 1–7, 2020, doi: 10.1088/1757-899X/835/1/012048.
[30] R. Muhendra and A. Amin, “Real-Time Monitoring: Development of Low Power Fire Detection System for Dense Residential Housing Based on Internet of Things (IoT) and Cloud Messenger,” *Sci. J. Informatics*, vol. 8, no. 2, pp. 202–212, 2021, doi: 10.15294/sji.v8i2.30811.
[31] C. Casenave, A. Bisson, S. Boudsocq, and T. Daufresne, “Impact of biological nitrogen fixation and livestock management on the manure transfer from grazing land in mixed farming systems,” *J. Theor. Biol.*, vol. 545, p. 111136, 2022, doi: 10.1016/j.jtbi.2022.111136.
[32] F. Barragán, J. Labastida, and A. Ramírez-Hernández, “Response of dung beetle diversity to three livestock management systems in drylands of central Mexico,” *J. Arid Environ.*, vol. 193, no. July, 2021, doi: 10.1016/j.jaridenv.2021.104598.
[33] Q. Yue, P. Guo, H. Wu, Y. Wang, and C. Zhang, “Towards sustainable circular agriculture: An integrated optimization framework for crop-livestock-biogas-crop recycling system management under uncertainty,” *Agric. Syst.*, vol. 196, no. November 2021, p. 103347, 2022, doi: 10.1016/j.agsy.2021.103347.
[34] M. S. Gaballah *et al.*, “A review targeting veterinary antibiotics removal from livestock manure management systems and future outlook,” *Bioresour. Technol.*, vol. 333, no. March, p. 125069,

2021, doi: 10.1016/j.biortech.2021.125069.

[35] S. Wahjuni, S. H. Sanjiwo, and A. R. Akbar, "The Development of Chicken Coop Automatic Remote Visual Monitoring System," vol. 9, no. 2, pp. 161–168, 2022, doi: 10.15294/sji.v9i2.34630.

[36] M. David, S. R. Sulistiyanti, H. Herlinawati, and H. Fitriawan, "Rancang Bangun Prototipe Kandang Kambing Sistem Terkoleksi dan Pemberian Pakan Otomatis Berbasis Arduino Uno R3," *J. Inform. dan Tek. Elektro Terap.*, vol. 10, no. 2, Apr. 2022, doi: 10.23960/jitet.v10i2.2442.