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Prediction of Chicken Meat Availability in Cilegon City Using iThink Dynamic Simulation Model

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Abstract

The availability of chicken meat is a crucial factor in maintaining price stability and food security in Cilegon City. The increasing demand, influenced by population growth and consumption patterns, must be balanced with optimal supply from farmers and distributors. This study aims to predict the availability of chicken meat using a dynamic simulation model based on iThink. This model is built with a stocks and flows approach and causal loop diagrams to understand the dynamics of the system involving production, import, distribution, consumption, and external factors such as government policies and weather conditions. The simulation results show that the balance of supply and demand is greatly influenced by the level of local production, per capita consumption levels, and import policies. The simulation scenario also reveals that increasing production efficiency and optimizing distribution can increase the availability of chicken meat in the market by 15-20% in the next five years. This model is expected to be a tool for stakeholders in formulating more adaptive policies to maintain the stability of supply and prices of chicken meat in Cilegon City.

Keywords: Availability of chicken meat, dynamic simulation, iThink, prediction, Cilegon City.

1. Introduction

Chicken meat is one of the most widely consumed sources of animal protein by the people of Cilegon City. Rapid population growth, increasing awareness of the importance of nutrition, and the development of the culinary sector are the main factors driving the increase in demand for chicken meat. However, an imbalance between supply and demand often occurs, especially during major holidays and national holidays, which is mostly triggered by fluctuations in broiler chicken production (Galarneau et al., 2020). Various factors affect chicken production, such as environmental conditions, disease risk, feed quality, and availability of DOC (Day-Old Chicks) (Vanany et al., 2021). However, the application of a dynamic system model specifically designed to predict the availability of chicken meat in Cilegon City is still limited (Sirajuddin et al., 2022). This study aims to develop a dynamic system model that can not only predict the need and availability of chicken meat with high accuracy but also provide strategic recommendations to overcome the deficit problem that often occurs. This model is expected to be the basis for policy making to support food security in Cilegon City.

To overcome these problems, an approach is needed that is able to analyze the chicken meat availability system comprehensively and dynamically. One method that can be used is System Dynamics, which allows modeling the relationship between various factors in the system simultaneously. iThink software is used in this study because of its ability to model complex systems with the stocks and flows approach and causal loop diagrams.

This study aims to analyze and predict the availability of chicken meat in Cilegon City using dynamic simulation based on iThink. With this model, various scenarios can be tested to understand the impact of changes in production, consumption, distribution, and policy interventions on the stability of chicken meat supply in the future. The results of this study are expected to provide insight for policy makers, farmers, and food industry players in formulating more effective and sustainable strategies to maintain the stability of chicken meat availability in Cilegon City.

2. Literature review

2.1 Dynamic System Model

Dynamic system modelling is an approach used to model and predict the behavior of complex systems over time. This method allows researchers to observe the impact of various input variables on the output of the system, and has been shown to be effective in predicting dynamics in various sectors (Richards et al., 2021). Dynamic systems consider the relationship between variables in the form of positive feedback loops that accelerate growth and negative feedback that stabilizes the system. Stock accumulation or inventory is a variable that represents the amount of resources available at a certain time, for example, the amount of chicken stock in the warehouse. Flow is a variable that describes changes in stock over time, for example, the level of production or consumption of chicken meat per day.

This model not only looks at the static relationships between variables but also how these relationships change dynamically over time. Dynamic System Model is a modeling approach used to understand, analyze, and simulate complex systems that change dynamically over time. This approach was developed by Jay W. Forrester in the 1950s at MIT to study system dynamics in business, economics, ecology, and various other fields.

2.2. Factors Affecting Chicken Production

Chicken production is influenced by various factors, ranging from environmental conditions, feed availability, to animal health management. Previous studies have shown that improvements in cage management can significantly increase production output (Mansilha et al., 2019).

2.3. Previous Studies

Research on predicting chicken meat availability using dynamic models is still limited, especially in Cilegon City. This study attempts to fill this gap by integrating historical data and local dynamic variables to predict future availability (Sahin et al., 2020).

2.3 iThink Software

iThink, which is part of the STELLA software suite, is a visual simulation software intended for modeling dynamic systems, particularly those related to business. Using a graphical approach, it allows users to visually view the dynamics of a system. Using elements such as stocks, flows, modifiers, and connectors, users can map relationships between variables and create models. This allows simulation of various policy scenarios or system changes for a comprehensive evaluation. iThink has been used in various studies in the literature. For example, iThink was used to create a model that simulates the case of a k-out-of-n weighted multi-state system in dynamic modeling of multi-state systems. In addition, iThink was used to model the changing internal systems of a company. This helps managers and decision makers understand their specific business environment and become more aware of common and specific dynamic problems.

In recent years, isee systems has begun developing web-based solutions such as isee Runtime and Stella Online, which allow users to access their models without the need for special software installations. These software tools are used to help organizations, academics, and professionals understand and analyze complex systems through stocks and flows modeling approaches and causal loop diagrams. Think has evolved by adding more flexible data import and export features, allowing it to be used in conjunction with other analytical tools such as Python, R, and Excel. Improvements in the visualization of simulation results have also made iThink increasingly attractive to users who want to present data in a more interactive way.

3. Research methods

3.1 Real System (Case Study)

This study was conducted in a broiler farming system in Cilegon City, where primary data were collected from the Cilegon City Livestock and Food Security Service. Additional data were collected through direct interviews with local farmers to understand the internal dynamics and challenges they face in production.

3.2 System Data

Table 1: Chicken Population

Research Data Description	Amount
Order of Day Old Chicks (DOC)	2,052,168 Chicks
Average mortality rate of DOC	280 Chicks
Chicken supply	160,000 Chickens
Chicken slaughter	14,250 Chickens
Average chicken weight	1.5 Kg
Chicken meat demand in hotels	45,000 Kg
Chicken meat demand in cafés	2,500 Kg
Chicken meat consumption per capita	10 Kg
Chicken meat demand in the industry	570,000 Kg
Birth rate	4%
Mortality rate	3%
Immigration rate	0.5%
Total population	456,288 People

The data used in this study includes:

a) Chicken Population Number Data on the number of broiler chickens kept in a certain period.
b) Production Capacity Information on total chicken meat production in kilograms per year.
c) Chicken Mortality Percentage of chicken deaths recorded on the farms that were the subject of the study.
d) Sales Data Volume of chicken meat sold to local and regional markets.
e) External Factors Conditions that affect production such as disease, weather and feed availability.

3.2 Data Model

Simulation of chicken meat demand and availability from 2024 to 2034 using iThink software version 9.1.3. This model integrates two main diagrams:

1. Causal Loop Diagram (CLD) Visualizes the cause-and-effect relationships between system variables such as production, chicken mortality, and market demand.
2. Stock and Flow Diagram (SFD): Shows the flow of system variables from one state to another, such as from production to consumption, including the rates of inflows and outflows.

3.3 Simulation Model

This simulation model is designed to:

a) Analyzing Trends Identifying patterns of demand and supply of chicken meat based on historical data and population growth predictions.
b) Intervention Strategy Proposes interventions to address possible production deficits, such as increasing production efficiency or importing chicken meat.
c) Long-Term Forecast Assess the impact of the proposed strategy on the stability of future chicken meat supply.

4. Results and Discussion

4.1 Results

Table 2: Comparison of Chicken Needs and Availability

Years	Total Population	Chicken Meat Demand	Chicken Availability
2024	458,288.00	5,180,380.00	0.00
2025	463,132.02	5,248,823.20	1,388,840.80
2026	470,079.30	5,318,293.05	8,800,688.75
2027	477,130.49	5,388,804.94	8,800,688.75
2028	484,287.45	5,460,374.52	13,840,441.81
2029	491,551.76	5,533,017.44	24,945,102.29
2030	498,925.51	5,606,749.66	38,304,775.25
2031	506,408.05	5,681,587.19	58,704,775.25
2032	514,000.08	5,757,546.99	77,437,962.55
2033	521,715.15	5,834,645.25	101,390,904.35
2034	529,540.85	5,912,908.52	128,658,373.53

Figure 1: Black box diagram

The results of this simulation show that Cilegon City will face significant challenges in meeting the need for chicken meat until 2027, due to the imbalance between high demand and limited supply. In 2024, the need for chicken meat is predicted to reach 5,180,380 kg, while the initial availability is estimated to be zero, resulting in a deficit of -1,900,000 kg. After the implementation of the production increase strategy, it is estimated that there will be a significant increase in the availability of chicken meat starting in 2025 with 1,388,841 kg, reaching a surplus of 6,800,689 kg in 2027. Towards the end of the simulation period in 2034, the availability of chicken meat is expected to soar to 128,583,573 kg, far exceeding the local need of only 6,100,542 kg.

Through the use of a dynamic system model, this study successfully mapped and analyzed the complex relationships between variables that affect the availability of chicken meat, such as population growth, chicken mortality rates, and industrial needs. A significant surplus at the end of the simulation period not only promises to meet local needs but also opens up opportunities for Cilegon City to support needs in other regions, thus strengthening its position as a regional food security center.

4.1.1 Black box diagram

The black-box diagram maps the relationship between inputs (such as population, birth rate, death rate, and DOC orders) and outputs (such as the number of chickens ready for slaughter and the availability of chicken meat). This diagram provides a macro view of the system being modeled.

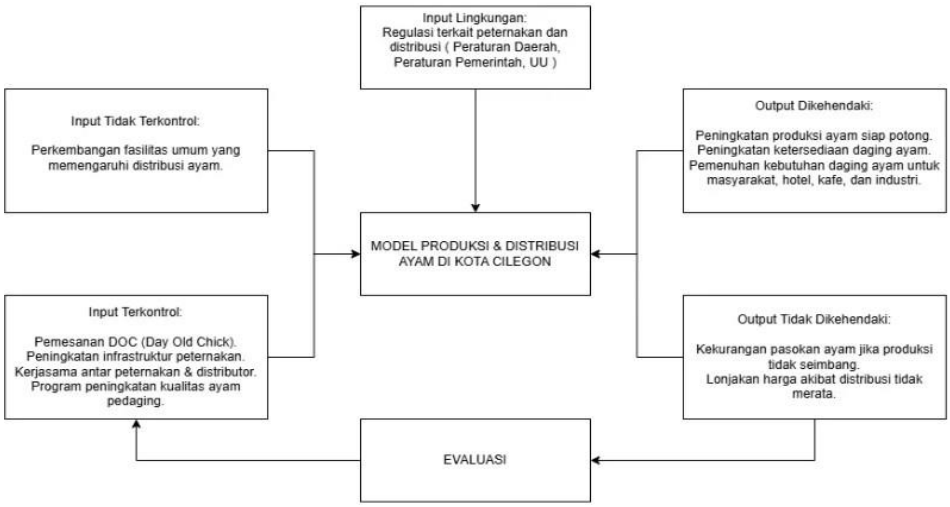

Figure 2: Black box diagram

4.1.2 Abstract Model

The conceptual model describes the relationships between variables in the system, including chicken production, industrial needs, and public consumption. Abstract model images are used to visualize these relationships.

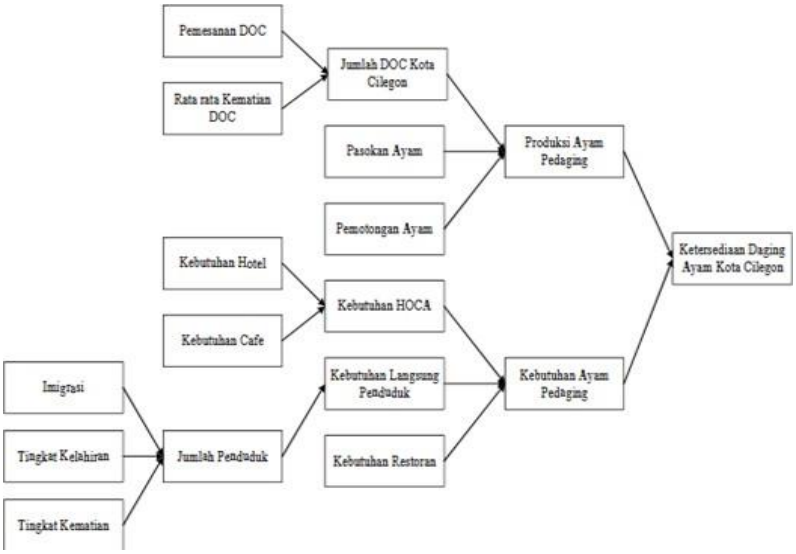

Figure 3: Abstract Model

This model consists of:

- Input DOC Order, DOC Mortality Rate, and Population (influenced by birth, death, and immigration rates).
- Process: Number of DOC in Cilegon City, Chicken Supply, Chicken Slaughter, and Broiler Chicken Production.
- Output: Availability of Chicken Meat in Cilegon City, with chicken needs consisting of direct needs of the population, HORECA needs (Hotels, Restaurants, and Cafes).

The image above explains the relationship between components in the broiler chicken meat availability system, which will then be analyzed using a dynamic system model simulation.

4.1.3 Causal Loop Diagram (CLD)

Causal loop diagram(CLD) explains the causal relationship between broiler chicken production variables, broiler chicken availability variables and population variables. The relationship between these variables forms a causal chain that will provide feedback to other variables.

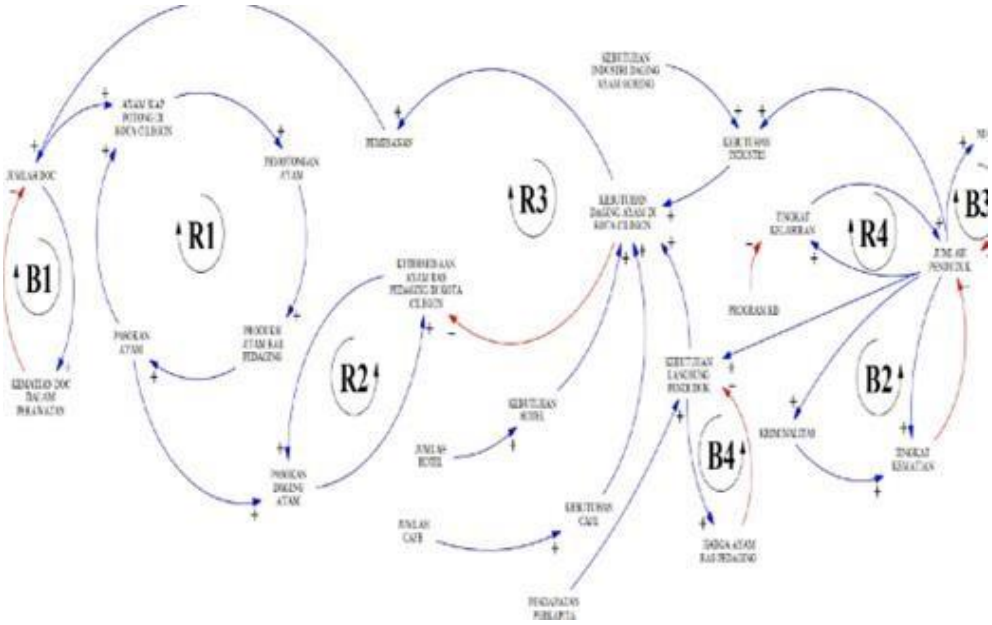

Figure 4*: Causal Loop Diagram (CLD)*

In the Causal loop diagram there are symbols such as B1, B2, B3, B4, R1, R2, R3, and R4 [15], [16], [17]. B1 can be interpreted as a balancing loop (negative loop) that describes the relationship between the number of chicks (day

old chicks/DOC) and DOC deaths in care. B2 is a balancing loop (negative loop) that describes the relationship between population, mortality rate and crime. B3 is a balancing loop (negative loop) that describes the relationship between population and migration. B4 is a balancing loop (negative loop) that describes the relationship between direct population needs and the price of broiler chickens.

4.5 Stock and Flow Diagram (SFD)

Stock and Flow Diagram (SFD) is a tool used in dynamic systems to visualize how stocks (collections of accumulations in a system) and flows (inputs and outputs from those stocks) interact over time. SFD helps in depicting and understanding the underlying structure of complex system dynamics.

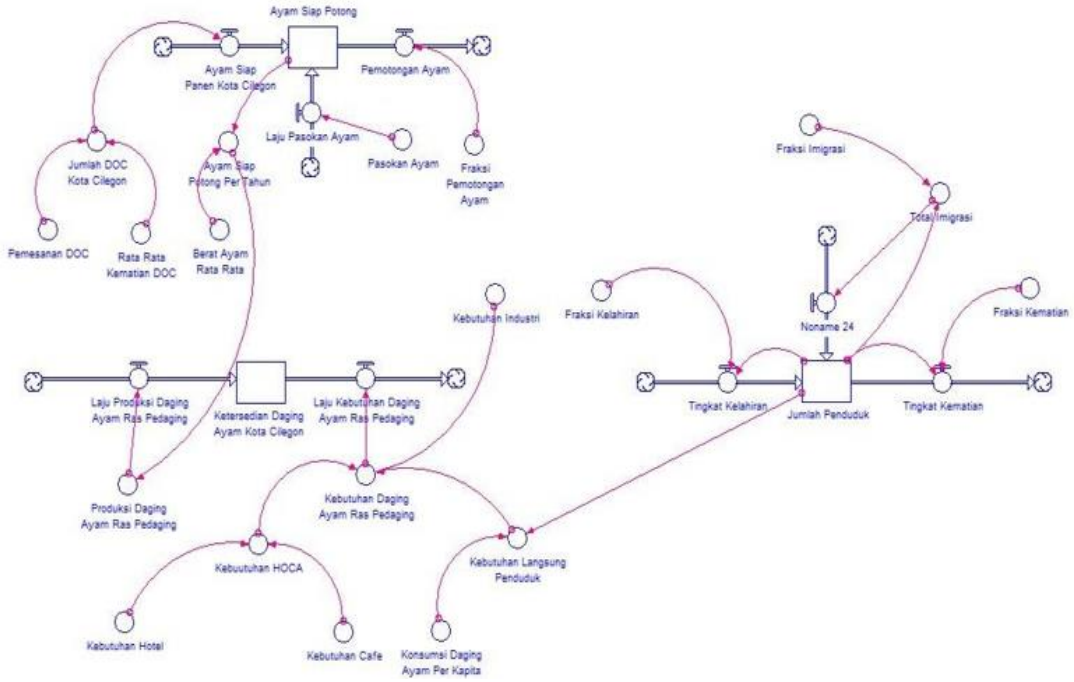

Figure 5: Stock and Flow Diagram

In the context of predicting the availability of chicken meat in Cilegon City, the SFD associated with this simulation may involve several key elements:

a. Stock:
- Number of DOC (Day-Old Chicks): This represents the total number of chicks available to be raised into broilers.
- Ready-to-Slaughter Chicken: The number of chickens that have reached the age or weight ready to be slaughtered to be marketed as chicken meat.
- Availability of Chicken Meat: The total amount of chicken meat available in the market to meet consumer needs in Cilegon City.

b. Flow
- DOC Ordering: This is the level at which the farmer orders DOCs to start or continue the rearing process.
- DOC Mortality: This represents the mortality rate of chickens that are still in the DOC stage.
- Broiler Chicken Production: Describes the transformation process from DOC to ready-to-slaughter chicken.
- Chicken Cutting: Shows the process of turning ready-to-cut chicken into chicken meat ready for sale.

c. Helper Variables and Parameters:
- Average Chicken Weight: Used to estimate how much meat can be produced from each chicken.
- Population Birth and Death Rates: Can affect the demand for chicken meat.
- Industrial and HORECA (Hotel, Restaurant, and Cafe) Needs: Shows how much chicken meat is needed by industry and the service sector.
- Per Capita Consumption: Average consumption of chicken meat per person.

d. Connectors and Feedback Loops:

Positive and negative feedback: For example, an increase in population can increase the demand for chicken meat, which increases the price, which in turn can motivate increased production (positive feedback). However, an increase

in price can also reduce per capita consumption (negative feedback).

In analyzing SFD, it is important to understand that each stock is filled by incoming flows and reduced by outgoing flows. For example, "Number of DOCs" is increased by "DOC Orders" and reduced by "DOC Deaths" and "Chicken Slaughter". This diagram helps in making accurate predictions about how much chicken meat will be available in the future based on the interacting variables in the system.

4.2 Discussion

In 2024, the predicted population of Cilegon City is 458,288 people, requiring 5,180,380 kg of chicken meat. This prediction highlights a significant challenge, where there is no availability of chicken meat at the beginning of the period. This situation is projected to change in 2025, with an estimated availability of 1,388,841 kg in 2026, and a continued increase to reach a significant surplus in 2027 with 6,800,689 kg. This prediction continues to be positive, until availability increases drastically to 128,583,573 kg in 2034.

The initial deficit in chicken meat availability, especially in 2024, is predicted to be caused by inadequate local production capacity and high dependence on supplies from outside the region. Factors such as feed quality, chicken health, and effectiveness of disease control are key determinants that are expected to influence success in meeting market needs. Intense demand fluctuations, especially during the festive period, highlight the urgent need for a more efficient distribution system that can address frequent supply imbalances.

In addressing these challenges, the strategy implemented focuses on increasing the efficiency of the livestock system. Through the use of technology, improved feed management, and better health programs, predictions show that the deficit can be overcome within the first five years. This success will open up opportunities for Cilegon City to not only meet local needs but also position itself as a major supplier of chicken meat at the regional level, which in turn can increase economic potential and strengthen regional food security.

5. Conclussion

This simulation shows that Cilegon City will face significant challenges in meeting its chicken meat needs until 2027, due to the imbalance between high demand and limited supply. In 2024, the need for chicken meat is predicted to reach 5,180,380 kg, while the initial availability is estimated to be zero, resulting in a deficit of -1,900,000 kg. After the implementation of the production increase strategy, it is estimated that there will be a significant increase in the availability of chicken meat starting in 2025 with 1,388,841 kg, reaching a surplus of 6,800,689 kg in 2027. Towards the end of the simulation period in 2034, the availability of chicken meat is expected to soar to 128,583,573 kg, far exceeding the local need of only 6,100,542 kg.

Through the use of a dynamic system model, this study successfully mapped and analyzed the complex relationships between variables that affect the availability of chicken meat, such as population growth, chicken mortality rates, and industrial needs. A significant surplus at the end of the simulation period not only promises to meet local needs but also opens up opportunities for Cilegon City to support needs in other regions, thus strengthening its position as a regional food security center.

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