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Optimization of Kampung Chicken Seedling Production Using the Monte Carlo Method (Case Study on Hacci Farm)

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Abstract

This research aims to optimize free-range chicken hatchery production at Hacci Farm using the Monte Carlo method, which is known for its ability to overcome uncertainty and variability in production. The data in this research uses chicken seed production data in 2022 and 2023 which is then used as input in the Monte Carlo simulation. The simulation results reveal that the Monte Carlo method provides more accurate predictions regarding free-range chicken seed production. Through this simulation, Hacci Farm can predict the amount of free-range chicken hatchery production in the future and can prepare more effective strategic steps in hatchery management to increase operational efficiency, reduce risks, and maximize free-range chicken production results. The results of implementing the Monte Carlo method show quite high accuracy, namely 98.7% in 2022 and 97.95% in 2023, this can help in planning and managing resources optimally. It is hoped that the use of this method can make a significant contribution in increasing the quality and quantity of free-range chicken production at Hacci Farm, as well as providing a model that can be adopted by other farms for similar purposes

Keywords: *Use about five key words or phrases in alphabetical order, Separated by Semicolon*

1. Introduction

One of the problems with the production of free-range chicken seeds is resource management, where the production of free-range chicken seeds requires a place for cultivation. Resource management that is not optimal can hamper the productivity of free-range chicken seeds. Apart from that, one of the main reasons is because the rearing system is still traditional, the insufficient amount of feed given, and the lack of understanding of nutritional requirements in providing feed [1].

Good production results are also influenced by several factors including proper livestock management. The availability of free-range chicken seed production is closely related to food needs in Indonesia. This is because the livestock sector has a role in the Indonesian economy, especially in providing food for the community. Consumption of livestock products in Indonesia such as meat, eggs, milk, cheese and other products has a high level among the public. Various livestock products can be found in various types of markets, both traditional and modern [2].

Production is one of the most important parts of a business. The amount of profit obtained is closely related to the number or size of products produced. Every company strives to increase production and carry out production activities efficiently. To predict future production and reduce production costs, applying simulation to production results can be a solution [3]. A simulation model is a test tool that considers the options given and makes important considerations to make the best decision, including using data from several years ago that shows cause-and-effect relationships in a computer model of a system that can visualize a real system with potential events [4]. In optimizing free-range chicken seed production, simulation models can be used to evaluate strategies to increase production efficiency. Production optimization methods usually involve data analysis, mathematical modeling, and the use of information technology.

Monte Carlo is an optimization method that can be used to optimize the production process by considering uncertainty or variations in production parameters. The Monte Carlo method is the basis of an algorithm in a simulation method that uses random values (random numbers) to increase the accuracy of the results of problem solving. [5]. The Monte Carlo method can be used as a reference to assess the level of confidence in the results of a system and anticipate factors that may arise during research implementation [6].

Based on the description of the problem that has been explained, this research aims to create a simulation model to optimize the optimal number of free-range chicken seed production using the Monte Carlo method. The solutions provided can certainly be useful for farmers

in increasing livestock productivity, reducing the risk of losses, and ensuring the sustainability of free-range chicken farming businesses.

2. Literature Review

2.1. Simulation

Simulation is a method used as a technique for estimating future earnings by analyzing earnings. Through simulation, the right decisions can be taken in a short time for the system. In particular, especially in inventory management, simulation allows users to understand future needs [3]. Simulation begins by building a real system model, which must be able to show interactions between components so that it accurately represents system behavior. Then the model is transformed into a computer program so that it can be simulated [7].

2.2. Optimization

Optimization is the process of finding one or more solutions related to the values of one or more objective functions in a problem to achieve an optimal value. Broadly, optimization refers to finding the best value (minimum or maximum) of various functions given in a context. Optimization can also be an effort to improve performance so as to produce good quality and optimal work results [8].

2.3. Monte Carlo

The Monte Carlo method is known as statistical sampling, inspired by pioneers in the field (including Stanislaw Marcin Ulam, Enrico Fermi, John von Neumann, and Nicholas Metropolis). The name "Monte Carlo" comes from the name of a famous casino in Monaco. The application of elements of randomness and repetition of the process in this method resembles activities carried out in a casino [9]. Random processes involve probability distributions of data variables that are analyzed based on available data as well as theoretical probability distributions. Random numbers are used to represent random events and follow changes that occur in the simulation process sequentially. The properties of random numbers are consistent for each set of random numbers generated, and the probability of a random number appearing is not affected by previous numbers. The use of the Monte Carlo method in simulation is used to predict demand [10]. By using random numbers for each variable from its probability distribution, the Monte Carlo method can simulate the system repeatedly [11]. To calculate this value, evaluation is carried out numerically by utilizing experimental samples using random numbers. Random numbers are used to describe the random occurrence of a random variable at each point in time, as well as following each change in the simulation process sequentially [12].

3. Research Methods

The method applied in this research is the Monte Carlo method. There are 2 types of Monte Carlo, namely Monte Carlo Variance Reduction and Monte Carlo Standard. The Standard Monte Carlo method is a method that obtains results most similar to experimental calculations by performing experimental calculations on large amounts of data called simulations. Several previous efforts of researchers demonstrated the success of the Monte Carlo approach in the field of predictive analytics. The steps that will be carried out in this analysis are in **Fig 1.**

Fig. 1: Flowchart of the Monte Carlo Method

3.1. Chicken Seed Data

In this section, it needs to be emphasized that combining chicken seed production data from 2022 to 2023 is very crucial in using the Monte Carlo simulation technique. This method uses past production data as a basis for predicting future results by considering the level of uncertainty.

3.4. Determining Probability Distributions

Probability Distribution can be determined through the use of mathematical formulas. The following is the production prediction formula using the Monte Carlo method.

$$P = \frac{F}{J} \quad (1)$$

Information:
P =Probability Value
F =Frequency
J =Amount

3.5. Calculating Cumulative Probability

$$I = Dk + Dp \quad (2)$$

Information:
I = Cumulative Probability Distribution Results
D_k = Cumulative Distribution
D_p = Probability Distribution

The procedure for determining the cumulative probability distribution is carried out by adding the probability distribution value to the total previous probability value. This method accumulates probabilities at each stage to obtain an overall cumulative probability distribution. It should be noted that the initial cumulative probability distribution reflects the value of the first probability distribution, which serves as an important starting point in the development of cumulative probability.

3.6. Determining Random Number Intervals

At this stage, determining the range of random numbers is done by calculating the cumulative probability value from the previous step. The main purpose of these random numbers is to serve as a boundary between different variables, thereby serving as a benchmark for simulation results. The random number range consists of two components, namely the initial threshold value and the final threshold value. The initial threshold value calculation for the first variable starts from 0, while the final threshold value is determined by multiplying the cumulative probability value of each variable by 100 and then rounding it off. For the second variable and so on, the initial threshold value is obtained by adding 1 to the final threshold value of the previous variable. This systematic approach ensures the orderly development and generation of random number intervals for the various variables in the simulation process. Through this rigorous process, simulation models can accurately generate and represent the randomness inherent in the system being studied.

3.7. Generating Random Numbers

The formula used to generate random numbers is given as follows:

$$Na_i = (K.Na_{i-1} + K_p) mod\ K_m \quad (3)$$

Information:
Na_i = Value of the ith random number
K = Excavator Constant$(K < K_m)$
Na_{i-1} = Value of the previous random number (For is the initial number which is the generating key and is also called bait, value is an integer with the conditions and $)Na_0 Na_0 Na_0 \geq 0 Na_0 < K_m$
K_p = Shift Constant$(K_p < K_m)$
K_m = Modulus Constant$(K_m > 0)$

3.8. Monte Carlo Simulation

Based on the results obtained using Monte Carlo, Hacci Fram obtains valuable information regarding production estimates for the coming year. The use of these computational techniques enables the exploration of multiple scenarios and possibilities, providing decision makers with a deep understanding of the various potential outcomes that may arise from different market conditions and operational strategies.

4. Results and Discussion

Simulation data management to predict the optimal number of free-range chicken seed production has several important steps, including:

4.1. Data on Number of Village Chicken Seed Production

The data used to predict the number of free-range chicken seed production, namely data for 2022, 2023, can be seen in Table 1.

Table 1: Data on the number of patients based on services in 2022, 2023

Production of Free-range Chicken Seeds	2022	2023
January	8000.00	9381.00
February	8250.00	9358.00
March	8900.00	9323.00
April	8720.00	9104.00

May	8220.00	9065.00
June	8350.00	9007.00
July	8100.00	9091.00
August	8450.00	9358.00
September	9100.00	9785.00
October	9010.00	10043.00
November	9071.00	10122.00
December	9128.00	10371.00
Total	**103299.00**	**114008.00**

4.2. Determining Probability Distributions

The data used to predict the number of free-range chicken seed production in 2022 and 2023 is in **Table 1. Table 2** presents the calculation of the probability distribution obtained from the monthly number of chicken seed production divided by the total for each year and so on.

Table 2: Probability Distribution

Production of Free-range Chicken Seeds	**Probability Distribution**	
	2022	**2023**
January	0.08	0.08
February	0.08	0.08
March	0.09	0.08
April	0.08	0.08
May	0.08	0.08
June	0.08	0.08
July	0.08	0.08
August	0.08	0.08
September	0.09	0.09
October	0.09	0.09
November	0.09	0.09
December	0.09	0.09
Total	**1**	**1**

4.3. Determining the Cumulative Probability Distribution

The next step is to create a cumulative value by adding each cumulative variable value with the probability distribution variable value, except for the initial cumulative variable value. The results of the cumulative distribution calculation are shown in **Table 3.**

Table 3: Cumulative Distribution

Production of Free-range Chicken Seeds	**Distribution Cumulative**	
	2022	**2023**
January	0.08	0.08
February	0.16	0.16
March	0.24	0.25
April	0.33	0.33
May	0.41	0.41
June	0.49	0.48
July	0.57	0.56
August	0.65	0.65
September	0.74	0.73
October	0.82	0.82
November	0.91	0.91
December	1.00	1.00

4.4. Determining Random Number Intervals

Following are the steps to determine the limit value on a random number interval:

1. The initial limit for the first variable is 1.
2. The final limit is obtained by multiplying the cumulative probability value of each variable by 100.
3. The initial limit for the second variable and so on is calculated by adding 1 to the final limit value of the previous variable.

The results of determining the random number interval can be seen in **Table 4**, **Table 5**.

Table 4: Random Number Intervals in 2022

Production of Free-range Chicken Seeds	2022 Data	Cumulative Probability	Random Number Interval
January	8000.00	0.08	00-07
February	8250.00	0.16	08-15
March	8900.00	0.24	16-24
April	8720.00	0.33	25-32
May	8220.00	0.41	33-40
June	8350.00	0.49	41-48
July	8100.00	0.57	49-56
August	8450.00	0.65	57-64
September	9100.00	0.74	65-73
October	9010.00	0.82	74-82
November	9071.00	0.91	83-91
December	9128.00	1.00	92-100

Table 5: Random Number Intervals in 2023

Production of Free-range Chicken Seeds	2023 data	Cumulative Probability	Random Number Interval
January	9381.00	0.08	00-08
February	9358.00	0.16	09-16
March	9323.00	0.25	17-24
April	9104.00	0.33	25-32
May	9065.00	0.41	33-40
June	9007.00	0.48	40-48
July	9091.00	0.56	49-56
August	9358.00	0.65	57-64
September	9785.00	0.73	65-73
October	10043.00	0.82	74-82
November	10122.00	0.91	83-90
December	10371.00	1.00	91-100

4.5. Generate random numbers

The Mixed Congruent Method requires four key parameters to be determined first, namely a, c, m, and Zi. In this phase, these parameters will be set with the values a = 2, c = 2, m = 100, and Zi = 2. After these values are set, the next step is to carry out calculations to generate random numbers. Random numbers have an important role in simulations because they help in determining the possible outcomes of a simulation. Simulations are used to represent real-world situations where there is uncertainty or variation in possible outcomes. 12 random numbers were obtained, namely 2, 6, 14, 30, 62, 26, 54, 10, 22, 46, 94, 90. These numbers will be used to predict the number of free-range chicken seed production at Hacci Farm.

4.6. Simulation Results

The random numbers that have been generated will be analyzed and presented in table form to compare the simulation results with actual data, and the level of accuracy is shown in Table 6 for the 2022 simulation and **Table 7** for the 2023 simulation results.

Table 6: Simulation Results for 2022

Production of Free-range Chicken Seeds	Real Data 2022	Simulation Results	Level of accuracy %
January	8000.00	8000.00	100
February	8250.00	8000.00	97.0
March	8900.00	8250.00	92.7
April	8720.00	8720.00	100
May	8220.00	8450.00	97.3
June	8350.00	8720.00	95.8
July	8100.00	8100.00	100
August	8450.00	8250.00	97.6
September	9100.00	8900.00	97.8
October	9010.00	8350.00	92.7
November	9071.00	9128.00	99.4

December	9128.00	9071.00	99.4
Average	**8495**	**8608**	**97.6**
Total	**103299.00**	**101939.00**	

Based on Table 6, real data for 2022 is 103,299.00 free-range chicken seed production. By carrying out simulation experiments, the results obtained in 2022 are 101,939.00 free-range chicken seed production with an accuracy rate of 97.6%.

Table 7. Simulation Results for 2023

Production of Free-range Chicken Seeds	Real Data 2023	Simulation Results	Level of accuracy %
January	9381.00	9381.00	100
February	9358.00	9381.00	99.8
March	9323.00	9358.00	99.6
April	9104.00	9104.00	100
May	9065.00	9358.00	96.9
June	9007.00	9104.00	98.9
July	9091.00	9091.00	100
August	9358.00	9358.00	100
September	9785.00	9323.00	95.3
October	10043.00	9007.00	89.7
November	10122.00	10371.00	97.6
December	10371.00	10122.00	97.6
Average	**9413**	**9381**	**97.95**
Total	**114008.00**	**112958.00**	

Based on Table 7, real data for 2023 was 114,008.00 free-range chicken seed production. By carrying out simulation experiments, results were obtained in 2022 of 102,958.00 free-range chicken seed production with an accuracy level of 97.95%.

5. Conclusion

This research succeeded in showing that the use of the Monte Carlo method in optimizing free-range chicken seed production at Hacci Farm. Monte Carlo simulations are able to model more accurate predictions regarding future production.

The final results of the prediction simulation show very positive results. In 2022, the predicted production success rate will reach 97.6%. This shows that by using the Monte Carlo method, Hacci Farm is able to identify production quantities, thereby increasing production efficiency. Further improvement is seen in predictions for 2023, where the production success rate is projected to reach 97.95%.

Overall, this research confirms the importance of the Monte Carlo method as a useful tool in making strategic decisions in the field of animal husbandry, especially in hatching free-range chickens. This research also provides a clear example of how scientific and technological approaches can be applied in the livestock industry to achieve better and more sustainable results.

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