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FUZZY ANALYTICAL HIERARCHY PROCESS (AHP) MODEL FOR CHICKEN EGG SUPPLY AND DEMAND MANAGEMENT STRATEGIES THROUGH SAFCES APPLICATION DEVELOPMENT

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Abstract The complexity of managing the supply and demand for egg agents causes conditions for egg agents to experience difficulties in determining the ideal number of eggs available in the warehouse and establishing the right strategy for controlling the supply from breeders. This research aims to assist egg agents in supporting the right strategic decisions in managing chicken eggs so that the supply and demand for chicken eggs are maintained through the development of the SAFCES application so that it is not done manually. The Fuzzy Analytical Hierarchy Process (AHP) model is used through the development of an application called SAFCES. The results showed that the main priority in managing chicken eggs was focusing on selling prices (0.63) and an alternative strategy that could be used as increasing agent area (0.78) to manage demand which was always maintained.

Keywords Chicken Egg, Fuzzy, SAFCES Application

1. Introduction

Fulfilling the needs of chicken eggs is inseparable from the supply chain activities of this commodity, starting from farmers to end consumers. The availability of chicken eggs in traditional markets and modern retail is necessary for stock management so as not to experience scarcity and to maintain stable prices. Achieving this requires short-term interventions so as not to burden people's expenses. The complexity of managing the supply and demand for egg agents is increasing along with the number of egg sales. This condition is caused by egg agents experiencing difficulties in determining the ideal number of eggs available in the warehouse and establishing the right strategy to control the amount of supply from breeders.

Supply management will be affected by product complexity, actor position, and number of actors. Complexity occurs because stocks are not maintained properly, so that they can experience scarcity and excess [1]–[3]. Actor uncertainty in making the right strategic decisions in managing ideal stocks will impact the supply and demand imbalance of chicken eggs [4]. Supply and demand must be met optimally through an appropriate supply chain scheme [5]–[8].

The digitalization era's transformation requires actors to utilize technology that leads to supply chain management 4.0. With the migration of manualization activities towards digitalization as a decision support for actors in establishing ideal stock management [9]–[11]. This research aims to assist egg agents in supporting the right strategic decisions in managing chicken eggs so that the supply and demand for chicken eggs is maintained through the development of the SAFCES application so that it is not done manually.

2. Materials and Methods

The method used in this study is the Fuzzy Analytical Hierarchy Process (AHP) method to determine the strategy for chicken egg availability. Fuzzy Logic calculations refer to the reliability of human thinking that can predict real behavior through a membership set [12]. The defuzzification process can be influenced by membership sets based on fuzzy rules [13]–[15]. The stages in determining the strategy are as follows:

1. Fuzzy Logic

1.1 Triangular Membership Function

This model is part of the trafezoidal membership function to obtain the highest value of the variable degree of membership based on the tested parameters [16]. The Triangular Membership Function model is as follows [17]:

$\mu F\ (a, b, c): R \rightarrow [0,1]$ (4)

1.2 Trapezoidal Membership Function

Has provisions for the lower limit, upper limit, lower support limit, and upper support limit, which are determined by the following model [18]:

$\mu F\ (a, b, c, d): R \rightarrow [0,1]$ (5)

1.3 Fuzzy Rule Base

The defuzzification process is obtained from the comparison of regional moments, which refers to the Fuzzy operator, which is given the boundaries of the Fuzzy Rule Base [19]. The model used is as follows [20]:

If x_1 is A_{i1} and … X_n is $A_{in,}$ Then C_i with CFi, i= 1... N where X set (X={x1, x2,…,xn}) (6)

1.4 Defuzzification

This model uses moments and areas, which are formulated in the following calculations [21]:

$$Xcoa = \frac{\int_{x=0}^{n} \mu A(x) x\, dx}{\int_{x=0}^{n} \mu A(x)\, dx} \quad (7)$$

2. Analytical Hierarchy Process (AHP)

The stages in using the AHP model are by determining the problem, the hierarchical model, pairwise comparisons by obtaining weight values using the time scale, then analyzing the results of the pairwise comparisons [22]. The AHP structure model is as follows [23]:

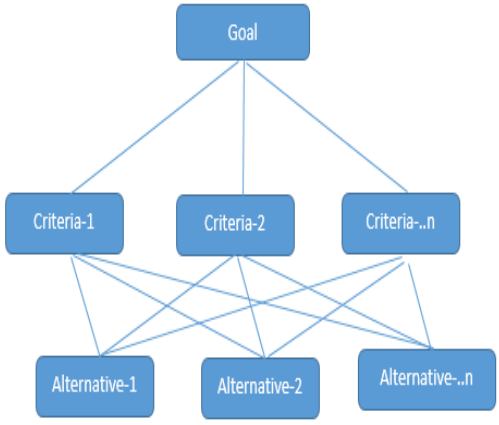

Figure 1. AHP Structure

3. Fuzzy AHP

Uncertainty in decision-makers on the AHP method in formulating problems can be ensured through the AHP Fuzzy model. This model provides certainty that refers to Fuzzy logic where fuzzy sets can anticipate these uncertainties [24]. The stages in using the Fuzzy AHP model are by building the AHP structure, setting the Fuzzy set membership function, determining the average weight of the criteria, and normalizing the average weight of the criteria [25].

3. Results and Discussion

The AHP Fuzzy model is used by first forming the AHP structure. Where this structure starts with setting goals based on the problems that occur. The purpose of this structure is to maintain a balance between supply and demand for chicken eggs. After that, determine the criteria and alternatives. The criteria obtained based on expert judgment are selling price, demand from consumers, supply from breeders, and available stock in warehouses. Alternatives used regarding adding agent areas (PP) to optimize existing demand, adding suppliers (PS), and reducing suppliers (PES) to be able to maintain a stable supply of chicken eggs. The following AHP structure is built:

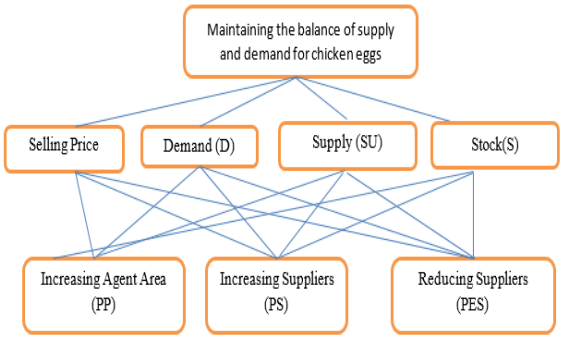

Figure 2. Decision Hierarchy Structure

After the AHP structure is determined, then determine the Fuzzy value comparison value. This value is obtained from the Saaty scale 1-9, where the value obtained is based on the results of filling out the judgment expert. The judgment expert in this study interviewed the owner of one of the sample egg agents in Bogor City. The decision hierarchy process performs a Pairwise comparison on each criterion and alternative.

3.1 Fuzzy Value Comparison for Criteria

The criteria formed in the AHP structure consist of four criteria, namely Selling Price, Demand, Supply, and Stock. The pairwise comparison of these criteria is as follows:

Table 1. Pairwise Comparison for Criteria

Goal	SP	D	Su	S
SP	1	9	6	4
D	0,11	1	5	3
Su	0,17	0,20	1	2
S	0,25	0,33	0,50	1

Based on the assessment from the judgment expert, it is then calculated using Fuzzy value comparison calculations to obtain priority weights against the established criteria. The calculation results can be seen in the following table.

Table 2. Fuzzy Value Comparison for Criteria

Goal	Value			Fuzzy Weight			CoA	Normalized Weight
	1	2	3	1	2	3		
SP	3,22	3,66	4,05	0,49	0,64	0,84	0,65	0,63
D	0,82	1,00	1,15	0,12	0,17	0,24	0,18	0,17
Su	0,45	0,60	0,78	0,07	0,11	0,16	0,11	0,11
S	0,36	0,45	0,64	0,05	0,08	0,13	0,09	0,09
Total	4,85	5,72	6,63				1,03	1,00

Based on the calculation results of the Fuzzy Value Comparison for each of the criteria above, it shows that the Selling Price has the greatest weight, so it can be used as a top priority in maintaining the balance of supply and demand for the management of chicken eggs for egg agents. However, to determine which alternative strategy can support the top priority, namely the selling price, pairwise comparisons must be made between the criteria and the alternatives according to the AHP structure that is being built.

3.2 Fuzzy Value Comparison For Criteria-Alternatives

The pairwise comparison for selling price criteria with other alternatives can be seen in the following table.

Table 3. Pairwise Comparison of Selling Price with Alternatives

SP	PP	PS	PES
PP	1	2	3
PS	0,50	1	2
PES	0,33	0,50	1

In this assessment, the greatest value is found in the comparison between increasing agent area alternatives and reducing suppliers. This is influenced by the increasing number of requests, but the area of the warehouse area is limited so that the expert provides the greatest value compared to other alternatives. In addition, note the comparison between the other criteria, in this case, the Demand criteria. The Pairwise comparison for demand criteria with other alternatives can be seen in the following table.

Table 4. Pairwise Comparison for Demand with Alternatives

D	PP	PS	PES
PP	1	4	6
PS	0,25	1	3
PES	0,17	0,33	1

The greatest value is found in the comparison between the Increasing Agent Area alternative and the reduction of suppliers. This is influenced because it is the same as the selling price ratio. Namely, the number of requests has increased, but the warehouse area is limited, so the expert provides the greatest value compared to other alternatives. In addition, another criterion comparison is the Supply criterion. The Pairwise comparison of Supply criteria with other alternatives can be seen in the following table.

Table 5. Pairwise Comparison for Supply with Alternatives

Su	PP	PS	PES
PP	1	3	7
PS	0,33	1	5
PES	0,14	0,20	1

In this assessment, the greatest value is found in the comparison between increasing agent area alternatives and reducing suppliers. This is influenced because it is the same as the selling price comparison, namely, the number of requests has increased, but the warehouse area is limited so that the expert provides the greatest value compared to other alternatives. In addition, the last criterion comparison is the Stock criterion. The Pairwise comparison of Stock criteria with other alternatives can be seen in the following table.

Table 6. Pairwise Comparison for Stock with Alternatives

S	PP	PS	PES
PP	1	3	7
PS	0,33	1	5
PES	0,14	0,20	1

In the final assessment, the greatest value is found in the comparison between the Increasing Agent Area alternative and the reduction of suppliers. This is influenced because it is the same as the previous comparison, namely the number of requests has increased but the warehouse area is limited so that the expert provides the greatest value compared to other alternatives. From this, it can be seen that the urgency associated with an increase in the number of requests with conditions of inadequate availability requires an appropriate alternative strategy. Therefore, a further step is needed by using Fuzzy Value Comparison to compare criteria against existing alternatives so that alternative strategies can be determined. Fuzzy Value Comparison for the selling price criteria with the alternatives can be seen in the following table.

Table 7. Fuzzy Value Comparison for Selling Price Criteria with alternatives

SP	Value			Fuzzy Weight			CoA	Normalised Weight
	1	2	3	1	2	3		
PP	0,67	2,00	4,00	0,13	0,84	4,97	1,98	0,78
PS	0,11	0,33	1,00	0,02	0,14	1,24	0,47	0,19
PES	0,03	0,06	0,17	0,01	0,02	0,21	0,08	0,03
Total	0,81	2,39	5,17				2,52	1,00

Based on the calculation results of the Fuzzy Value Comparison for selling price comparisons with alternatives, it shows that the increasing agent area has the greatest weight of 0.78. This shows that alternative strategies can be used as decision support in maintaining a balance of supply and demand for the management of chicken eggs. In addition, a comparison of the Fuzzy Value Comparison for the Demand criteria with alternatives can be seen in the following table.

Table 8. Fuzzy Value Comparison for Demand Criteria with alternatives

D	Value			Fuzzy Weight			CoA	Normalised Weight
	1	2	3	1	2	3		
PP	5,00	8,00	11,67	0,41	0,97	2,27	1,22	0,97
PS	0,13	0,25	0,44	0,01	0,03	0,09	0,04	0,03
PES	0,01	0,02	0,03	0,00	0,00	0,01	0,00	0,00
Total	5,15	8,27	12,14				1,26	1,00

Based on the results of Fuzzy Value Comparison calculations for comparison of demand with alternatives, it shows that the increasing agent area also has the largest weight of 0.97. This shows that alternative strategies can be used as decision support in maintaining a balance of supply and demand for the management of chicken eggs. In addition, the comparison of Fuzzy Value Comparison for Supply criteria with alternatives can be seen in the following table.

Table 9. Fuzzy Value Comparison for Supply Criteria with alternatives

Su	Value			Fuzzy Weight			CoA	Normalised Weight
	1	2	3	1	2	3		
PP	4,00	7,00	10,67	0,34	0,93	2,46	1,24	0,92
PS	0,33	0,56	1,00	0,03	0,07	0,23	0,11	0,08
PES	0,01	0,01	0,01	0,00	0,00	0,00	0,00	0,00
Total	4,34	7,57	11,68				1,35	1,00

Based on the Fuzzy Value Comparison calculation results for the comparison of supply with alternatives, it shows that the increasing agent area also has the greatest weight of 0.92. Therefore, an alternative strategy can be used as decision support in maintaining a balance of supply and demand for managing chicken eggs. In addition, a comparison of the Fuzzy Value Comparison for the Stock criteria with alternatives can be seen in the following table.

Table 10. Fuzzy Value Comparison for Stock Criteria with Alternatives

S	Value			Fuzzy Weight			CoA	Normalized Weight
	1	2	3	1	2	3		
PP	4,00	7,00	10,67	0,34	0,93	2,46	1,24	0,92
PS	0,33	0,56	1,00	0,03	0,07	0,23	0,11	0,08
PES	0,01	0,01	0,01	0,00	0,00	0,00	0,00	0,00
Total	4,34	7,57	11,68				1,35	1,00

Based on the Fuzzy Value Comparison calculation results for stock comparisons with alternatives, it shows that the increasing agent area also has the largest weight of 0.92. Therefore, an alternative strategy can be used as decision support in maintaining a balance of supply and demand for managing chicken eggs. So, from that, it can be seen that the main priority in managing chicken eggs lies in how to set the selling price of chicken eggs to consumers so that demand increases but also purchases and alternative strategies that can be determined are increasing agent areas. With this strategy, it is hoped that egg agents can increase their market share so that the demand for chicken eggs is always maintained. Application development is designed to help make it easier for egg agents to manage chicken eggs in real time. This application is called Smart Application For Egg Stock (SAFCES). Android-based applications can make it easier for egg agents to manage chicken eggs in real-time. Egg Agent owners can find out immediately what strategy is right by simply entering the value of the pairwise comparison. The display of the SAFCES Application can be seen in the following figure.

Figure 3. Initial display of the application

This display shows several menus for egg agent owners to input supplier data, stock conditions available every day, stock availability to meet demand on that day, and evaluation to determine strategies. In this view, to set a strategy, you can click on the evaluation menu, where in this menu, the egg agent owner can enter a value from 1-9 against the criteria that have been set. The results of calculations using this application follow the Fuzzy value comparison calculations above. The display of the calculation results can be seen in the following figure.

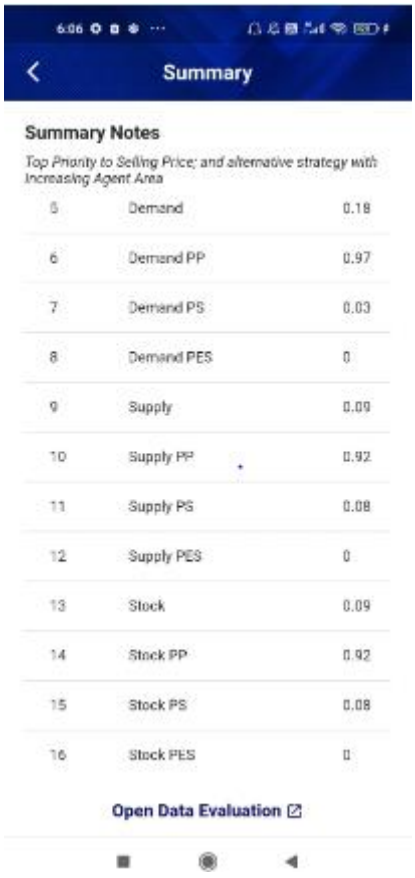

Figure 4. Strategy Information Display

The information, in conclusion, is in accordance with the calculations above so that the transformation of manualization into digitization can be seen by egg agents in real-time so that it can help as decision support for egg agents in managing chicken eggs, especially in the balance between supply and demand that occurs.

4. Conclusion

The AHP Fuzzy model is very helpful for actors managing chicken eggs, especially chicken egg agents in developing the right strategy to maintain a balance of supply and demand. With the transformation from manualization to digitalization, it can help support real-time decisions. In the future, this research needs to be carried out related to the model of the risk of damage to chicken eggs from breeders to consumers through digitization.

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