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A System Dynamics Model for Developing an Agropolitan Area based on Laying Hens in Lima Puluh Kota Regency

A System Dynamics Model for Developing an Agropolitan Area based on Laying Hens in Lima Puluh Kota Regency

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Abstract. The development of an agropolitan area based on laying hens in Lima Puluh Kota Regency faces many problems. One method that can be used to solve these complex problems is the systems approach. This study aimed to build a model for developing a sustainable agropolitan area based on integrated laying hens farming. The results of the system performance indicated that the current system is in a fairly sustainable position. The dynamics of time will make changes in system performance in the future. There are six factors that influence the interdependent system, namely carrying capacity, egg prices, farmer income, employment, infrastructure, and utilization of livestock waste. Based on the state of each factor, three scenarios were formulated for the development of a sustainable laying hens farming system in Lima Puluh Kota Regency: (1) conservative-pessimistic scenario, (2) moderate-optimistic scenario, and (3) progressive-optimistic scenario.

Keywords: dynamic system; agropolitan; key factor; scenario; simulation.

1. Introduction

Not only does it cause a backwash effect, the failure of development in rural areas also results in capital and market control. If the agricultural sector with agribusiness can act as a leading sector in the economy, then every agribusiness will have forward and backward linkages [1]. To narrow the gap between village and city governments, regional development policies have been implemented through an agropolitan concept based on regional potential. Covering physical, social, economic, and developmental bases, the program involved establishes centers of rural growth areas which are called agricultural centers [2]. Lima Puluh Kota Regency, West Sumatra, has implemented an agropolitan policy based on the Lima Puluh Kota Regency Government Decree No. 398/BLK/2005 dated June 6, 2005, which stipulates that Payakumbuh, Mungka, and Guguak Districts are agropolitan areas for laying hens agribusiness. At the

beginning of its implementation, laying hens provided a good economic improvement for farmers. However, in recent years, level of egg production and number of farmers have decreased. In this case, the farmers even went bankrupt and closed their businesses. Many factors were responsible for the decrease in production in relation to the implementation of agropolitan policies. This condition needs to be assessed as a consideration to develop a more comprehensive agropolitan area model so that it can contribute significantly to food security, especially when it comes down to chicken eggs availability in the Central Sumatra region.

2. Methodology

This study used secondary data in the form of time series data for the period 2016 to 2020. The data were obtained from the Ministry of Agriculture, Statistics Indonesia (BPS), and other sources that supported this research. In data processing, the researcher used a system dynamics approach, which consisted of the following stages of analysis [3]:

1) A System Dynamics Model of Chicken Egg Production in Lima Puluh Kota Regency
   Model Development was carried out according to the stages of the dynamics model approach. System dynamics models can help in understanding the structure and behavior of a system with non-linear links and feedback [4]. A needs analysis was carried out to find out the needs of system actors. Each system actor had different needs but interacted with each other and affected the entire existing system [5].
2) Model Formulation was performed according to past historical data and information.
3) Model Validation was carried out by comparing the behavior of the model to the real system through a Mean Absolute Percentage Error (MAPE) test. The MAPE formula is as follows: $MAPE = \frac{1}{n}\frac{|X_m - X_d|}{X_d} \times 100\%$, where X_m is the simulation result data, X_d is the actual data, and n is the period/number of data. The criteria for the accuracy of the model using the MAPE test [6] were as follows: MAPE < 5%: very precise; 5% < MAPE < 10%: precise; MAPE > 10%: not precise.

3. Results and Discussion

1) Dynamics of Chicken Egg Production in Lima Puluh Kota Regency

Layer chickens are laying hens that are ready to produce with a production period of 55 weeks. The layer chicken population in Lima Puluh Kota Regency in the period 2016 to 2020 showed an increasing trend.

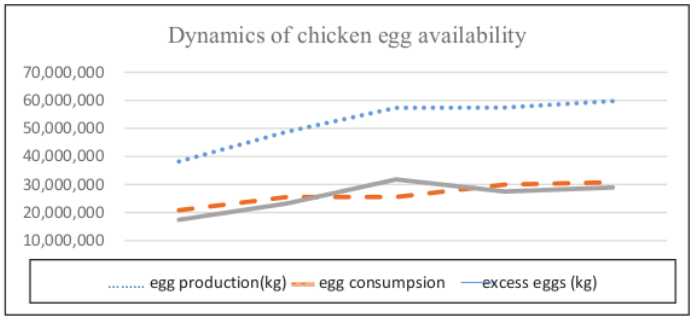

Figure 1. Dynamics of Availability of Chicken Eggs in Lima Puluh Kota Regency for the 2016–2020 Period

2) Description of the Chicken Egg Production System in Lima Puluh Kota Regency

A system analysis involves identifying the components of a system, building a mental model of how they relate to one another, and presenting it as a causal loop diagram (CLD) [7]. Based on the literature review, several system actors that played a role in the production of layer chicken eggs can be identified. Table 1 presents the needs of each system actor.

Table 1. Identified System Actors and Their Needs

Actors	Needs
Breeder	Production and business profits increase
Government	Eggs and chicken meat sufficient availability to meet the community's needs
Poultry industry	Continuity of egg production and big profit margin
Society	Fulfilment of the needs for eggs and chicken meat

The system performers and their needs have been adapted to the research limitations. The input-output diagram of this system can be seen in Figure 2.

3) System Conceptualization

The problem of egg production in Lima Puluh Kota Regency is a complex problem involving various interacting and integrated variable components. Egg production is illustrated in the cause-and-effect diagram in Figure 3.

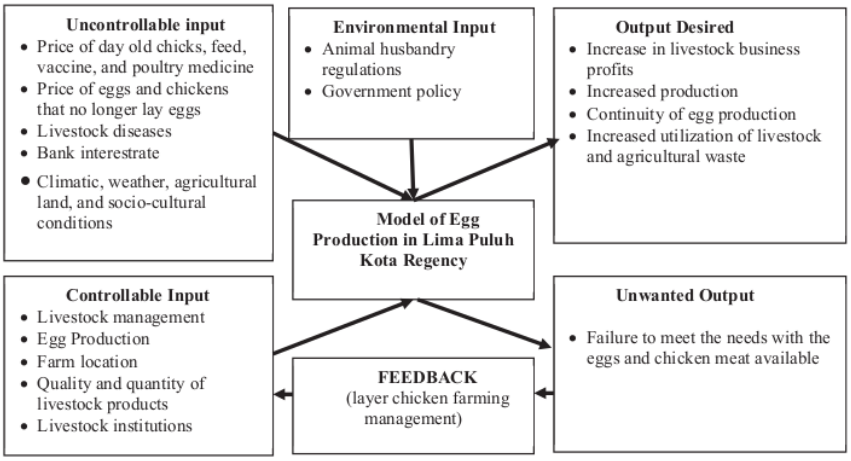

Figure 2. Input-Output Diagram of the System Dynamics in the Chicken Egg Production in Lima Puluh Kota Regency

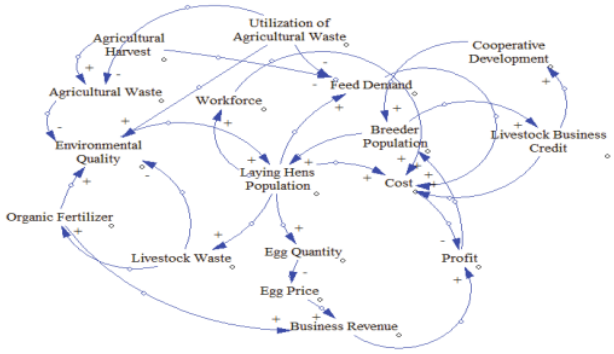

Figure 3. Causal Loop Diagram of the Egg Production Model in Lima Puluh Kota Regency

Egg production was influenced by the layer chicken population size, while the layer chicken population size depended on the number of breeders and the quality of the environment of the farm area. The number of farmers was influenced by the amount of profits from farming laying hens and business incentives from livestock farmer cooperatives. Increasing profits and attractive business incentives would increase the number of laying hens and indirectly increase the layer chicken population size and egg production. Business profits depended on the amount of costs and business revenues, in which case the greater the business costs the smaller the business profits. The largest cost component came from animal feed, while the largest revenue component came from egg sales. The system dynamics model developed was limited to matters related to egg production, which was influenced by layer chicken population and business profits variables. To facilitate modeling, the egg production system was divided into two main sub-systems, namely the layer chicken population sub-system and the business profits sub-system.

4) System Formulation

Model formulation is the process of translating a conceptual model into a quantitative model so that simulations can be carried out [8]. Model formulation is the formulation of a problem into a mathematical form that can represent a real system. It relates the variables that have been identified in the conceptual model. A complete arrow box diagram for the chicken egg production model in Lima Puluh Kota Regency can be seen in Figure 4.

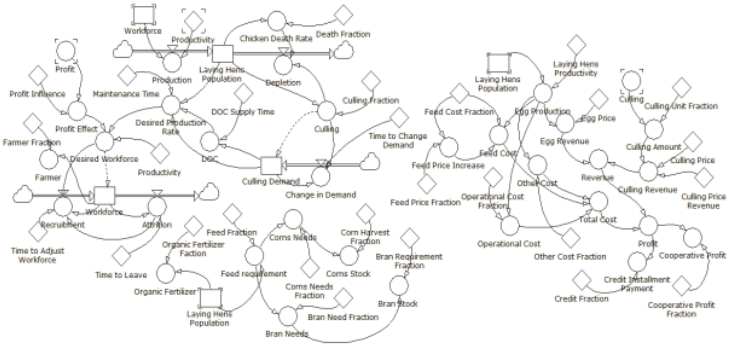

Figure 4. Stock Flow Diagram of the Egg Production Model in Lima Puluh Kota Regency

Some of the assumptions used in the modeling of this research are as follows:
The dynamics of population growth were assumed to be influenced by inflows in the form of production variables and outflows in the form of depletion variables. The feed consumed by chickens (feed requirement) was assumed to consist of a mixture of 45% concentrate, 15% rice bran, and 40% corn. The demand for culling chicken was influenced by the interaction of the culling and the time variable for changes in demand. Revenue from the egg sales is calculated based on these assumptions: layer chickens have a productivity level of 7.7 kg/head/week and the price of eggs is IDR 23,700/kg; total operating costs are the sum of feed costs, other costs, and operational costs; the profits from laying hens farming is used for credit installment payments and payments of contributions to poultry cooperatives; the variable adjustment time for workers is 8 weeks; labor productivity is worth 1,500 heads/person/week where every one worker is able to take care of 1,500 chickens; the number of breeders is 25% of the total number of workers; all laying hens breeders are members of a livestock cooperative and donate 5% of the profits to the cooperative directly; and payment of credit installments is 20% of the business profits.

5) Scenario and Simulation Results

Dynamic model simulation can explain the processes that occur in the system and predict the results of various scenarios [9]. The simulation model is more realistic on the real system because it requires fewer assumptions [10]. Several scenarios were used to analyze the chicken egg production in Lima Puluh Kota Regency, and the results are as follows:

1. Scenario of No Component Change (Moderate)

In this scenario, the system runs according to the initial formulation or according to the current conditions. The simulation results show that the growth rate of layer chicken population, egg production, and demand for rejected chickens grow by 26 percent/year, while the number of workers grows by 25 percent/year. Business revenues, total operating costs, and business profits also grow at a rate of 26 percent/year. Business profits grow by 1 percent/breeder every year.

2. Scenario of Increased Egg Price (Optimistic)

The price of eggs is a constant variable whose value is assumed to be constant every year. This is due to the many factors that affect the price of domestic chicken eggs. The optimistic scenario in the model assumes that egg prices have increased by 6.88 percent/year [11]. The increase in egg prices causes a) an increase in farmer income by 1 to 27 percent/year; b) an increase in farmer profits by 2 to 28 percent/year; c) an increase in profits per farmer by 2 to 3 percent/year; and d) an increase in chicken egg production by 15 percent/year.

3. Scenario of Increased Feed Prices (Pessimistic)

Egg prices and feed prices are two important variables that affect chicken egg production. In the pessimistic scenario, the price of feed experiences a higher increase of 60 percent/year. The simulation results in the pessimistic scenario showed a) an increase in total operating costs by 32 percent/year, b) a decrease in operating profits by 22 percent/year to only 4 percent/year, c) a decrease in profits per farmer by 16 percent/year; and d) a decrease in egg production by 25 percent/year. The results of the simulation of egg production variables under various scenarios are shown in Figure 5.

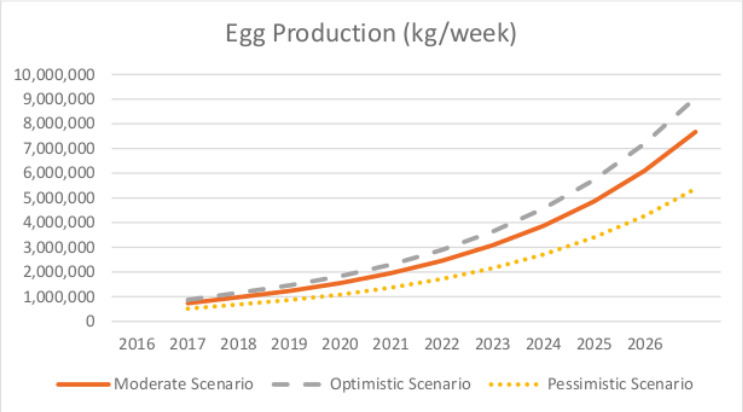

Figure 5. Chicken egg production in moderate, optimistic, and pessimistic scenarios

6) Model Validation

Model validation was carried out by comparing the simulation results with the actual data obtained from the real system. Model validation was carried out on layer chicken population and egg production variables by comparing the real system data in the 2016–2020 range with the data from the simulation results. The variable tested was the amount of chicken egg production. The validation of the model produced a value of 5.09%, meaning that the model built was categorized as "right" in estimating the amount of chicken egg production in Lima Puluh Kota Regency in the 2016–2026 time period. The system dynamics model of the chicken egg production in Lima Puluh Kota Regency that was developed has been able to describe the condition of chicken egg production. The simulation results showed that until 2026 chicken egg production will experience growth. Based on these three scenarios, chicken egg production continues to increase even though the growth rate slows down when there is an increase in feed prices. In the future, the overall production of chicken eggs in Lima Puluh Kota Regency tends to increase. In line with this, the profits of laying hens farming will increase. However, an

increase in feed prices that is not followed by an increase in egg prices will hinder the rate of increase in egg production in Lima Puluh Kota Regency.

4. Conclusion

The system dynamics model of the chicken egg production in Lima Puluh Kota Regency that was developed has been able to describe the condition of chicken egg production in accordance with the real system. The simulation results showed that until 2026, chicken egg production in Lima Puluh Kota Regency will experience growth. In the future, the overall egg production in Lima Puluh Kota Regency tends to increase.

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References

[1] E. Rustiadi, S. Hadi, and and W. A. Muttaqien, *Agropolitan area concept of rural-urban development is balanced.* Bogor: IPB Press, 2006.
[2] Agricultural Human Resources Development Agency. Ministry of Agriculture, *General Guidelines for Agropolitan Regional Development and Guidelines for Agropolitan Regional Development Pilot Programs*. Jakarta, 2002.
[3] L. R. Andhika, "Dynamic System Model: Simulation Method in Formulation Public Policy," *Ekon. dan Kebijak. publik*, vol. 10, no. 1, pp. 73–86, 2009.
[4] P. B. Mirjana and C. Vlatco, "Developing system dynamics models with 'step-by-step' approach.," *J. Inf. Organ. Sci.*, vol. 31, no. 1, 2007.
[5] H. Purnomo, *Pemodelan dan Simulasi untuk Pengelolaan Adaptif Sumber Daya Alam dan Lingkungan*. Bogor: IPB Press, 2012.
[6] S. S. Agus and Machfud, "Analisis Sistem Dinamika untuk Kebijakan Penyediaan Ubi Kayu : (Studi Kasus di Kabupaten Bogor)," *Bul. Teknol. Pascapanen Pertan.*, vol. 2, pp. 36–48, 2006.
[7] J. D. Sterman, "Business dynamics: systems thinking and modeling for a complex world," *No. HD30. 2 S7835 2000*, 2000.
[8] G. S. Robert, "Verification and validation of simulation models," in *Winter Simulation Conference ·37 (2). January 2011*, 2011, pp. 166–183, doi: 10.1109/WSC.2010.5679166.
[9] Hartrisari, "Sistem Dinamik: konsep sistem dan permodelan untuk industri dan lingkungan. Bogor," *Seameo Biotrop*, 2007.
[10] S. N. Nuroniah, "Penjadwalan Produksi dengan Pendekatan Metode Dinamik (Studi Kasus di PT Goodyear Indonesia, tbk).," Institut Pertanian Bogor, 2003.
[11] R. P. Destiarni, "Peramalan Harga Telur Ayam Ras Pada Hari Besar Keagamaan di Pasar Jawa Timur," *Berk. Ilm. AGRIDEVINA*, vol. 7, no. 1, Jul. 2018, doi: 10.33005/adv.v7i1.1131.

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