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IMPROVING FOOD SECURITY IN EAST JAVA PROVINCE THROUGH DYNAMIC MODELING OF BROILER CHICKEN AVAILABILITY

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This study models the broiler chicken supply chain in East Java Province using a dynamic system modeling approach to improve food security. The research focuses on the broiler chicken supply chain system, which, despite increasing production, still faces challenges of availability and price volatility. The main problem addressed is the lack of dynamic model capable of capturing the complex and non-linear relationships within this system, which hinders the development of proactive strategic insights.

The dynamic model was successfully validated with a high degree of accuracy, with the E1 error value being less than 2.59% and E2 less than 2.09%. Simulation results demonstrate that the adoption of industrial technology has a significant and measurable impact. The automated cage technology (closed-house) scenario can increase average production by 5.5% in the long term, with projected production reaching 633,684 tons by 2034. This is explained by a decrease in mortality rates from 4–5% to 2–3%, which creates a positive reinforcing loop. Meanwhile, the big data scenario can increase the accuracy of demand predictions by 3.7%, enabling better and more stable supply adjustments and consequently reducing the gap between production and consumption.

The key advantage of these findings is their ability to predict long-term system behavior and integrate the cumulative impact of technological changes, a feature that conventional static methods lack. The solution can be used by policymakers and industry players to design proactive, data-driven strategies. The results can be applied to formulate investment policies, resource allocation, and supply chain management strategies to ensure a stable supply of animal protein in East Java, directly contributing to the achievement of sustainable food security goals

Keywords: dynamic system modeling, broiler chicken supply chain, sustainable food security

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1. Introduction

Currently, Indonesia is still unable to meet all of its animal protein needs. Most of these materials must be imported, especially to meet the growing needs of cattle. Meanwhile, poultry is a major component in meeting national animal protein needs, with approximately 60% of national meat needs being met by poultry, especially chickens [1]. The poultry industry sub-sector meets around 65% of animal protein demand and is a very important part of the country's economy, providing employment to 12 million people and having an estimated production value of more than 34 billion USD [2].

Broiler chicken meat, as the most affordable source of protein, can make a significant contribution to reducing poverty, overcoming hunger, and achieving sustainable food security goals. As a country undergoing urbanization, population growth, and economic change, the poultry industry faces various challenges [3]. The demand for chicken meat in East Java Province is increasing every year in line with production levels. Based on data from the Badan Pusat Statistik (BPS), in the last five years, average chicken meat consumption has increased annually, from 0.124 kg per person per week to 0.158 kg per person per week in 2019 to 2023 [4]. Although production continues to rise, consumption needs are also increasing, so there is still a gap between the amount of broiler chicken meat produced and consumed [5].

One way to address the challenges of hunger and food insecurity among vulnerable communities in most countries (especially developing countries) is to adopt sustainable, affordable, and accessible food production systems to meet their nutritional needs [6]. The poultry industry plays a critical role in strengthening national food security, especially in densely populated areas such as East Java, where this industry meets most of the population's protein needs. However, the dynamics of this sector are complex, influenced by various interacting factors, including production, consumption, population growth, and technology adoption. Despite continued increases in production, persistent gaps between supply and demand, as well as price volatility, highlight the fundamental need for more resilient and forward-looking strategies. Traditional forecasting methods often fail to capture the complex and non-linear relationships in this system, causing policymakers to be more reactive than proactive. The challenge is not only to increase production, but to create a stable, predictable, and resilient supply chain that can withstand market fluctuations and ensure long-term food availability. Therefore, scientific topics on dynamic modeling and simulation of broiler chicken supply chains are highly relevant. Such research is crucial for providing practical, data-driven insights that can guide policymakers and industry players in developing effective and proactive strategies to ensure food security for a growing population.

2. Literature review and problem statement

Literature on food supply chain dynamics, particularly in the poultry sector, shows solid research focusing on quantitative methods and dynamic simulations. Studies by [7] have successfully established dynamic systems as a robust framework for modeling complex agricultural relationships, as demonstrated in applications for sustainable apple farming [8], chicken production for national food security [9], rice production [10], and CPO availability for energy security [11]. This demonstrates the recognized usefulness of dynamic modeling in addressing broad food and resource security challenges.

However, there remains a critical research gap in translating these macro-level insights into applicable operational optimization. Although existing dynamic models successfully predict commodity production or availability [9–11], existing research is often suboptimal in modeling the complex, multi-stage, and cascading impacts of modern industrial technology adoption across supply chains. Previous research, such as that conducted by [12], treats technology and policy only as intermediate variables, ignoring how technological changes at one stage (e.g., modern agriculture) generate complex feedback and time delays at subsequent stages such as logistics and distribution. This limitation prevents the holistic optimization of operational metrics.

Furthermore, most existing research, as highlighted in the [13] study on national-level supply chains, relies heavily on global or national data, thereby neglecting crucial local factors. This broad focus ignores critical regional specifications, such as unique provincial policies, different consumption patterns, and local agricultural practices that are necessary to provide actionable insights for provincial or local policymakers, such as in East Java Province. Although a location-based approach has been attempted by [5] to model regional poultry supply chains, their model does not fully integrate the detailed cause-and-effect relationships associated with comprehensive technology adoption.

All this allows to assert that it is expedient to conduct a study on develop a System Dynamics model for the broiler chicken supply chain in East Java Province. This is necessary for comprehensively evaluate the specific impact of modern industrial technology on improving local food security, utilizing a granular, location-based approach that integrates technology-driven sub-models to capture complex chain effects.

3. The aim and objectives of the study

The aim of this study is the development of a dynamic model for the broiler chicken supply chain, specifically focusing on meeting local demand and improving food security in East Java Province. This model will allow stakeholders to rigorously evaluate various strategic policy scenarios and assess the comprehensive impact of modern industrial technology on supply chain performance.

To achieve this aim, the following objectives were accomplished:

– designing a conceptual model that clearly illustrates the cause-and-effect relationships in the broiler chicken supply chain system in East Java Province;

– developing causal loop diagrams and stock and flow diagrams to visualize the dynamics of this complex system, which will form the basis for model simulation;

– validate the model that has been created to ensure that it accurately represents the actual system conditions;

– simulate and develop strategic scenarios to evaluate the impact of technology implementation in improving broiler chicken availability and sustainable food security.

4. Materials and methods

4. 1. The object and hypothesis of the study

The object of this study is the broiler chicken supply chain in East Java Province. This study explores the dynamics and complex relationships in each stage from production on the farm to distribution to consumers.

The hypothesis in this study is that the application of industrial technology in the broiler chicken supply chain in East Java can increase supply stability and improve regional food security. The adoption of technology at the upstream level will directly reduce mortality rates and increase production efficiency, thereby maintaining the availability of broiler chicken supply at the downstream level.

The assumption in this study is that the broiler chicken supply chain process in East Java Province can be modeled and tested appropriately using a dynamic systems approach.

This study focuses only on the broiler chicken supply chain in East Java Province. This simplification aims to ensure that the dynamic system model accurately reflects conditions at the regional level, which are often overlooked in national or global studies. By limiting the scope of the study, local factors such as regional policies and community consumption habits can be properly integrated, as these factors may not be widely available.

4. 2. Methodology

This study uses a quantitative approach with Dynamic System modeling and simulation methods. The model designed is used to analyze changes in the broiler chicken supply chain in East Java Province. The simulation was conducted using historical data from 2015 to 2024 to forecast the period from 2025 to 2034. The data used consisted of secondary data obtained from official sources such as the East Java Livestock Service, the Central Statistics Agency (BPS), and the Ministry of Agriculture. This data covered various variables such as population, annual supply, annual demand, DOC orders, and per capita consumption. In addition, primary data was also collected through interviews and discussions with stakeholders, such as farmers and distributors, to gain a deeper understanding of the decision-making process, risks, and barriers to technology adoption. The following are the stages of the research illustrated in Fig. 1.

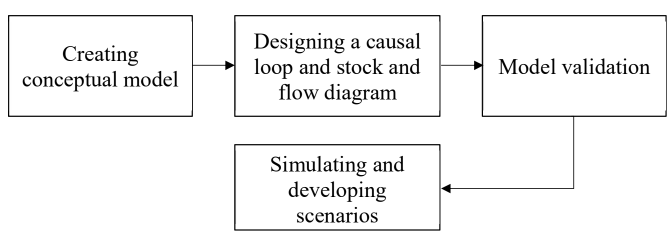

Fig. 1. Research stages

The explanation of the research stages above is as follows:

a) creating conceptual model.

A conceptual model was developed by defining the boundaries of the system, which covers the entire supply chain process from start to finish. Several important variables, such as population size, annual supply, annual demand, number of DOC orders, and per capita consumption, were identified as vital parts of the system. In addition, factors outside the system, such as the application of industrial technology, were also taken into account and included in the model;

b) designing a causal loop diagram and stock and flow diagram.

Causal loop diagrams (CLD) are a commonly used method for identifying, analyzing, and explaining the cause-and-effect structure of complex problems. CLDs consist of variables and arrows with signs (positive or negative) that indicate cause-and-effect relationships. Reinforcing loops (denoted by "R") serve to reinforce the changes that occur. Conversely, balancing loops (symbolized by "B") work to find balance, maintaining system stability by counteracting changes that occur [14].

Stock flow diagrams are a key tool in the tradition of system dynamics modeling, first developed by Forrester in the 1950s. Stocks represent state variables, and to create them, initial values must be determined. Flows represent changes to stocks, and each flow has a mathematical equation determined by the modeler, which indicates how fast the flow occurs (amount per unit of time) [15]. In this study, the design of the stock and flow diagram is described in detail by showing the relationships between variables that have been expressed in specific symbols, making it easier to compile mathematical equations to determine parameter values and estimate initial values;

c) model validation.

Model validation is carried out to ensure that the structure and functioning of the model accurately represent actual conditions. This stage is important because it helps to determine the extent to which the model can be relied upon to simulate real conditions. System validation testing is carried out using two methods, namely structural validation and behavioral validation. Behavioral testing is carried out in two ways, namely mean comparison testing, where the model is considered valid if the result is $E1 \leq 5\%$, and amplitude variation comparison testing (% error variance), where the model is considered valid if the result is $E2 \leq 30\%$ [16];

d) simulating and developing scenarios.

Scenario design is carried out after the model is considered valid. This scenario design is carried out so that system performance can be improved to achieve the planned objectives. The purpose of this simulation is to compare the results of the scenario model experiment with the results of the model that shows the actual system, so that the most optimal results can be obtained. Scenario development in this study uses industrial technology with the aim of increasing the supply of broiler chickens, which supports the achievement of food security in East Java Province.

Based on the results of the scenario simulation, the final stage is scenario development. This stage focuses on identifying the most effective combination of technologies to stabilize supply and improve food security.

5. Results of dynamic system model simulations

5. 1. Conceptualization model of broiler chicken supply

The conceptualization model in this study serves to explain the supply of broiler chickens to facilitate the process of designing a causal loop diagram. The conceptualization model of this study is illustrated in Fig. 2.

Based on Fig. 2 the conceptual model illustrates the cause-and-effect relationships in the broiler chicken supply chain system in East Java. This model shows the logical flow from production to demand, which is a solid basis for dynamic system simulation.

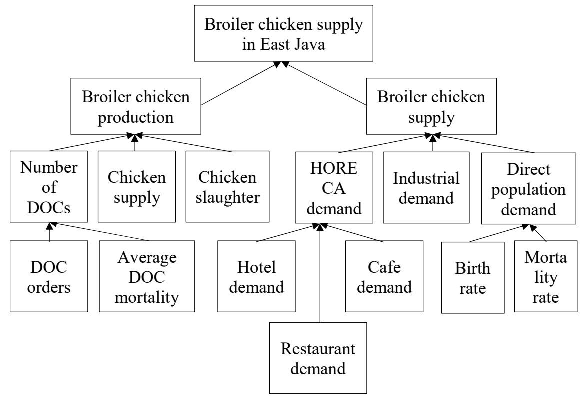

Fig. 2. Conceptualization model of the broiler chicken supply in East Java

5. 2. Causal loop diagram and stock and flow diagram of broiler chicken availability

A causal loop diagram (CLD) explains the relationship between the variables of broiler chicken production, the availability of broiler chickens, and the population size. The relationship between these three variables forms a series of causes and effects, in which any change in one variable can repeatedly affect the other variables and influence each other. For a clearer visualization of the causal loop diagram, these relationships can be seen in Fig. 3.

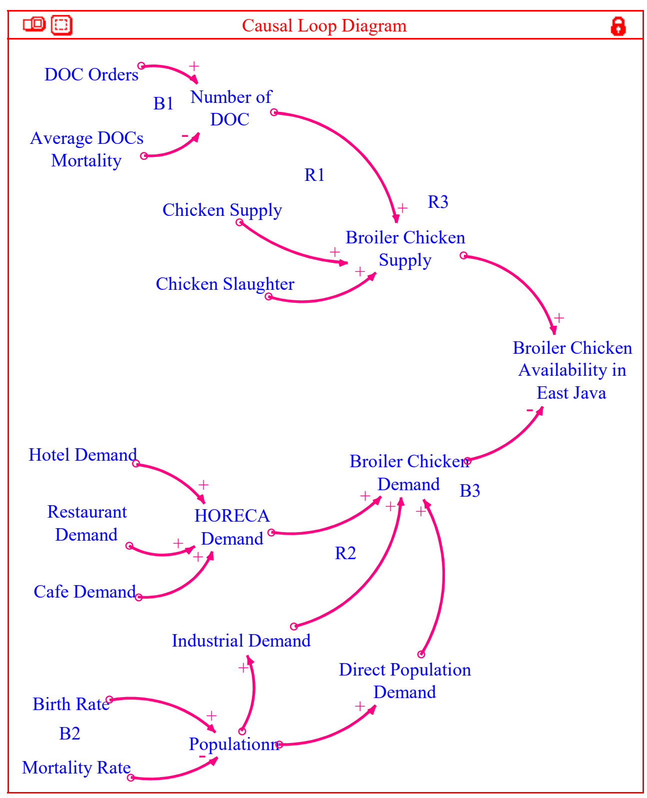

Fig. 3. Causal loop diagram of broiler chicken availability in East Java

As can be seen in Fig. 3, the causal loop diagram contains symbols such as B1, B2, B3, R1, R2, and R3. B1 can be interpreted as a balancing loop (negative loop) that illustrates the relationship between higher DOC mortality rates and a reduction in the number of DOCs and broiler chicken production. B2 illustrates the relationship between higher mortality rates and a reduction in population and direct population needs. B3 illustrates the relationship whereby the higher the demand for broiler chickens, the lower the availability of broiler chickens. R1 can be interpreted as a reinforcing loop (positive loop) which illustrates the relationship between higher DOC numbers and chicken supply, which will increase broiler chicken production. R2 illustrates the relationship between higher birth rates, which will increase the population and direct demand of the population. R3 illustrates the relationship between higher broiler chicken production, which will increase the availability of broiler chickens.

Fig. 4 stock and flow diagram is a tool used to illustrate how a system works dynamically. This diagram shows the relationship between the amount stored in the system (stock) and the inflow or outflow of that amount (flow). This diagram is used as a tool to understand how changes in a certain amount are affected by inflows and outflows. This diagram is a visual representation that helps in understanding systems that change over time, especially in matters involving long-term processes and interactions between parts of the system.

In Fig. 4, stock and flow diagram, the data entered into the model is data obtained from the Badan Pusat Statistik and Direktorat Jenderal Peternakan dan Kesehatan Hewan for the period 2015–2024. This data includes the population of East Java, birth rates, death rates, number of day-old chicks, broiler chicken production, broiler chicken demand, and per capita consumption in East Java.

5. 3. Validation of the actual model of broiler chicken availability

Model validation is performed to ensure that the model can accurately describe the actual system. There are two methods for model validation: structural testing and behavioral validity testing. Behavioral validity testing is specifically used to check if the model aligns with the desired objectives. The test is conducted by comparing the results of two error metrics, E1 and E2. If the E1 value is not more than 5% and the E2 value is not more than 30%, the model is considered valid [10]. The results of the behavioral validity test for the broiler chicken availability model in East Java can be seen in Table 1.

Table 1

Behavior validity test

Year	Population		Broiler chicken production (ton)		Broiler chicken demand (ton)	
	Actual	Model	Actual	Model	Actual	Model
2015	38,899,992	38,916,680	203,139	208,081.26	151,505	156,358.76
2016	39,248,828	39,273,820	219,833	224,835.02	160,598	164,102.28
2017	39,593,682	39,624,220	270,882	275,712.91	181,926	186,089.36
2018	39,940,093	39,976,806	280,309	285,430.74	171,829	175,947.84
2019	40,297,962	40,333,410	275,758	280,520.74	196,111	201,358.76
2020	40,665,696	40,714,240	308,820	313,848.97	198,449	203,738.08
2021	40,878,761	40,912,980	321,408	326,544.94	197,640	204,211.74
2022	41,150,046	41,181,860	338,590	343,532.74	203,467	208,796.85
2023	41,644,223	41,689,320	355,728	360,806.55	209,295	214,406.43
2024	41,929,135	41,968,600	370,725	375,795.23	215,122	219,708.38
Average	40,424,842	40,459,194	294,519	299,511	188,594	193,471.85
Stdev	1,010,491.90	1,017,343.77	55,241.52	55,289.02	21,275.51	21,720.34
E1 < 5%	0.08%		1.69%		2.59%	
E2 < 30%	0.68%		0.09%		2.09%	

Sources: primary data processing (2025).

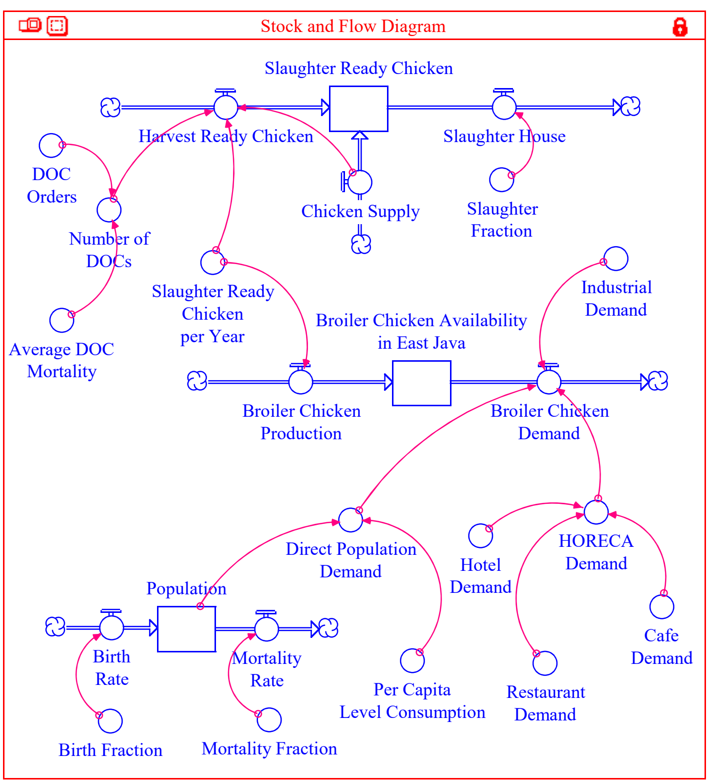

Fig. 4. Stock and flow diagram of broiler chicken availability in East Java

The results of the model behavior testing in Table 1 show that the calculated behavior validity values for the E1 population are 0.08% and E2 are 0.68%, broiler chicken production E1 is 1.69% and E2 is 0.09%, broiler chicken demand for E1 is 2.59% and for E2 is 2.09% from the simulated model can be declared valid.

5. 4. Simulation results and scenario development

The simulation scenario was designed based on various influencing factors, with the aim of identifying and addressing factors related to problems in meeting the availability of broiler chickens in order to achieve food security in East Java Province.

The proposed scenario is an improvement scenario in terms of the use of modern technology. The first scenario is the use of automated cage technology to create a more controlled cage environment, such as temperature, humidity, ventilation, feed conversion, and water. This is expected to increase production efficiency and reduce the mortality rate of broiler chickens. The second scenario is the use of big data technology to improve the accuracy of predicting the demand for broiler chickens from the market. This is expected to create a feedback mechanism that helps stabilize the supply of broiler chickens in the market:

a) scenario 1: automated cage technology (closed house).

To evaluate the impact of technology on the availability of broiler chickens, researchers created a scenario of closed-house automation. This scenario shows how the use of coop technology gradually affects the production process. This analysis discusses feedback mechanisms that can reduce chicken mortality rates and increase production efficiency, resulting in a greater supply of chickens. This can be seen in Fig. 5. The causal loop diagram visually explains the relationship between the use of technology and its impact, and shows how initial investment can start a positive cycle that increases profits and more stable production.

Table 2 shows the simulation results that estimate how technology adoption can increase broiler chicken production from 2025 to 2034.

The results of the simulation show that the adoption of automated cage technology can increase annual production. The difference between the two projections becomes more significant from year to year, due to a decrease in mortality rates from 4–5% to 2–3%. Thus, in 2034, broiler chicken production will reach 567,665 tons, which represents a significant increase of 5.5% compared to the base model;

Table 2

Broiler chicken production in the scenario of using automatic cage technology

Year	Broiler chicken production (ton)	
	Base model	Scenario
2025	390,419	391,111
2026	410,113	412,622
2027	429,807	435,314
2028	449,501	459,250
2029	469,195	484,514
2030	488,889	511,189
2031	508,583	539,360
2032	528,277	569,110
3033	547,971	600,521
2034	567,665	633,684
Average	479,042	503,668
Influential	5.5%	

Sources: primary data processing (2025).

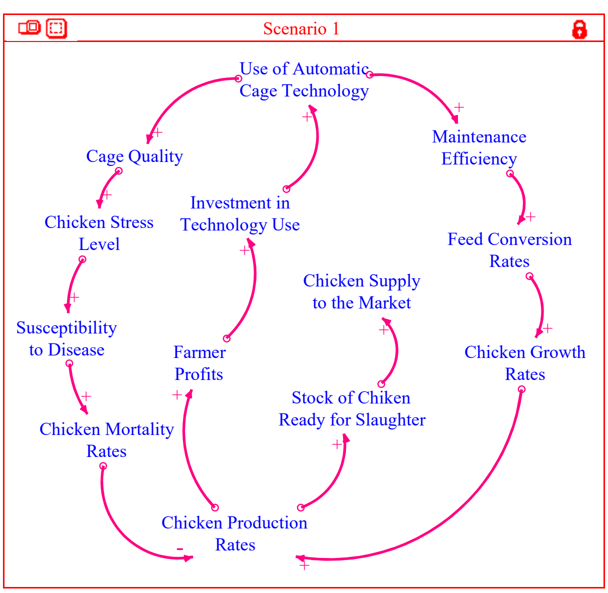

Fig. 5. Causal loop diagram scenario 1 (automated cage technology)

b) scenario 2: big data technology.

The second scenario focuses on big data technology and demand analytics. The goal is to show how the use of historical data and predictive analytics can help optimize supply planning. Researchers will explain how increased accuracy in demand forecasting enables manufacturers to adjust production according to market needs, thereby helping to stabilize product availability. This is illustrated in Fig. 6, where a causal loop diagram shows the complex relationship between prediction accuracy, production planning, and market changes, emphasizing the important role of information technology in improving supply chain resilience.

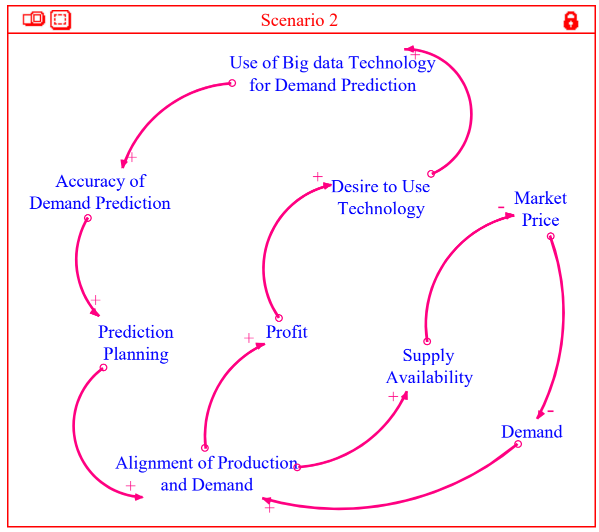

Fig. 6. Causal loop diagram scenario 2 (big data technology)
Source: Author's analysis (2025)

Table 3 shows the simulation results that estimate how technology adoption can affect the accuracy and growth of broiler chicken demand from 2025 to 2034.

Table 3

Demand for broiler chickens in the big data technology usage scenario

Year	Broiler chicken production (ton)	
	Base model	Scenario
2025	226,250	227,849
2026	232,791	236,276
2027	239,332	245,006
2028	245,873	254,053
2029	252,414	263,430
2030	258,955	273,153
2031	265,496	283,238
2032	272,037	293,703
3033	278,578	304,568
2034	285,119	315,850
Average	255,685	269,713
Influential	3.7%	

Source: primary data processing (2025).

The results of the simulation show that the use of big data technology can increase the accuracy and growth rate of broiler chicken demand. In the base model, demand is projected to reach 285,119 tons in 2034. However, with the use of big data technology, demand could reach 315,850 tons, which means that it could significantly increase and stabilize demand accuracy by 3.7%.

6. Discussion of dynamic modeling for food security

Based on the results presented, dynamic modeling has proven to be an effective tool in analyzing and projecting the broiler chicken supply chain system in East Java to achieve food security. The simulation results from Table 2, 3 clearly show the significant potential of technological intervention. The application of automated cage technology (closed-house) in scenario 1 directly increases production, as predicted by the causal loop diagram in Fig. 5. The reduction in mortality rates from 4–5% to 2–3% creates a reinforcing loop that results in a cumulative increase in production, reaching 5.5% compared to the baseline model.

On the other side, scenario 2 shows that the use of big data can increase the accuracy of demand predictions by 3.7%, helping producers align supply with market needs. This illustrates the important role of information technology in creating more resilient systems, as depicted in the causal loop diagram in Fig. 6. The system dynamics approach used in this study has advantages over static methods, as it is capable of modeling feedback loops and non-linear interactions that underlie supply chain systems, in line with the framework proposed by experts in this field [13]. Model validation through the E1 and E2 metrics (Table 1) also confirms the reliability of the model, with all values meeting the specified criteria (E1 < 5%, E2 < 30%).

Although robust, this study has several limitations. First, the validity of the model is highly dependent on the quality and availability of historical data from Statistics Indonesia and the Directorate General of Livestock. This model may not fully capture the variation in data in the field. Second, the proposed scenarios focus only on two types of technology, without considering other crucial external variables such as feed price fluctuations, policy changes, or the impact of climate change. In addition, the assumption that technology adoption occurs linearly may not reflect reality.

The main limitation of this study is the absence of sensitivity testing. Without this analysis, it is difficult to assess how stable the simulation results are to changes in key parameters, for example, how tolerant the model is to increases in feed costs or decreases in people's purchasing power. In the future, this research can be developed by conducting sensitivity analysis to identify the most sensitive variables. In addition, the model could be expanded by integrating more external variables or developed into a spatial model for more specific analysis per region in East Java. The difficulties that may be encountered are the collection of detailed data and the mathematical complexity that will arise from the addition of interactions between variables.

7. Conclusion

1. The conceptual model developed serves as an important foundation for this research. This model effectively visualizes and explains the complex cause-and-effect relationships in the broiler chicken supply chain system in East Java. By mapping the logical flow from production to demand, this model provides a strong and clear basis for the development of further flow diagrams, such as causal loop diagrams (CLDs) and stock and flow diagrams (SFDs), which are key tools in dynamic system simulation.

2. The causal loop diagram (CLD) successfully identifies and maps the complex relationships between key variables such as production, broiler chicken availability, and population size. The diagram explains how reinforcing loops (R1, R2, R3) drive growth, while balancing loops (B1, B2, B3) tend to stabilize the system. Then, the stock and flow diagram (SFD) serves as the quantitative foundation of this model by incorporating historical data from 2015 to 2024. This allows for a deep understanding of how these variables change over time, ultimately providing a solid tool for analyzing complex systems.

3. The dynamic model constructed has been accurately validated, ensuring that its simulations are reliable in reflecting real-world conditions. Behavioral validity testing shows that the E1 error value is no more than 2.59% and the E2 value is no more than 2.09% for all key variables (population, production, and demand). These criteria meet strict validity thresholds (E1 < 5%, E2 < 30%), which significantly distinguish this model from many other less-tested models. The success of this validation proves that the dynamic system modeling approach is suitable for addressing local issues, overcoming the limitations of national or global models that often lack the necessary granularity.

4. Scenario simulations show that technology adoption has a significant quantitative impact on food security. The application of closed-house technology can increase average broiler chicken production by 5.5% from the baseline model, with annual production in 2034 reaching 633,684 tons. This is due to a decrease in mortality rates from 4–5% to 2–3%. Meanwhile, the use of big data technology can increase the accuracy of demand predictions by 3.7%, enabling producers to optimize supply and reduce market instability. These results confirm the research hypothesis and provide concrete evidence that investment in modern technology is an effective and proactive strategy to address supply and demand challenges in East Java, providing a data-driven foundation for policy making.

Conflict of interest

The author of this article has no conflicts of interest in writing it. There are no financial, personal, or other issues that could affect the fairness of this article. The article is entirely the researcher's own work, has not been copied from any other sources, and has never been sent to any other publication for consideration.

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Data availability

Data will be made available on reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

References

1. Rosita, G., Prawesti, L. N., Fadlilah, U., Nugrahini, Y. L. R. E. (2020). Pengembangan potensi ayam lokal untuk menunjang ketahanan pangan di era new normal covid-19. Agrista J. Ilm. Mhs. Agribisnis UNS, 4 (1), 452–460. Available at: https://www.neliti.com/id/publications/365637/
2. Haryana, A., Suprayogi, Wangsaputra, R., Govindaraju, R. (2025). Estimating Day Old Chick (DOC) Final Stock (FS) Broiler Demand Based on Broiler Meat Consumption Using System Dynamics Model. IOP Conference Series: Earth and Environmental Science, 1502 (1), 012042. https://doi.org/10.1088/1755-1315/1502/1/012042
3. Mmila, G., Myeki, L. W. (2025). The Dynamics of Broiler Meat Supply in South Africa and Its Implications for Achieving SDG 2: Zero Hunger. Agriculture, 15 (12), 1236. https://doi.org/10.3390/agriculture15121236
4. Fernanda, M. F., Yudhistiro, K. (2024). Sistem peramalan produksi daging ayam pedagang di provinsi jawa timur tahun 2024 dengan metode double exponential smoothing menggunakan PHP dan MySQL. Semin. Nas. Sist. Inf., 8, 4827–4836. Available at: https://jurnalfti.unmer.ac.id/index.php/senasif/article/view/574/527
5. Surya Atmaja, I. P., Satriawan, I. K., Sedana Yoga, I. W. G. (2019). Sistem Dinamis Ketersediaan Daging Ayam Ras Pedaging (Broiler) Di Provinsi Bali. Jurnal Rekayasa Dan Manajemen Agroindustri, 7 (2), 229. https://doi.org/10.24843/jrma.2019.v07.i02.p07
6. Idamokoro, E. M., Hosu, Y. S. (2022). Village chicken production and food security: a two-decade bibliometric analysis of global research trends. Agriculture & Food Security, 11 (1). https://doi.org/10.1186/s40066-022-00379-0
7. Turner, B., Menendez, H., Gates, R., Tedeschi, L., Atzori, A. (2016). System Dynamics Modeling for Agricultural and Natural Resource Management Issues: Review of Some Past Cases and Forecasting Future Roles. Resources, 5 (4), 40. https://doi.org/10.3390/resources5040040
8. Samudra, F. B., Sitorus, S. R., Santosa, E., Machfud, M. (2022). Systems dynamic modeling on sustainable apples agriculture. Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management), 11 (4), 567–577. https://doi.org/10.29244/jpsl.11.4.567-577
9. Vanany, I., Maftuhah, D. I., Jaelani, L. M., Hajar, G., Utami, N. M. C. (2019). Modeling of Chicken Production for Food Security in Indonesia. 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 627–631. https://doi.org/10.1109/ieem44572.2019.8978877
10. Aprillya, M. R., Suryani, E., Dzulkarnain, A. (2019). System Dynamics Simulation Model to Increase Paddy Production for Food Security. Journal of Information Systems Engineering and Business Intelligence, 5 (1), 67. https://doi.org/10.20473/jisebi.5.1.67-75
11. Rahman, T., Arkeman, Y., Setyaningsih, D., Saparita, R. (2017). Indonesian CPO availability analysis to support food and energy security: a system dynamic approach. IOP Conference Series: Earth and Environmental Science, 65, 012024. https://doi.org/10.1088/1755-1315/65/1/012024
12. Aminuddin, R. R., Okdinawati, L. (2023). A Dynamic Model For Poultry Supply Chain In West Java. Journal of Business and Management Review, 4 (2), 104–128. https://doi.org/10.47153/jbmr42.6272023
13. Lolanda, H. A., Puspitasari, W. T. (2024). Rancangan Simulasi Model Sistem Dinamis Pasok Kentang di Indonesia. Journal of Agribusiness Science and Rural Development, 3 (2), 63–73. https://doi.org/10.32639/nn50ax39
14. Veldhuis, G. A., Smits-Clijsen, E. M., van Waas, R. P. M., Hof, T., Maccatrozzo, V., Rouwette, E. A. J. A., Kerstholt, J. H. (2025). The influence of causal loop diagrams on systems thinking and information utilization in complex problem-solving. Computers in Human Behavior Reports, 17, 100613. https://doi.org/10.1016/j.chbr.2025.100613
15. Baez, J., Li, X., Libkind, S., Osgood, N. D., Patterson, E. (2023). Compositional Modeling with Stock and Flow Diagrams. Electronic Proceedings in Theoretical Computer Science, 380, 77–96. https://doi.org/10.4204/eptcs.380.5
16. Suryani, E., Rafi, H., Utamima, A. (2024). Model-based Decision Support System Using a System Dynamics Approach to Increase Corn Productivity. Journal of Information Systems Engineering and Business Intelligence, 10 (1), 139–151. https://doi.org/10.20473/jisebi.10.1.139-151