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UNIVERSITAS ATMA JAYA YOGYAKARTA

JBI

Volume 11

Nomor 1

Halaman 1-73

Yogyakarta, April 2020

ISSN 2087-2534

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## Determining Laying Hens Production Performance Using Analytical Hierarchy Process and Simple Additive Weighting Methods

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Masuk: 09 Januari 2020; Direvisi: 25 Maret 2020; Diterima: 25 April 2020

**Abstract.** *The high consumption of chicken eggs in Indonesia must be balanced with the productivity level of laying hens to avoid scarcity resulting in an increasing price of chicken eggs. The maximum egg production can be possibly achieved by implementing a system of grouping chickens into good quality and poor performance different groups. This grouping can be made with a decision support system using the Analytical Hierarchy Process and Simple Additive Weighting methods. The criteria used in this test are eggs total, total of hens per coop, age, and hens' death per coop. Alternatives used are coop 1, 2, 3, and 4. The coops were chosen as the alternative for the breeders compared the laying hens' production performance based on the production per coop. The testing results, with the same input, show the same ranking order for both methods. The ranking order respectively the best to the worst is coop 1, coop 3, coop 2 and coop 4.*

**Keywords:** *Laying hens, production performance, decision support system, Analytical Hierarchy Process, Simple Additive Weighing.*

**Abstrak.** *Banyaknya konsumsi telur ayam di Indonesia, harus diimbangi dengan tingkat produktivitas ayam petelur agar tidak terjadi kelangkaan yang mengakibatkan kenaikan harga telur ayam. Produksi telur yang maksimal bisa dicapai dengan menerapkan sistem pengelompokan ayam-ayam dengan kualitas performa yang baik dan yang kurang baik. Pengelompokan ini bisa dibuat dengan sistem pendukung keputusan menggunakan metode Analytical Hierarchy Process dan Simple Additive Weighting. Kriteria yang digunakan dalam pengujian ini adalah Total telur, Total ayam per kandang, umur ayam dan kematian ayam per kandang. Alternative yang digunakan adalah kandang 1, 2, 3, and 4. Kandang dipilih sebagai alternative karena peternak membandingkan performa produksi ayam petelur berdasarkan produksi per kandangnya. Hasil pengujian, dengan masukan yang sama, menunjukkan hasil perbandingan dengan urutan yang sama untuk kedua metode. Rangkaian terbaik sampai dengan terburuk, secara berturut-turut: kandang 1, kandang 3, kandang 2 dan kandang 4.*

**Kata Kunci:** *Ayam Petelur, Performa Produksi, Sistem Pendukung Keputusan, Analytical Hierarchy Process, Simple Additive Weighing.*

### 1. Introduction

Chicken eggs are one of the foods that are included in the nine staples or basic needs, so that there is a high demand for chicken eggs. The eggs produced by laying hens are the result of reproduction cycles of hens. The eggs of laying hens are not produced for breeding yet for consumption and it is widely consumed by Indonesian people. The eggs are easy to obtain and the price is affordable. Besides, it has adequate nutrition [1]. The high consumption of chicken eggs must be balanced with the productivity of laying hens in order to avoid scarcity resulting in an increase in chicken eggs prices.

Laying hens usually begin to produce eggs at the age of 18 weeks. Egg production will continue to increase until passing the peak production period [2]. The best egg production can be obtained in the first year, but afterwards the egg production tends to decrease. The egg production will be in between 250 to 280 eggs per year [3]. Many factors must be considered in order to get the maximum egg production. One of which is faster sexual maturity, which in general will accelerate the peak of egg production. The other factors are feed quantity and quality, the chicken

coop, the density inside the coop, the laying hens' health quality, and other environmental factors. Laying hens have a life cycle that is divided into three phases, namely, the starter phase when chickens are 1-8 weeks old, the grower phase or growth phase when chickens are 8-20 weeks old, and the layer or production phase when chickens are 20 weeks old [4].

To increase egg production, the breeders should be able to identify and group the laying hens with good performance producing eggs and laying hens with poor production performance. In order to help breeders to make these groupings more easily, a decision support system is created using Analytical Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods.

## **2. Literature Review**

Some previous studies that are relevant to this research are various studies that focus on the development of Decision Support Systems (DSS) using AHP and SAW methods. Some of the objectives of this study are to determine the egg quality of laying hens using SAW [1] and AHP [5] methods for the ranking process to determine the best alternative to get qualified eggs, to determine the quality of laying ducks by using SAW method [6], to choose productive broody using the SAW method [7], to determine chicken production performance based on body weight uniformity [2], to determine the quality of hens based on the eggshell colour using AHP method [8], to determine proper coop with chickens to maintain the laying hens' quality by using genetic algorithms with AHP method and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [9] and Weighted Product (WP) [10].

After conducting literature study of previous studies that focused on DSS development on with chicken quality as research objects explained in the previous paragraph, it can be concluded that the research which is going to be elaborated in this article has never been conducted by other researchers. There are different criteria discussed in this study namely the number of eggs, number of chickens per coop, age of chickens and death of chickens per coop, as well as the method used which are AHP and SAW methods.

## **3. Research Methodology**

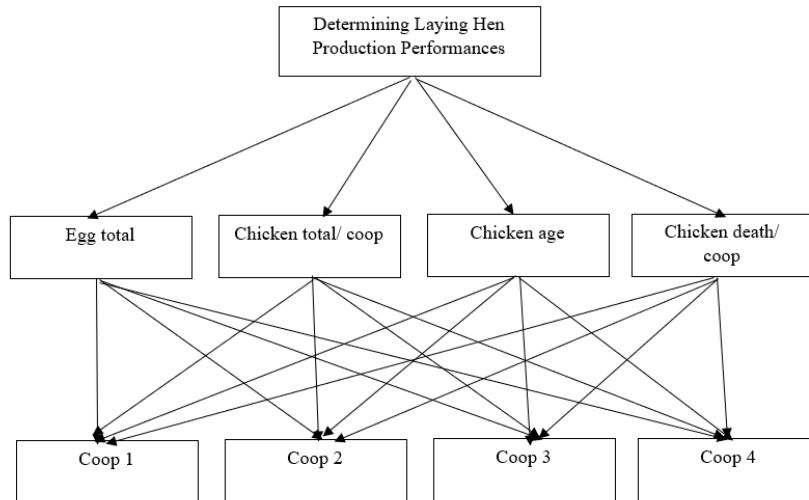
The methodology used in this study includes several stages, namely: (1) Interview, done with the laying hen farmer for the data collection. (2) Observation, directly conducted on laying hens in order to obtain factual data and information. The results of this observation include the state of the farm's environment and the problems found. (3) Literature study, carried out to look for sources of literature and relevant literature to this research and in order to provide the theoretical basis needed in the system development. (4) Application development, including the analysis process, design, coding and application testing.

### **3.1. AHP Implementation Method**

AHP method is used because it can solve multi-objective and multi-criteria problems based on comparing the preferences of each element in the hierarchy. With a hierarchy, a complex problem can be described so that the problem will appear in more structured and systematic way [11]. The calculation implementation using AHP method begins with arranging the right hierarchy by determining the goals that are the top level of the hierarchy. The next level is to determine the criteria used in the calculation, namely the number of eggs, chickens per coop, chickens age, and chickens death per coop. The selection of these criteria is based on researcher's observations. These criteria are considered to be used to determine the performance of laying hens production. The last level is to determine the alternatives used in the calculation, namely, coop 1, coop 2, coop 3, and coop 4. Coops are chosen as alternatives because chicken breeders usually place chickens that have the same age at the same coop and the number of chickens in each coop is usually slightly different. From the age of chickens and the number of chickens that are almost the same per coop should produce a relatively equal number of eggs. So when the number of eggs produced is significantly different, the cause can be traced. The same numbers of chicken which are at the same age in every coop should lay the relatively same number or eggs. If the numbers of eggs laid are different, the causes should be able to be traced. As an example, if there is an increasing



chicken’s mortality in every coop which is caused by virus, there will be significant impacts on the production performances. Figure 1 shows the hierarchy of AHP method.



**Figure 1. Hierarchy of AHP Method**

The next step is to insert a comparison for each criterion. The comparison of criteria is determined using pairwise comparisons. This pairwise comparison can be measured using Table 1. Decision making to provide comparison values for each criterion is listed in Table 2. Then the criteria value of all the criteria that will be used to normalize, as in Table 3.

**Table 1. Pairwise Comparison Table**

Relative Importance	Definition	Explanation
1	Equal Importance	Two elements contribute equally to objective.
3	Weak importance	Experience and judgment slightly favor one element over another.
5	Strong importance	Experience and judgment strongly favor one element over another
7	Demonstrated importance	One element is strongly favored and demonstrated in practice.
9	Extreme importance	The evidence favouring one element over another is of higher possible order of affirmation.
2,4,6,8	Intermediate values	When compromise is needed between two adjacent judgments.

**Table 2. Determining Criteria Value**

Criteria	Egg	Chicken / coop	Death rate/ coop	Age
Egg	1/1	3/1	5/1	7/1
Chicken / coop	1/3	1/1	3/1	5/1
Death rate/ coop	1/5	1/3	1/1	5/1
Age	1/7	1/5	1/5	1/1

**Table 3. Calculating Criteria Weight**

Criteria	Egg	Chicken / coop	Death rate/ coop	Age
Egg	1,00	3,00	5,00	7,00
Chicken / coop	0,33	1,00	3,00	5,00
Death rate/ coop	0,20	0,33	1,00	5,00
Age	0,14	0,20	0,20	1,00
Total	1,68	4,53	9,2	18,00

Next is the normalization calculation of all criteria. This calculation gets the divider value from the total value in Table 3. The results of this calculation will be outlined in Table 4. Next is calculating the results of all the criteria, which is done by taking the value of the criteria weights in Table 3, which is multiplied by the average value the average in Table 4. After summarizing, the normalization matrix is obtained as in Table 4.

**Table 4. Normalization Matrix Table**

Criteria	Egg	Chicken / coop	Death rate/ coop	Age	Total	Average	Result
Egg	0,60	0,66	0,54	0,39	2,19	0,55	2,40
Chicken / coop	0,20	0,22	0,33	0,28	1,02	0,26	1,13
Death rate/ coop	0,12	0,07	0,11	0,28	0,58	0,15	0,59
Age	0,09	0,04	0,02	0,06	0,21	0,05	0,21

P value (number of criteria), CI (index consistency), RI (index ratio), and CR (criteria consistency ratio) are subsequently calculated. The alternative values that will be used are then determined as shown in Table 5. Starting in Table 5, the word coop will be written with the notation Kd. For the input criteria for chickens per coop obtained from the number of chickens per coop minus the number of chicken deaths per coop, for example the number of chickens per coop is 1000 and death of chickens in each coop is 20, then the formulation will be 1000 - 20 = 980, so what is input on the death of chickens per coop is 980.

$$CI = \frac{(\lambda_{max} - n)}{n - 1} = \frac{\left( \left( \frac{(2,400939)}{0,55} \right) + \left( \frac{1,13118}{0,26} \right) + \left( \frac{0,597942}{0,15} \right) + \left( \frac{0,210032}{0,05} \right) \right) - 4}{(4 - 1)} = \frac{\left( \frac{(16,99968942)}{4} \right) - 4}{(4 - 1)} = \frac{(0,24992)}{(3)} = 0,083307$$

P = 4    RI = 0,9

CR =  $\frac{CI}{RI} = \frac{0,083307}{0,9} = 0,092564 \leq 0,1$  (Konsisten)

**Table 5. AHP Data Table**

Alternative	Criteria			
	Egg	Chicken / coop	Death rate/ coop	Age
Kd1	902	1000	980	55
Kd2	880	980	973	55
Kd3	894	1000	975	55
Kd4	850	950	942	55

To get a normalized matrix is to calculate alternatives from each criterion. Here are the calculations for the number of eggs criteria. Data is taken from the values in Table 5, and the results of this calculation can be seen in Table 6. The calculations for other criteria, namely the number of chickens per coop, chicken mortality per coop, and age of chickens, are carried out in the same way. The calculations results can be seen in Table 7, Table 8, and Table 9.

**Table 6. Alternative Matrix Table of Egg**

Egg	Kd				
	Kd1	Kd2	Kd3	Kd4	
	902	880	894	850	
Kd1	902	1,00	1,03	1,01	1,06
Kd2	880	0,98	1,00	0,98	1,04
Kd3	894	0,99	1,02	1,00	1,05
Kd4	850	0,94	1,02	0,95	1,00
Total	3,91	4,06	3,94	4,15	

**Table 7. Alternative Matrix Table of Chicken/ Coop**

Chicken/ coop	Kd				
	Kd1	Kd2	Kd3	Kd4	
	1000	980	1000	950	
Kd1	1000	1,00	1,02	1,00	1,05
Kd2	980	0,98	1,00	0,98	1,03
Kd3	1000	1,00	1,02	1,00	1,05
Kd4	950	0,95	0,97	0,95	1,00
Total	3,93	4,01	3,93	4,14	

**Table 8. Alternative Matrix Table of Chicken Death/ Coop**

Chicken death/ coop	Kd				
	Kd1	Kd2	Kd3	Kd4	
	980	973	975	942	
Kd1	980	1,00	1,01	1,01	1,04
Kd2	973	0,99	1,00	1,00	1,03
Kd3	975	0,99	1,00	1,00	1,04
Kd4	942	0,96	0,97	0,97	1,00
Total	3,95	3,98	3,97	4,11	

**Table 9. Alternative Matrix Table of Chicken Age**

Age	Kd				
	Kd1	Kd2	Kd3	Kd4	
	55	55	55	55	
Kd1	55	1,00	1,00	1,00	1,00
Kd2	55	1,00	1,00	1,00	1,00
Kd3	55	1,00	1,00	1,00	1,00
Kd4	55	1,00	1,00	1,00	1,00
Total	4	4	4	4	

The calculation of the alternative normalized matrix of each criterion is done to get a ranking. The data are taken from Table 6 for the number of eggs criteria while the results of this calculation are shown in Table 10. The normalized matrix calculations for other criteria, namely number of chickens per coop, death of chickens per coop, and age of chickens are carried out in the same way, where the data are taken from Table 7, Table 8 and Table 9. The calculation results are in Tables 11, Table 12, and Table 13.

**Table 10. Normalized Matrix Table of Egg Total**

Alternative	Kd1	Kd2	Kd3	Kd4	Kd1
Kd1	0,26	0,25	0,26	0,26	1,03
Kd2	0,25	0,25	0,25	0,25	1,00
Kd3	0,25	0,25	0,25	0,25	1,00
Kd4	0,24	0,25	0,24	0,24	0,97

**Table 11. Normalized Matrix Table of Chicken/ Coop Total**

Alternative	Kd1	Kd2	Kd3	Kd4	Kd1
Kd1	0,25	0,25	0,25	0,25	1,02
Kd2	0,25	0,25	0,25	0,25	1,00
Kd3	0,25	0,25	0,25	0,25	1,02
Kd4	0,24	0,24	0,24	0,24	0,97

**Table 12. Normalized Matrix Table of Chicken Death/ Coop**

Alternative	Kd1	Kd2	Kd3	Kd4	Kd1
Kd1	0,25	0,25	0,25	0,25	1,01
Kd2	0,25	0,25	0,25	0,25	1,01
Kd3	0,25	0,25	0,25	0,25	1,01
Kd4	0,24	0,24	0,24	0,24	0,97

**Table 13. Normalized Matrix Table of Chicken Age**

Alternative	Kd1	Kd2	Kd3	Kd4	Kd1
Kd1	0,25	0,25	0,25	0,25	1,00
Kd2	0,25	0,25	0,25	0,25	1,00
Kd3	0,25	0,25	0,25	0,25	1,00
Kd4	0,25	0,25	0,25	0,25	1,00

The next step is calculating the normalized weight of each criterion to get a ranking. In order to calculate alternative weights for the number of eggs criteria, the data is taken from Table 6, and the results of this calculation are shown in Table 14.

Normalized weight calculations for other criteria, namely the number of chickens per coop, chicken mortality per coop, and age of chickens, are done in the same way, where data are taken from Table 7, Table 8 and Table 9. The calculation results can be seen in Table 14. Then rank in the order from the largest to the smallest value.

**Table 14. Normalized Matrix Table of Chicken Age**

Alternative	Egg Total	Chicken/ Coop Total	Age	Chicken Death/ Coop	Average	Results	Ranking
Kd1	0,26	0,25	0,25	0,25	0,55	0,254	1
Kd2	0,25	0,25	0,25	0,25	0,27	0,249	3
Kd3	0,25	0,25	0,25	0,25	0,12	0,253	2
Kd4	0,24	0,24	0,24	0,25	0,06	0,242	4

Based on the manual calculation using AHP method, it can be concluded that coop (Kd) 1 has the best production performance because it is in the first rank with a result of 0.254, second rank is occupied by coop (Kd) 3 with a result of 0.253, third rank is occupied by coop (Kd) 2 with a result of 0.249, and the last is occupied by coop (Kd) 4 with results .242. The higher obtained results, the better production performance and the lower obtained the results indicates the worse production performance. Referring to these results, it can be traced whether the cause of coop (Kd) 4 production performance is at the last rank.

### 3.2. SAW Method Implementation

Simple Additive Weighting method is often referred to as the weighted sum method. This method has a basic concept of finding the weighted sum of the branches of performance in each alternative in all its attributes. This method requires the process of normalizing the decision matrix to a scale that is used to compare all existing alternative branches [12]. The calculation implementation of using SAW method begins by determining the criteria used in the calculation, namely, the number of eggs, number of chickens per coop, age of chickens, and mortality of chickens per coop.

Determining the amount alternatives will be used and input the alternative values are the next steps to do. The entry of chickens per coop criteria is obtained from the number of chickens per coop minus the number of chicken deaths per coop. As an example, the number of chickens per coop is 1000 and death of chickens per coop is 20. It is then formulated as  $1000 - 20 = 980$ . The input on the death of chickens per coop is 980. This data can be seen in Table 15.

**Table 15. SAW Data Table**

Alternative	Criteria			
	Egg Total	Chicken/ Coop Total	Chicken Death/ Coop	Age
Kd1	902	1000	980	55
Kd2	880	980	973	55
Kd3	894	1000	975	55
Kd4	850	950	942	55

The weights of each criterion are then determined. The weight is determined by the user within a range of 1 to 4. The greater weight indicates how more important criteria are. The next step is to calculate the normalization results for each criterion. The data for this calculation is taken from Table 15, and the results of these calculations can be seen in Table 16.

**Table 16. SAW Normalization Table**

Alternative	Criteria			
	Egg Total	Chicken Total	Death	Age
Kd1	1	1	1	1
Kd2	0,975	0,98	0,992	1
Kd3	0,991	1	0,994	1
Kd4	0,942	0,95	0,961	1

Next is to calculate the final preference value, which is then sorted from the largest value to the smallest value. This sequence determines the ranking of the alternatives. The results of these calculations and sequences can be seen in Table 17.

**Table 17. SAW Ranking Table**

Alternative	Result	Ranking
Kd1	10	1
Kd2	9,828	3
Kd3	9,954	2
Kd4	9,541	4

Based on the manual calculation using SAW method, it can be concluded that coop (Kd) 1 has the best production performance because it is ranked in the first place with results 10, second rank is occupied by coop (Kd) 3 with a result of 9,954, third rank is occupied by coop (Kd) 3 with a result of 9,828, and the last is occupied by coop (Kd) 4 with results 9,541. The higher results obtained indicate the better production performance and the lower results obtained indicate the worse production performance. It can be traced from these results the reason why coop (Kd) 4 performance is ranked last.

**4. Results and Discussion**

**4.1. Results**

This research results into Decision Support System (DSS) applied in web platform, built in laravel framework using Hypertext Preprocessor (PHP) and Database Management System (DBMS) MySQL. PHP is a language programming which is open source used to develop web and can be input in HTML scripts which then processes the data in a server and its results will be delivered to the client to do a request [13]. Meanwhile, MySQL is an open source DBMS and its server perform so fast, reliable, and easy to use. Moreover, it works with client server architecture or embedded systems [14].

DSS helps in taking decision by utilizing data and model to solve the unstructured problem [15]. DSS build in this research is used to determine which laying hens have good and which ones

have poor production. By comparing the difference, the breeders can identify the problems in hens with a poor production.

In this DSS, there are some functions namely to manage users' data, show the calculation of AHP and SAW, and show history. Data used as input to determine the production of laying hens are the age, numbers of eggs, numbers of hens per coop, and the number of death per coop.

The results of DSS may help the breeders to determine the production performance of laying hens per coop. This calculation is taken from fundamental data of the past month then being managed by giving ratio value of each criterion for calculating AHP and the value for each criterion for measuring SAW. The criteria and its value have been decided before.

Once the criteria are decided, the users determine the alternatives that will be used and they will input the data from each coop that will be calculated in alternative value. The results will be added in data basis and sorted from the highest to the lowest. Thus, it results into a data that can be used for taking decision.

On the research results, the interface for calculating using AHP method was made. They consist of AHP criteria value interface, AHP alternative value interface, AHP normalization interface, AHP alternative value interface, AHP ranking results interface, and AHP rank history interface respectively. Besides, an interface to calculate using SAW method was also made, respectively consisting of SAW criteria interface, SAW alternative value interface, SAW normalization interface, SAW ranking results interface, and SAW history interface. The calculation displayed on these interface is suited to the manual calculation, as stated in chapter 3. Therefore, in this report, there are only AHP added value criteria interface (seen in Figure 2) and ranking results (seen in figure 3 and figure 4) that becomes the final results of calculation.

Masukkan Nilai Kriteria

Jumlah Telur	3. Sedikit Lebih Penting ▾	Pilih ... ▾	Jumlah Ayam Perkandang
Jumlah Telur	5. Lebih Penting ▾	Pilih ... ▾	Kematian Ayam Perkandang
Jumlah Telur	7. Sangat Penting ▾	Pilih ... ▾	Umur Ayam
Jumlah Ayam Perkandang	3. Sedikit Lebih Penting ▾	Pilih ... ▾	Kematian Ayam Perkandang
Jumlah Ayam Perkandang	5. Lebih Penting ▾	Pilih ... ▾	Umur Ayam
Kematian Ayam Perkandar	5. Lebih Penting ▾	Pilih ... ▾	Umur Ayam

Simpan Batal

Figure 2. Adding AHP Criteria Value

**Hasil Perankingan**

NO	ALTERNATIF	NILAI
1	Kandang 1	0.254
2	Kandang 3	0.253
3	Kandang 2	0.250
4	Kandang 4	0.242

**Kesimpulan :**

Dari hasil perankingan pada metode AHP menyatakan bahwa Kandang 1 mempunyai performa produksi paling baik sedangkan Kandang 4 mempunyai performa produksi paling buruk.

**Figure3. AHP Ranking Result****Hasil Perankingan**

NO	ALTERNATIF	NILAI
1	Kandang 1	10.000
2	Kandang 3	9.963
3	Kandang 2	9.843
4	Kandang 4	9.556

**Kesimpulan :**

Dari hasil perankingan pada metode SAW menyatakan bahwa Kandang 1 mempunyai performa produksi paling baik sedangkan Kandang 4 mempunyai performa produksi paling buruk.

**Figure4. SAW Ranking Result****4.2. System Testing**

System testing was done by the researchers through using interface and done manually. The testing was done for all functions aiming to make sure that the implementation of all functions in the system can work in accordance with the design and result into the expected output. If there is an incompatibleresult, the system should be revised. Once this process is done, it can be concluded that this system is reliable to proceed all functions and has been compatible as designed.

This system was tested to the users which are the breeders of laying hens. This testing was done by distributing questionnaires to 10 breeders. Its result can be seen in table 18. Based on table 18, it can be concluded that the system has an interesting display. It is easy to usedapat disimpulkan bahwa sistem memiliki tampilan menarik, mudah digunakan, kriterianya sudah sesuai, dan perankingan bermanfaat dalam pengambilan keputusan dalam pada performa produksi ayam petelur.

**Table 18. Testing to Users**

No	Pertanyaan	SA	D	N	A	SS
1	Is the system display interesting?	0	0	1	2	7
2	It the system easy to use?	0	0	1	4	5
3	Are the criteria compatible to the user's data?	0	0	2	2	6
4	Can the system help to take decision in laying hens' production performance?	0	0	2	3	5
5	Is the ranking system beneficial for the users?	0	0	1	2	7
6	Are you satisfied with the system?	0	0	1	5	4

Notes :

SA = Strongly Agree

D = Disagree

A = Agree

SD = Strongly Disagree

N = Neutral

**5. Conclusions and Sugestions**

In conclusion, the Decision Support System built to determine the production performance of laying hens using Analitical Hierarchy Process (AHP) and Simple Additive Weighting (SAW) has been successfully created buy sing four criteria namely the age of hens, number of hen per coop, and the death number of hens per coop. This system helps the breeder to decide which laying hens have good and poor production performance. The ranking can be used by the breeders to identify whether there is a problem in laying hens with poor production performance.

Based on the calculation using the same input, it is found that both AHP and SAW methods result into the same order in ranks started from the best rank to the worst respectively got by coop 1, coop 3, coop 2, and coop 4. This ranking can be used to check why the production performance of coop 4 is the worst. Once a problem is found, it can be solved sooner so the breeders will not get loss in the future.

Referring to calculation process that has been done, this system is able to do calculations using data which have benefit value only, not data which have cost value. To input the data with cost value, it must be changed first into the data with benefits value. The calculation process is then able to be executed. For the further research, the system is recommended to work with using the data with cost value.

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