IMPLEMENTATION OF SENSITIVITY ANALYSIS IN THE GOAL PROGRAMMING METHOD IN ETAWA CROSSBREED GOAT PRODUCTION PLANNING

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Abstract: In production planning of a business, especially the Etawa crossbred goat farming business, an analysis of production planning is needed in a business that has been running and developing. This can be a benchmark and description of planning and development for farmers who will start their business. In this study, the author analyzes the production of PE goats at Tharaya Farm as a description and initial planning in building goat farming in Al Amin Science and Industrial Park (Living Lab) Area, Glugur Rimbun, Sampecita Village, Kutalimbaru District, Deli Serdang Regency. Tharaya Farm is a goat farm that produces products in the form of milk, soap, yogurt, goat meat for aqiqah and sells processed goat meat foods.

The method used in this study is Sensitivity Analysis with the goal programming method. First, the author becomes a case study into the Linear Program mathematical model which is then iterated with the Simplex Method. The results from the Simplex Method are then optimized again using the Goal Programming Method. To get the most optimal results in the case study in this study and also to make decisions, the author uses Sensitivity Analysis as a solution. So it is concluded that the capacity of process I ($b1$) can be reduced by 20 hours with a maximum profit of Rp. 3,200,000. The capacity of process II ($b2$) can be increased by 20 hours and can be reduced by 40 hours with a maximum profit of Rp. 4,800,000. The profit target on goal 1 can be increased by goat farmers by Rp. 1,400,000. The production target of product A on goal 2 can be reduced by goat farmers by 2. The production target of product B on goal 3 can be reduced by goat farmers by 1.75.

INTRODUCTION

Sensitivity analysis is an important step in producing an optimal solution from a decision-making process, in general sensitivity analysis is intended to calculate the stability of the optimal solution results if there is a change in weight to several assessment parameters in decision-making. The optimal solution is the result of calculating the best alternative, which is influenced by the value of each alternative and the parameters or assessment criteria used. This method can be used to obtain an optimal solution in a business plan that is useful in

decision-making for the sustainability of a business, both micro and macro. For example, a farmer who will establish a PE goat farming business. It is necessary to conduct a study analysis first before deciding to establish a livestock business. Goat farmers will usually conduct a study analysis on livestock businesses that have been established with the aim that goat farmers can later make production plans for their livestock businesses.

Production planning is a function of the management system, where in the planning the efforts and actions that need to be taken by goat farmers to achieve goals are determined. The advantages of the management system that have been applied to several industrial goat farmers have made these goat farmers grow rapidly in line with consumer needs and demands. According to Chowdary and J. Slomp (2002), in making a production plan there are three elements that need to be considered, namely consumers, products, and manufacturing processes, these three problems are very complex problems and must be faced by every industrial goat farmer.

In addition, sensitivity analysis certainly plays an important role in achieving production planning for a goat farmer, where the aim is to see changes in parameters to the optimal solution that has been obtained using Goal Programming in the sense that sensitivity analysis in goat farmers is generally used to determine how much influence changes in the price of products produced without reducing or increasing the production of these products have on the income obtained through analysis of changes in the objective function coefficient. While the analysis of changes in the right-hand value constant in the constraint function aims to determine how much influence changes in the resources owned and indirectly affect the change in the number of products produced on income.

Forecasting Production planning in this study is a forecast of PE goat livestock product planning. This forecast aims to simulate the description of the PE goat livestock production planning that will be built in the Al Amin Science and Industrial Park (Living Lab) Area, Glugur Rimbun, Sampecita Village, Kutalimbaru District, Deli Serdang Regency. This forecast is the initial step in analyzing a business that will be run by taking into account the actual production planning data from the PE goat farming business that has been producing and has similarities in certain conditions.

According to Hidayati (2024) the Al Amin Science and Industrial Park (Living Lab) Glugur Rimbun area was built with the aim of being an alternative location for implementing the teaching and learning process and a nature-themed campus where each Study Program at

the Panca Budi Development University Medan (UNPAB) can carry out activities such as the MBKM Program, PKL, Final Project Research, or as a place to hold student events and events. After conducting a survey and observation in this livestock area, it was discovered that there were deviations in the activities carried out by employees during working hours where this would affect employee performance in the livestock office and the cause needed to be identified.

The data used in this study is data sourced from Tharaya Farm where Tharaya Farm is a goat farming business that has been in production for quite a long time and has the same type of PE goat as the type of goat that will be used in the Al Amin Science and Industrial Park (Living Lab) Area, Glugur Rimbun, Sampecita Village, Kutalimbaru District, Deli Serdang Regency. The data needed in this study includes production data, production costs, production time, and cost of goods sold data.

In general, the results of these calculations will later be useful as comparative data to provide an overview of PE goat livestock production from products produced by PE goats. So that with the data that describes the production of PE goat livestock, a decision can be taken and the best strategies can be formulated in developing PE goat livestock in the Al Amin Science and Industrial Park (Living Lab) Area, Glugur Rimbun, Sampecita Village, Kutalimbaru District, Deli Serdang Regency in the future.

THEORETICAL BASIS

   A. Linear Program

Linear programming is a method for making decisions between various alternative activities when the activities are limited by certain activities. The decision to be taken is stated as an objective function, while the constraints faced in making the decision are stated in the form of constraint functions (Rangkuti. A, 2013). According to (Rangkuti. A, 2013) the general form of the linear programming model is as follows:

$$Z = \sum_{j=1}^{n} c_j x_j|$$

Maximizing or minimizing:

With the constraint :

$$\sum_{j=1}^{n} a_{ij} x_j \quad \leq, =, \geq b_i \qquad \text{untuk } i = 1,2,3,\dots,m$$

$$x_j \geq 0 \qquad \text{untuk } j = 1,2,3,\dots,n$$

Maximizing or minimizing the objective function:

$$Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

With the contraints :

$$
\begin{array}{lcc}
a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n & \leq, =, \geq & b_1 \\
a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n & \leq, =, \geq & b_2 \\
\cdots & & \\
\cdots & & \\
a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n & \leq, =, \geq & b_m \\
x_1, x_2, x_3, \ldots \ldots, x_n & \geq & 0
\end{array}
$$

Description:

Z : objective function whose optimum value is sought (maximum or minimum)

cj : increase in the value of Z if there is an increase in the level of activity xj by one unit

   or the contribution of each unit of activity output j to Z

n : type of activity that uses available resources or facilities

m : type of limitation of available resources or facilities

xj : level of activity j (decision variable)

aij : amount of resource i needed to produce each element of activity output j

bi : capacity of resource i available to be allocated to each unit of activity.

According to (Rangkuti. A, 2013) in general the linear programming model can be arranged as follows:

1. The function whose optimal value will be sought (Z) is called the objective function which can be maximum or minimum.

2. The function that affects the problem of the objective function to be achieved is called the constraint function which is an inequality and equality.

3. The variables that affect the problem in decision making are called decision variables which are non-negative.

A. Simplex Method

In solving linear programming problems using the simplex method, the linear programming problem must first be transformed into a canonical form obtained by adding

tightening variables in this case slack variables and surplus variables. Slack variables are variables added to the linear programming constraint function to change the inequality sign ($\leq$) to equality (=), while surplus variables are variables subtracted from the linear programming constraint function to change the inequality sign ($\geq$) to equality (=) (Muhiddin, 2007).

B. Goal Programming

The steps to solve the goal programming problem are as follows:

1. Determining the decision variables
2. Determining the objectives (goals)
3. Formulating the constraint functions for each objective
4. Formulating the objective function
5. Formulating the goal programming model
6. Solving the goal programming model

Solving the goal programming problem is the same as solving a linear program, namely using the graphical method and the simplex method, but because goal programming generally has more than two decision variables, the problem solving is increasingly complex, so the graphical method is not effective for use as an alternative problem solving. Therefore, goal programming problems that have more than two decision variables will be more effective using the simplex method. The following are the steps in solving goal programming using the simplex method:

1. Create an initial simplex table.
2. Determine the pivot column by selecting the maximum value or the largest positive value in the row $c_j - Z_j$. If $c_j - Z_j > 0$, continue to the next iteration, but if $c_j - Z_j \leq 0$ then the iteration is stopped.
3. Determine the ratio or θ_i by dividing the elements in the b_i column by the elements in the pivot column.
4. Select the smallest positive value in the θ_i column to determine the pivot row. The row that shows the smallest positive value in the θ_i column is the pivot row.
5. Determine the pivot element, namely the intersection of the pivot column and the pivot row.
6. Change the decision variables in the pivot row with the decision variables in the pivot column, and change all elements in the pivot row by dividing them by the pivot element.

7. Change the values in other rows (outside the pivot row) using the OBE (elementary row operation) approach where the new row values are the same as the old row values minus the values in the new key row that have been multiplied by the key column coefficient in the initial row. Then return to step 2.

C. Sensitivity Analysis

According to (Putri E. Yunitasari et al, 2017) Sensitivity analysis is an analytical tool used to determine changes in parameters so that the solution remains optimal. In sensitivity analysis, parameter changes can be made to:

1. Objective function coefficient
2. Right-hand side constant of the constraint function
3. Constraint function

Sensitivity analysis is designed to determine the effect of changes in linear programming problem parameters on optimal solutions. The ultimate goal of this analysis is to obtain information about the new optimal solution (Rangkuti. A, 2013).

D. Etawa crossbred goat (PE)

The Etawah Crossbred (PE) goat is a breed of goat obtained from a cross between native Indonesian goats (Kacang goats) and Etawah goats imported from India (Ramdani and Kusmayadi, 2016). PE goats are one of the famous goats in Indonesia because they are dual-purpose livestock, namely as producers of milk and meat (Ratya et al., 2017). The reason for choosing PE goats for development is their fast growth rate and litter size of up to 2 goats. The maintenance of these goats is also easy and does not require a large area of land (Rosartio et al., 2015).

The characteristics of PE goats include a convex face shape, relatively long ears (18-30 cm) and drooping. Males and females have short horns. The color of the fur varies from cream to black. The fur on the back of the thighs, neck and shoulders is thicker and longer than the other parts. The white color with black or brown stripes is quite dominant. Height ranges from 70-100 cm, with adult weight reaching 40-80 kg for males and 30-50 kg for females (Wasiati and Faizal, 2018). Sexual maturity in goats for males is at the age of 8 months, while for female goats at the age of 15 months. Female goats begin to mature at the age of 6-8 months. At that age, goats can be mated. However, at that age it is still avoided because their reproductive

organs are not fully developed. The best mating period is between 10-12 months. One male can mate with 20-25 females and can mate 4-5 times a day for 2-3 days/week. The estrus period for female goats lasts for 24-28 hours and will occur every 18-21 days (Lubis, 2016).

RESEARCH METHODS

The type of research used in this study is descriptive quantitative research. Descriptive quantitative research is a study aimed at describing existing phenomena, which are taking place at present or in the past. This study uses real data sourced from the Tharaya Farm livestock business. The Tharaya Farm Goat Livestock Business has certain conditions in common such as the same type of goat.

In addition, the goat products (processed) produced from the Tahraya Farm livestock business are also diverse such as Goat Milk, Goat Yogurt, Aqiqah Meat, processed dishes made from goat meat from the livestock business. So that Tharaya Farm can describe the conditions of the Al Amin Science and Industrial Park (Living Lab) Glugur Rimbun Area, Sampecita Village, Kutalimbaru District, Deli Serdang Regency in the future. This research was conducted in the Al Amin Science and Industrial Park (Living Lab) Glugur Rimbun Area, Sampecita Village, Kutalimbaru District, Deli Serdang Regency. Deli Serdang in November 2023 to April 2023. The data collection methods used in this study are as follows :

1. Observation, namely by visiting the research location in the Al Amin Science and Industrial Park (Living Lab) Area, Glugur Rimbun, Sampecita Village, Kutalimbaru District, Deli Serdang Regency.

2. Conducting an excursion study to the Tharaya Farm goat farming business to then collect the data needed to obtain production planning that will be implemented in the Al Amin Science and Industrial Park (Living Lab) Area, Glugur Rimbun, Sampecita Village, Kutalimbaru District, Deli Serdang Regency.

3. Taking literature study data as consideration and reference in analyzing PE goat farming production planning.

4. Interviews, namely by conducting direct interviews with experts (professionals) in the field of PE goat farming.

The data to be collected are:

1. Primary data, namely data sourced from direct interviews with experts (professionals) in the field of PE goat farming related to this research.

2. Secondary data, namely data sourced from literature studies related to this research. The

secondary data to be collected are:

a. The amount of main ingredients needed

b. Working hours per day

c. Goat Business Capital

d. Production Time for each Dependent Variable

e. Selling Price for each Dependent Variable

f. Employee Wages

RESULTS AND DISCUSSION

Case study: A goat farm that has processed products from goat farming, produces 2 types of products, namely goat milk symbolized as product A, and goat meat symbolized as product B. Each product requires time to be handled in 2 processes, namely process I and process II. Product A requires 20 hours in process I and 10 hours in process II. Product B requires 10 hours in process I and 10 hours in process II. Each process has a limited time capacity, process I has a time limitation of up to 60 hours and process 2 has a time limitation of up to 40 hours. If the goat farmer gets a profit from each type of product respectively Rp. 400,000 and Rp. 800,000, then what is the maximum profit obtained when the goat farmer targets Rp. 1,000,000 with a minimum production of 2 units for each type of product

 Solution:

Decision variables: $x1$ = product A, $x2$ = product B, The form of the linear programming model in the problem above is as follows:

Maximize :

$$Z = 400.000x_1 + 800.000x_2$$

Constraint:

$$20x_1 + 10x_2 \leq 60$$

$$10x_1 + 10x_2 \leq 40$$

$$x_1, x_2 \geq 0$$

Because the constraint function is in the form of an inequality ($\leq$), the constraint function is changed into an equation (=) by adding a slack variable, so that we obtain;

Maximize:

$$Z = 400.000x_1 + 800.000x_2 + 0x_3 + 0x_4$$

Constraint :

$$20x_1 + 10x_2 + x_3 = 60$$

$$10x_1 + 10x_2 + x_4 = 40$$

$$x_1, x_2, x_3, x_4 \geq 0$$

Based on these objectives and constraints, the initial simplex table form is obtained as follows:

Initial Simplex Table

V_B	c_i	Z_j	400.000	800.000	0	0	θ_i
		b_i	x_1	x_2	x_3	x_4	
x_3	0	60	20	10	1	0	6
x_4	0	40	10	10	0	1	4
c_j		0	0	0	0	0	
$c_j - Z_j \geq 0$		0	- 400.000	- 800.000	0	0	

Based on the value of $c_j - Z_j < 0$, to determine the pivot column, the minimum value of $c_j - Z_j$ is chosen (-800,000) so that column x_2 is the pivot column and will then replace the position of the pivot row (x_4) which has the smallest positive θ_i value. So that the first iteration table is obtained as follows:

First Iteration Simplex Table

V_B	c_i	Z_j	400.000	800.000	0	0
		b_i	x_1	x_2	x_3	x_4
x_3	0	20	10	0	1	-1
x_2	800.000	4	1	1	0	0,1
c_j		3.200.000	800.000	800.000	0	80.000
$c_j - Z_j \geq 0$		3.200.000	400.000	0	0	80.000

Based on the table above, it can be seen that the values in the row $cj - Zj$ have shown ≥ 0, so the solution has been achieved.

$$\{x_1, x_2, x_3, x_4\} = \{0,4,20,0\}$$

With the maximum benefits as follows:

$$Z = 400.000x_1 + 800.000x_2 + 0x_3 + 0x_4$$
$$= 400.000(0) + 800.000(4) + 0(20) + 0(0)$$
$$= Rp. 3.200.000$$

So it can be seen that the amount of profit obtained by goat farmers in the case study of Etawa crossbred goats is Rp. 3,200,000 by producing 0 units of product A and 4 units of product B. This result is not good enough. So it is necessary to optimize using the Goal Programming Method. Then the results of the iteration on the simplex method can be continued for optimization of the case above with the goal Programming method as follows:

Decision variables: $x1$ = product A, $x2$ = product B

Formulation of constraint functions and objective functions

Tujuan (Goals) :

- **Goal 1**   : Maximizing profits ($\geq$ Rp. 1.000.000)
- **Goal 2**   : Maximizing product production A ($\geq$ 2 unit)
- **Goal 3**   : Maximizing product production B ($\geq$ 2 unit)

Goal Achievement Table

No	Connstraint	Goal	Results	Information
1	Maximizing Profits	$\geq$ Rp. 1.000.000	Rp. 2.400.000	Achieved
2	Maximizing product production A	$\geq$ 2 unit	2	Achieved
3	Maximizing product production B	$\geq$ 2 unit	2	Achieved

Based on the table above, it can be seen that;

1. Goal 1 is achieved, meaning that the goat farmer's target to maximize profits is met, this is because there is no negative deviation value, namely $\eta 1 = 0$.

2. Goal 2 is achieved, meaning that the goat farmer's target to maximize production of product

A is met, this is because there is no negative deviation value, namely $\eta 2 = 0$.

3. Goal 3 is achieved, meaning that the goat farmer's target to maximize production of product B is met, this is because there is no negative deviation value, namely $\eta 3 = 0$.

As an illustration, review the goal programming model of the problem above. Based on this model, it will be analyzed how much change can be made by goat farmers to increase or decrease the previously set target (goal) through the analysis of changes in the right-hand value constant of the constraint function without affecting the optimal solution. Suppose there is a change in goal 1, goal 2, and goal 3. If the magnitude of the change can be expressed as Δ then

goal 1: $b1 = 10 + \Delta$, goal 2: $b2 = 2 + \Delta$, and goal 3: $b3 = 2 + \Delta$. It is known that $B = \begin{bmatrix} 8 & 4 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$,

$B^{-1} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 4 & 8 \end{bmatrix}$, and $b = \begin{bmatrix} 10 \\ 2 \\ 2 \end{bmatrix}$ so that the analysis of the change in the right value constant

for the goal is obtained

$$= \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 4 & 8 \end{bmatrix} \begin{bmatrix} 10 + \Delta \\ 2 \\ 2 \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \\ 14 - \Delta \end{bmatrix}$$

Since $b\_1 \geq 0$, so that $\Delta \leq 14$ is obtained, the result is $10 \leq b1 \leq 24$ or $10 \leq b2 \leq 24$. This shows that the profit target in goal 1 can be increased by goat farmers by Rp. 1,400,000. Furthermore, the analysis of the change in the right-hand value constant for goal 2 ($b2$) is obtained:

$$\hat{b} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 4 & 8 \end{bmatrix} \begin{bmatrix} 10 \\ 2 + \Delta \\ 2 \end{bmatrix} = \begin{bmatrix} 2 \\ 2 + \Delta \\ 14 + 4\Delta \end{bmatrix}$$

Since $\hat{b} \geq 0$, it is obtained that $\Delta \geq -2$, this shows that the production target of product A in goal 2 can be reduced by goat farmers by 2. Furthermore, the analysis of the change in the right-hand value constant for goal 3 ($b3$) is obtained :

$$\hat{b} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 4 & 8 \end{bmatrix} \begin{bmatrix} 10 \\ 2 \\ 2 + \Delta \end{bmatrix} = \begin{bmatrix} 2 + \Delta \\ 2 \\ 14 + 8\Delta \end{bmatrix}$$

Since $\hat{b} \geq 0$, so that $\Delta \geq -1.75$ is obtained, this shows that the production target for product B in goal 3 can be reduced by goat farmers by 1.75.

5. CONCLUSION

From the results of the research that has been done, the conclusions are as follows:

1. The capacity of process I ($b1$) can be reduced by 20 hours with a maximum profit of Rp. 3,200,000.

2. The capacity of process II ($b2$) can be increased by 20 hours and can be reduced by 40 hours with a maximum profit of Rp. 4,800,000

3. The profit target on goal 1 can be increased by goat farmers by Rp. 1,400,000

4. The production target of product A on goal 2 can be reduced by goat farmers by 2.

5. The production target of product B on goal 3 can be reduced by goat farmers by 1.75

REFERENCE

Adriani, Sutama I.K., Sudono A., Sutardi T., dan Manalu W. 2004. Pengaruh superovulasi sebelum perkawinan dan suplementasi seng terhadap produksi susu kambing peranakan etawah. Animal Production. 6(2) : 86– 94.

Adriani, Latif A., Fachri S., dan Sulaksana I. 2014. Peningkatan produksi dan kualitas susu kambing Peranakan Etawah sebagai respon perbaikan kualitas pakan. Jurnal Ilmiah Ilmu-ilmu Peternakan. XVII(1) :15–21.

Adriani, S. Novianti, dan Fatati. 2021. Peningkatan produksi susu kambing Peranakan Etawah melalui pemberian Coleus amboinicur Lour dan Sauropus androgynus L. mers. Jurnal Agripet.21(1) : 42-52.

Franita, Riska., dkk. 2022. SUMA Innovation Budget. Proceeding International Conference of Science Technology and Social Humanities. ICESSHI.

Izhari, Fahmi., dkk. 2023. Optimalisasi Akses Informasi melalui *Website* Profil Kampung Darul Amin Glugur Rimbun. Journal of Computer Science and Technology.

Lubis, Hidayati Purnama., dkk. 2024. Pengaruh Struktur Organisasi Terhadap Kinerja Di Area Peternakan Kawasan *Living Lab* Glugur Rimbun. Jurnal Nuansa: Publikasi Ilmu Manajemen dan Ekonomi Syariah. Vol. 2, No. 1 Maret 2024.

Makridakis, S., dan S.C. Wheelwright. 1991. Metode dan Aplikasi Peramalan Jilid 1. Erlangga. Jakarta. 82 Makridakis, S., S.C. Wheelwright, dan G.V. Mc. 1993. Metode dan Aplikasi Peramalan Edisi Kedua Jilid Satu. Erlangga. Jakarta.

Nouman, S. dan M.A. Khan. 2014. Modeling and forecasting of beef, mutton, poultry meat and total meat production of Pakistan for year 2020 by using time series arima models. European Scientific Journal. 3(1): 285-296.

Pinem, E. 2012. Metode Eksponential Smoothing untuk Peramalan Jumlah Air Minum yang Disalurkan PDAM Tirtanadi Medan Tahun 2014. Skripsi. Universitas Sumatera Utara. Medan.

Pinem, E. 2012. Metode Eksponential Smoothing untuk Peramalan Jumlah Air Minum yang Disalurkan PDAM Tirtanadi Medan Tahun 2014. Skripsi. Universitas Sumatera Utara. Medan.

Sari, A. P., & Supiyandi, S. (2024). Sistem Pendukung Keputusan Perekrutan Panitia Pemilihan Kecamatan Menggunakan Metode Additive Ratio Assessment. *Sistem Pendukung Keputusan dengan Aplikasi*, *3*(2), 88-99.

Supiyandi, S., & Mailok, R. B. (2024). Application of Geographic Information Systems in Sustainable Development Initiatives. *Prosiding Universitas Dharmawangsa*, *4*(1), 410-415.

Syam, Fariz Harindra., 2023. ARSITEKTUR BERKELANJUTAN (Studi Kasus: *Living Lab* di Kecamatan Kutalimbaru). Tahta Media Group.

Wisdianti, Dara., dkk. 2023. Sosialisasi Peracangan Bangunan Area Peternakan Al-Amin *Science* dan Industrial Park (*Living Lab*) Berbasis GAHP di Desa Sampecita Kecamatan Kutalimbaru Kabupaten Deli Serdang. Jurnal Marhalado. Vol. 1 No. 2 Agustus 2023