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OPTIMIZATION THE NUMBER OF UNITS HOUSE EACH TYPE ON HOUSING MONTESA PERMAI BANJAR REGENCY

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ABSTRACT

Housing is a collection of houses as part of settlements, both urban and rural, which are equipped with infrastructure, facilities, and public utilities as a result of efforts to fulfill decent homes. In housing construction, the developer needs to calculate the optimization of the number of house units of each type so as not to suffer losses because there are several houses of a certain type that are not sold out. Optimizing the number of housing units is done to get the optimal results in the form of the optimal number of houses each type and the maximum profit according to existing restrictions. In addition, the sensitivity analysis calculation is performed to find out how the effect occurs if there are changes in the existing limits.

In this research, the model used is integer programming. Integer programming is a linear program in which the variables are in integer type. After primary and secondary data have been collected, data analysis is carried out, namely deciding decision variables, formulating the objective function, and formulating the functional function. There are 4 (four) decision variables used, namely the number of 36 type subsidized houses, 36 type non-subsidized houses, 45 type houses, and 54 types of houses. There are 4 (four) formulation of constraint functions, namely residential land area, housing construction time, production costs of housing construction, people's buying interest, and people's purchasing ability. Furthermore, optimization calculations are carried out with the help of the QM for Windows 2 program. Sensitivity analysis is carried out with conditions of changes in production costs, production capital, implementation time, the deadline for implementation, community buying interest, and community purchasing ability. Optimization the number of units house carried out resulted in an optimal number of houses built as many as 170 houses with a combination of type 36 subsidized houses as many as 52 units, the number of non-subsidized type 36 houses as many as 57 units, the number of 45 type houses as many as 45 units and the number of 54 type houses as many as 16 units. The results of the sensitivity analysis include changes in production costs considered to be very sensitive to optimal results. Then the change in the coefficient of purchasing ability, time of implementation, and changes in the public interest is considered quite sensitive to the optimal results. Changes in the implementation deadline and changes in the cost of production (capital production) are considered not too sensitive to optimal results.

***Keywords**: Optimization, Housing, Sensitivity Analysis, Integer Programming, QM for Windows 2.*

I. INTRODUCTION

One problem for developers is the difficulty in determining the number of housing units for each type to be built. This research will discuss the optimization of the number of housing units of each type in the Montesa Permai housing complex in Banjar Regency. This housing provides 4 types of housing, 36 types of subsidies, 36 non-subsidies, 45, and 54. The Montesa Permai housing complex was built in 2 stages. In construction phase 1, several houses were not sold, causing losses for the developers. In order not to experience losses such as the construction of phase 1, before carrying out the construction of phase 2, the developer must take into account the combination of the number of housing units of each type to be built with existing constraints. These limitations include limitation of production costs, limits on land area, limits on development time, and limits on people's purchasing ability. Calculation of sensitivity analysis is also carried out to determine the effect that will occur if there is a change in the limits that have been determined. The purpose of this study is to obtain the optimal number of houses of each type and the maximum profitability in housing construction following existing restrictions. Besides, it is also to find out the optimal number of houses for each type and the maximum profitability and sensitivity to the optimal results if there is a change in the specified limits.

II. LITERATURE REVIEW

Optimization according to the Big Indonesian Dictionary is optimization. Optimization comes from the optimal word which has the best, highest, most beneficial meaning, and so on. Optimization itself has the meaning of processes, ways, actions to optimize, make the best, make the highest, and so on. So that optimization can be interpreted as a process, way, or action to make something the best, highest, and most profitable. According to Law No. 1 of 2011 concerning housing and settlement areas, in article 1 (paragraph 2) explains that housing is a collection of houses as part of settlements, both urban and rural, which is equipped with infrastructure, facilities, and public utilities as a result of housing fulfillment efforts livable.

Linear programming is one technique that can help in making an optimal allocation of limited and scarce resources. These limited resources if in one industry or company include all factors of production such as machinery, labor, raw materials, capital, technology, and information (Syaifuddin, 2011). Sudarsana (2011) distinguishes linear program functions into 2 types namely the objective function and the boundary function. The objective function is a function that describes the purpose of the optimal allocation of resources to obtain the maximum profit or the minimum cost. The limitation function is the available capacity that will be optimally allocated to various company operations. The decision variable (decision variable) is a variable that influences the achievement of the goals of a problem. This variable represents the goods or products produced using limited resources in a production process (Andoyo, 2011).

Sensitivity analysis is an analysis that studies the impact of changes that occur both in the parameters (coefficient of the objective function) and on the availability of resources (the right-hand value), on the solution and the shadow price value of the resource (Alamsyah, 2008). Maspaitella (2016) groups changes in the parameters of sensitivity analysis into changes in the coefficient of the objective function, changes in the input-output coefficient, changes in the right value of the constraint function, adding new constraint functions and changes in decision-making variables.

The QM for Windows program is a computer program package for solving quantitative method problems, science management, or operations research (Riniwati, 2015). QM for Windows provides modules in the area of business decision making. The module used in this study is the integer programming module.

III. DATA AND ANALYSIS

Data Collection

The data collected is primary data and secondary data. Primary data collected in the form of interviews with developers and the distribution of questionnaires, where interviews aimed at finding more detailed information about the Montesa Permai Housing and the information will be further informed to respondents filling out the questionnaire. From the questionnaire, we will get the data on people's buying ability on each type of house. Secondary data were obtained from the developer of Montesa Permai Phase 2 Housing that is PT. Cempaga Alam Sutra.

A. Primary Data

The following is the respondent's purchasing power data on the type of house:

- 9 out of 30 respondents were able to buy a type 36 subsidized house;
- 10 out of 30 respondents were able to buy a house of type 36;
- 8 out of 30 respondents can afford a type 45 house;
- 3 out of 30 respondents can afford a type 54 house.

B. Secondary Data

1. The Land Area Of Housing

   The area of residential land to be built is 2.95 Ha. The effective land area for plots is 2.04 Ha or 20,400 m^2 for 170 housing units and the land for infrastructure is 0,915 Ha. The land area for all types of houses is equal, which is 120 m^2.

2. Selling Price of Each Type of Home

   a. Type 36 Subsidized

   The selling price of a subsidized type 36 house is Rp. 153,000,000.00 with a down payment of Rp. 8,000,000.00 and a principal of Rp. 145,000,000.00 and can be paid in installments for 10 years, 15 years and 20 years

b. Type 36 Non Subsidized
The selling price of type 36 non-subsidized houses is Rp. 153,000,000.00 for purchases in cash and can be credited for 1 (one) year at Rp. 178,000,000.00. For credit purchases, the buyer must pay a down payment of 50%, namely Rp. 89,000,000.00 and the rest can be paid in installments for 1 year.

c. Type 45 (Non-Subsidized
The selling price of non-subsidized type 45 houses is Rp 275,000,000.00 for cash purchases and can be credited for 1 (one) year at Rp 295,000,000.00. For credit purchases, the buyer must pay a down payment of 50%, namely Rp. 147,500,000.00 and the rest can be paid in installments for 1 year.

d. Type 54 (Non-Subsidized)
The selling price of non-subsidized type 54 houses is Rp 300,000,000.00 for cash purchases and can be credited for 1 (one) year at Rp 160,000,000.00. For credit purchases, the buyer must pay a down payment of 50%, namely Rp. 160,000,000.00 and the rest can be paid in installments for 1 year.

3. Home Production Costs and Supporting Facilities
The cost of producing houses and supporting facilities for subsidized and non-subsidized type 36 is Rp. 117,000,000.00; type 45 in the amount of Rp 201,000,000.00 and type 54 in the amount of Rp 220,000,000.00.

4. Housing Development Capital
The developer has a capital of 30 billion for the construction of Montesa Phase 2 Housing.

5. Time of Implementation of Housing Development
The developer targets the construction of Montesa Phase 2 Housing to be completed within 1 year or 52 weeks. The implementation of housing development in the field is carried out simultaneously, where different working groups are formed so that each unit can be carried out by the working group simultaneously. In type 36 subsidies and non-subsidies, the average housing unit built every week is 4 houses so that the construction time per unit is 0.25 weeks. In type 45, the average house built every week is 3 houses, so the construction time per unit is 0.33 weeks. In type 54, the average number of houses built per week is 2, so the time to build houses per unit is 0.5 weeks.

Data Processing

A. Decision Variable
The decision variables used are 4 (four) variables. The decision variables are:
Variable x_1 = Number of Houses Type 36 Subsidies
Variable x_2 = Number of Houses Type 36 Non Subsidized
Variable x_3 = Number of Houses of Type 45
Variable x_4 = Number of Houses of Type 54

B. Constraint Function Formulation

1) Constraint of Land Area
$\mathbf{120x_1 + 120x_2 + 120x_3 + 120x_4 \leq 20400}$ .... **(1)**

2) Time Limits for Housing Development
$\mathbf{0.25x_1 + 0.25x_2 + 0.33x_3 + 0.5x_4 \leq 52}$ .... **(2)**

3) Limitation of Production Costs for Housing Development
$117{,}000{,}000x_1 + 117{,}000{,}000x_2 + 201{,}000{,}000x_3 + 220{,}000{,}000x_4 \leq 30{,}000{,}000{,}000$ (3)

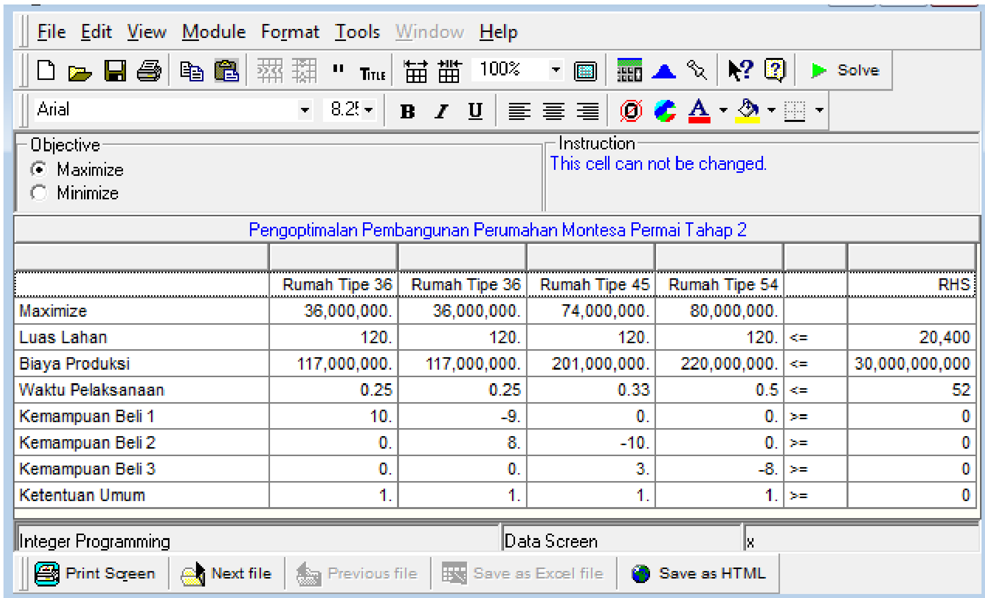
4) Limitation of Community Buying Ability
$\boldsymbol{x_1 \geq \frac{9}{10}x_2 \quad become \quad 10x_1 - 9x_2 \geq 0}$ .... **(4)**
$x_2 \geq \frac{10}{8}x_3 \quad become \quad 8x_2 - 10x_3 \geq 0$ .... (5)
$x_3 \geq \frac{8}{3}x_4 \quad become \quad 3x_3 - 8x_4 \geq 0$ .... (6)

5) General Provisions
Houses built for each type are more than or equal to 0, so they can be formulated as follows:
$x_1 + x_2 + x_3 + x_4 \geq 0$ .... (7)

C. Purpose Function Formulation
The objective function is obtained from the reduction in the selling price of houses of each type with the cost of producing houses of each type. The goal function formulation (Z) by maximizing profits is:
$Z = 36{,}000{,}000x_1 + 36{,}000{,}000x_2 + 74{,}000{,}000x_3 + 80{,}000{,}000x_4$ .... (8)

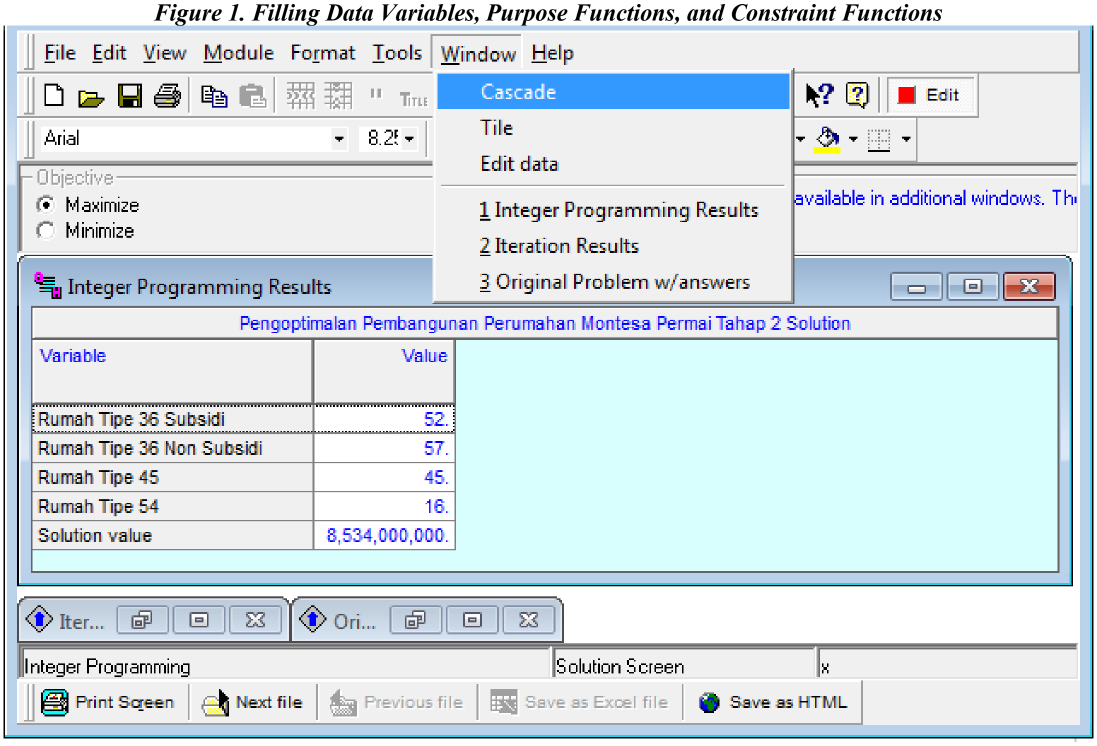
Analisis Data

Optimization of the Montesa Permai Phase 2 Housing development problem was carried out with the help of the QM for Windows 2. The data analysis was performed using an integer programming model. Open the program, select the integer programming model, then enter the decision variables, objective functions and constraint functions as in Figure 1 then click solve and the optimization results will appear as Figure 2.



	Rumah Tipe 36	Rumah Tipe 36	Rumah Tipe 45	Rumah Tipe 54		RHS
Maximize	36,000,000.	36,000,000.	74,000,000.	80,000,000.		
Luas Lahan	120.	120.	120.	120.	<=	20,400
Biaya Produksi	117,000,000.	117,000,000.	201,000,000.	220,000,000.	<=	30,000,000,000
Waktu Pelaksanaan	0.25	0.25	0.33	0.5	<=	52
Kemampuan Beli 1	10.	-9.	0.	0.	>=	0
Kemampuan Beli 2	0.	8.	-10.	0.	>=	0
Kemampuan Beli 3	0.	0.	3.	-8.	>=	0
Ketentuan Umum	1.	1.	1.	1.	>=	0

Figure 1. Filling Data Variables, Purpose Functions, and Constraint Functions



Variable	Value
Rumah Tipe 36 Subsidi	52.
Rumah Tipe 36 Non Subsidi	57.
Rumah Tipe 45	45.
Rumah Tipe 54	16.
Solution value	8,534,000,000.

Figure 2. Optimization Calculation Results

Based on the results of the optimization calculations in Figure 2, the optimization results obtained as in Table 1:

Table 1. Optimization Results

Optimal Number of Houses				Total Number of Houses	Maximum Profit (Rp)
Type 36 Subsidized	Type 36 Non Subsidized	Type 45	Type 54		
52	57	45	16	170	8,534,000,000

Source: Calculation Results

Sensitivity Analysis
Sensitivity analysis is carried out under several conditions of change, namely:

D. Changes in Production Costs
The change to be analyzed is an increase in production costs by 3.03%, 6.85% and 11.11%. The percentage increase in production costs was obtained from the comparison of the unit price of goods and services in Banjar Regency in 2018 and 2019. The minimum increase was 3.03%, the maximum increase was 11.11%, and the average increase was 6.85%. Optimization results for changes in housing production costs can be seen in Table 2.

Table 2. Optimization Results for Changes in Housing Production Costs

Changes in Production Costs		Optimal Number of Houses				Total Number of Houses	Maximum Profit (Rp)
		Type 36 Subsidized	Type 36 Non Subsidized	Type 45	Type 54		
Initial Production Costs		52	57	45	16	170	8,534,000,000
Increase in Production Costs	3,03%	52	57	45	16	170	7,766,864,000
	6,85%	52	57	45	16	170	6,799,717,000
	11,11%	52	57	45	16	170	5,721,170,000

Source: Calculation Results

E. Changes to the Production Cost Limit (Production Capital)
Optimization will be carried out on increasing production cost limits of 35 billion and 36 billion and on decreasing production cost limits of 26 billion and 25 billion. Optimization results for changes in housing production cost limits can be seen in Table 3.

Table 3. Optimization Results for Changes in Housing Production Costs Limits

Changes to Production Cost Limits		Optimal Number of Houses				Total Number of Houses	Maximum Profit (Rp)
		Type 36 Subsidized	Type 36 Non Subsidized	Type 45	Type 54		
Initial Production Cost Limit		52	57	45	16	170	8,534,000,000
Increase Production Cost Limits (Billion)	35	52	57	45	16	170	8,534,000,000
	36	52	57	45	16	170	8,534,000,000
Reduction in Production Cost Limits (Billion)	25	53	55	44	16	170	8,424,000,000
	26	52	57	45	16	170	8,534,000,000

Source: Calculation Results

F. Changes in the Time of Implementation of Development

Changes in implementation time (housing completion time for each type) can be in the form of delays or acceleration of construction. At the time of construction delays, the construction time for type 36 subsidized and non-subsidized houses, type 45 and type 54 were 0.33 weeks, 0.5 weeks, and 0.5 weeks per unit, respectively. In the acceleration of development, the time of construction of type 36 subsidized and non-subsidized houses, type 45 and type 54 are 0.2 weeks, 0.25 weeks, and 0.4 weeks per unit, respectively. Optimization results for changes in development implementation time can be seen in Table 4.

Table 4. Optimization Results for Changes in Development Implementation Time

Changes in Development Implementation Time	Optimal Number of Houses				Total Number of Houses	Maximum Profit (Rp)
	Type 36 Subsidized	Type 36 Non Subsidized	Type 45	Type 54		
In accordance with the original plan	52	57	45	16	170	8,534,000,000
Delay occurs	40	44	35	13	132	6,654,000,000
Acceleration occurs	52	57	45	16	170	8,534,000,000

Source: Calculation Results

G. Changes to the Deadline for Implementing Housing Development

Changes to the deadline for housing construction by adding and subtracting implementation deadlines from 1 to 2 weeks. So the implementation deadline to be analyzed is 50 weeks, 51 weeks, 53 weeks, and 53 weeks. Optimization results can be seen in Table 5.

Table 5. Optimization Results for Changes to the Deadline for Development Implementation

Change in Deadline for Development Implementation		Optimal Number of Houses				Total Number of Houses	Maximum Profit (Rp)
		Type 36 Subsidized	Type 36 Non Subsidized	Type 45	Type 54		
As Per the Initial Plan (Weeks)	52	52	57	45	16	170	8,534,000,000
Deadline Reduced (Weeks)	50	53	57	45	15	170	8,490,000,000
	51	52	57	45	16	170	8,534,000,000
Deadline Added (Weeks)	53	52	57	45	16	170	8,534,000,000
	54	52	57	45	16	170	8,534,000,000

Source: Calculation Results

H. Change in Purchase Ability Coefficient

Data on changes in the coefficient of purchasing ability I and II are as follows:

- Change I by comparison $x_1 : x_2 : x_3 : x_4 = 11 : 11 : 7 : 1$.
- Change II by comparison $x_1 : x_2 : x_3 : x_4 = 8 : 9 : 9 : 4$.

The results of optimizing changes in the community's purchasing ability coefficient can be seen in Table 6.

Table 6. Optimization Results for Changes in the Community Purchasing Ability Coefficient

Optimal Number of Houses

Change in Community Purchasing Ability Coefficient	Type 36 Subsidized	Type 36 Non Subsidized	Type 45	Type 54	Total Number of Houses	Maximum Profit (Rp)
In accordance with the results of the questionnaire	52	57	45	16	170	8,534,000,000
Amended Questionnaire Results (I)	64	62	39	5	170	7,822,000,000
Amended Questionnaire Results (II)	48	50	50	22	170	8,988,000,000

Source: Calculation Results

IV. DISCUSSION RESULTS

The results of the optimization calculations following the specified limits can be seen in Table 1 and the results of the optimization calculations with changes to the specified limits can be seen in Table 2 to Table 6. After the results of the optimization calculations for parameter changes are obtained, then a comparison with the optimization results early. From the results of the comparison, it can be seen which parameter changes have the most influence on the optimization results.

After being analyzed, changes that need to be considered because they are very sensitive to optimal results are changes in production costs. Changes in production costs are considered very sensitive to optimal results because if there is a change in production costs it will automatically change the maximum profit gained. People's purchasing ability is also quite sensitive because of the greater the change in the coefficient of people's purchasing ability the greater the effect on optimal results. Changes in implementation time are also quite sensitive and need to be considered to avoid delays. For changes in the implementation deadline, it is known that the minimum time limit so that the optimal results do not change is 50 weeks, therefore the developer needs to control so that the implementation development limit does not change or does not exceed the minimum time limit. Changes to the production cost limit (production capital) are not sensitive and need not be considered because the changes do not affect the optimal results. Recapitulation of the effect and sensitivity to optimal results in more detail can be seen in Table 7, as follows:

Table 7. Recapitulation of Influence & Sensitivity on Optimal Results

Description		Effect		Sensitivity	
		Optimal Number of Houses for Each Type	Maximum Profit	Optimal Number of Houses for Each Type	Maximum Profit
Changes in Production Costs					
Increase in Production Costs	3,03%	No Effect	Take Effect	Not Sensitive	Very Sensitive
	6,85%	No Effect	Take Effect	Not Sensitive	Very Sensitive
	11,11%	No Effect	Take Effect	Not Sensitive	Very Sensitive
Changes to Production Cost Limits					
Increase Production Cost Limits (Billion)	35	No Effect	No Effect	Not Sensitive	Not Sensitive
	36	No Effect	No Effect	Not Sensitive	Not Sensitive

Reduction in Production Cost Limits (Billion)	25	Take Effect	Take Effect	Sensitive	Sensitive
	26	No Effect	No Effect	Not Sensitive	Not Sensitive
Changes in Development Implementation Time					
Delay Occurs		Take Effect	Take Effect	Very Sensitive	Very Sensitive
Acceleration Occurs		No Effect	No Effect	Not Sensitive	Not Sensitive
Change in Deadline for Development Implementation					
Deadline Reduced (Weeks)	50	Take Effect	Take Effect	Sensitive	Sensitive
	51	No Effect	No Effect	Not Sensitive	Not Sensitive
Deadline Added (Weeks)	53	No Effect	No Effect	Not Sensitive	Not Sensitive
	54	No Effect	No Effect	Not Sensitive	Not Sensitive
Change in Community Purchasing Ability Coefficient					
Amended Questionnaire Results (I)		Take Effect	Take Effect	Sensitive	Sensitive
Amended Questionnaire Results (II)		Take Effect	Take Effect	Sensitive	Sensitive

Source: Calculation Results

V. CLOSING

Conclusions

Optimization results in the form of maximum profit and a combination of the number of houses of each type for the construction of the Montesa Permai Phase 2 Housing following the existing limits are obtained with the help of the *QM for Windows 2* application. The combination of the number of types of houses according to plan restrictions is:

Type 36 Subsidized = 52 unit
Type 36 Non Subsidized = 57 unit
Type 45 = 45 unit
Type 54 = 16 unit

The number of houses built was 170 units and the maximum profit gained was Rp 8,534,000,000.00.

Then the sensitivity analysis is carried out to determine the effect or effect of the changes that occur in the parameters of the integer programming model to the optimal solution that has been achieved. In this research, sensitivity analysis is carried out on changes in production costs, changes in production capital, changes in the time of work implementation, changes in time of implementation, and changes in people's purchasing ability. Optimization results for the boundary changes can be seen in Table 2 to Table 6 and a recapitulation of the effect and sensitivity to the optimal results can be seen in Table 7.

After the sensitivity analysis is done it can be seen the changes that need to be considered because it is very sensitive to the optimal results. Changes in production costs are considered very sensitive to optimal results. Then the change in the coefficient of purchasing ability and changes in implementation time is considered quite sensitive to the optimal results. Changes in the implementation deadline and changes in the cost of production (capital production) are considered not too sensitive to optimal results because the changes do not affect the optimal results so that the developer can ignore these two changes.

Suggestions

As for suggestions that can be given include:

1. Sensitivity analysis obtained is less detailed or detailed, because the change in the boundary analysis in the range of values is lacking.
2. The number of questionnaires distributed is still insufficient, it is necessary to add the number of questionnaires distributed so that the results obtained are more accurate.

In this study the change in boundary checks is only one change per data analysis (for example: in data analysis, the boundary changes are only the value of production costs) because it is necessary to analyze the data using 2 or 3 changes to the combination limit, so that can find out the optimal results obtained if more than 1 change of boundary occurs.

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