Case Study of Housing Development with Optimization of Housing Land Utilization by Using Linear Programs

by Arfan Utiarahman

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Abstract:- This is a way to optimize the land based on the types of houses that would be built, give the maximum benefit. The research site is the development site of Bumi Wongkaditi Permai III Residence of Gorontalo city.This research Data from the Simplex Table optimization of Linear Programming and QM for Windows as its controlling program. The optimization of land from this calculation is $29{,}806m^2$.The optimum composition for the housing is as follows: 135units of housing for type 42 housing, 91 units of type 45 housing, and 45 units for type 54 housing and the sale profit is Rp.41,270.500,000.

Keywords:- Land Optimization, Simplex Table Method of Linear Program.

I. INTRODUCTION

Home is one of the primary needs for the community besides being used as a place to live in a house as well as a necessity for daily routines with family members. Along with the development of time, the growth in population is accompanied by the increasing need for housing. Realizing the importance of housing needs has resulted in many housing *developers* or *developers* appearing to provide homes or housing as a place to live. Developing a construction project in this regard is the development of the housing sector, the need for a land continues to rise. Availability of a fixed amount of land, but the growing number of requests makes land a limited resource. Diverse consumer demand encourages housing developers to offer a variety of types of houses from a variety of architectural design options, environmental arrangements, housing locations and other supporting public facilities. Aware of this, land use and utilization must be carried out optimally from available land.

The population growth in Gorontalo City is directly proportional to the need for housing. Population density which has been increasing, a number of *developers* and the city government have built housing to facilitate the community to get decent housing. The availability of land makes it a limitation for *developers to* build a housing, therefore special analysis or study is needed in land use and utilization so that the available land can function optimally.

Based on the explanation above, a study was carried out in one of the houses to be built. The planned study is the *Optimization of Housing Land Utilization Using Linear Programs (A Case Study of the Development of Wongkaditi Permai III Earth Corporation in Gorontalo City) is* expected to provide an optimal description of land use in Gorontalo City to utilize available land. The expected objectives of the results of this study are. Getting the optimization of land based on the number of each type of house.

II. THEORETICAL BASIS

A. Houses and Settlements

Each housing has a value system that applies to its citizens. The value system is different between one housing and another housing, depending on the region or the state of the local community (Sarwono in Budihardjo, 1998).According to Law No. 4 of 1992 concerning housing and settlements, a house is a building that functions as a place of residence or shelter and a means of fostering families. The broad definition, a house is not only a building (structural), but also a place of residence that fulfills the conditions of a decent life, viewed from various aspects of people's lives. The house can be understood as a place of refuge, to enjoy life, rest and rejoice with family. Being in the house, residents get the first impression of their lives in this world. Houses must guarantee the interests of the family, namely to grow, give the possibility to live with their neighbors, and more than that, the house must provide peace, pleasure, happiness, and comfort in all events of his life (Frick, 2006).

According to Law No. 4 of 1992 concerning housing settlements, housing is located and is part of housing, housing is a group of houses that function as a residential or residential environment equipped with environmental infrastructure and facilities (Article 1 paragraph 2).Housing development is believed to also be able to encourage more than one hundred kinds of industrial activities related to housing and settlements (National Policies and Strategies on Housing and Settlements of the Department of Settlements and Settlement Marketing). Settlements are parts of the environment outside protected areas both in the form of urban and rural areas that function as neighborhoods of living or residential environments and places of activity that support livelihoods and livelihoods (Law No.4 of 1992 Article 3).

B. Land and its use

Land is a physical environment that includes climate, relief, soil, hydrology, and plants which to a certain extent will affect the ability of land use (Purwowidodo, 1983), Land is a physical environment that includes topographic climate soil, hydrology, and vegetation. These basic physical conditions can affect the potential of its users, including there are various human activities, both in the past

and now and in the future (Wika Eka Syahardyn and Haryo Sulistyarso, 2013).Land is also defined as land settlement with solid, liquid and even gas.(Rafi'I, 1985).Determining the highest and best use of a plot of vacant land, several testing steps must be taken The testing process involves 4 criteria with each requirement that must be fulfilled based on Indonesian assessment standards. These criteria are as follows (Fanning, The Appraisal Institute, 1999: 2001).

A land use unit is nothing more than a *mental construct* designed to facilitate inventory and mapping activities (Malingreau and Rosalina, 1981).Identification, analysis and evaluation of land use needs to be carried out at any given period, because it can be the basis for in-depth research on human behavior in utilizing land. The use of land is an important part in an effort to make land planning an important part in formulating spatial policies in a region. The policy principle for urban land aims to optimize land use and land acquisition to accommodate various urban activities. The relationship with the optimization of land use, land use policy is defined as a series of systematic and organized actions in the provision of land, and in time, for utilization and other purposes in accordance with the interests of the community (Suryantoro 2002).

C. Linear Program

Linear programming (*linear programming*) is a model of optimization of linear equations which is related to linear problems. The linear program problem means the optimum value problem (maximal or minimum) of a linear function in a system of linear inequalities that must meet the objective function optimization. Many situations are common problems associated with the linear program, so that the optimization problem can be solved with linear programming, then the problem is must be translated in the form of a mathematical model (Mulyono, Sri. 2007).

Linear Programming or in Indonesian known as the Linear Program is a form of Mathematical model that is very popular especially in the world of economy or trade. The word is derived from the program is not a program like the one in the field of komputerasi melainkansinonim of said plan or planning. The word linear means that the entire mathematical functions that exist in this model is a linear mathematical f u n c t i o n s . Linear program means a plan or plans of some activities to obtain optimum results are a result that gives the best alternative among the other possible alternatives. The basic form of this linear model was first introduced by Jordan in 1873, then by Minkowski in 1896 and by Farkas in 1903. Linear Program is getting popular again after the simplex method developed by George B. Dantzig in 1947.

The problem of linear programs is not always simple because it involves many *constraints* (constraints) and many variables so that it is impossible to solve with the graph method. Therefore a series of mathematical procedures (near algebra) are needed to find solutions to these complex problems. The most widely used procedure is the simplex method. The discovery of this method is a big leap in operations research and it is used as a procedure for completing each computer program. The simplex method was first introduced by George B. Dantzig (Mulyono, Sri., 2007) in 1947 and has been corrected by several other experts. The method of resolving the problem of linear programs is always repeated (iteration) where calculation steps are repeated many times before the optimal solution is reached.

The simplex method is a repeat procedure that moves from an appropriate answer base to the next answer such that the price of the objective function continues to rise (in the maximization problem).This process will continue until the optimal answer (if any) is reached which gives the maximum price (Siagian, P., 2006).Simplex method is a method of systematically beginning of a solution to basic feasible to solving feasible others and this is done repeatedly (with the number of replications are limited) and eventually reached a settlement basis optimal and at each step results in a value of the function the destination is always bigger (smaller) or the same from the previous steps (Taylor III, 2001).

QM stands for *Quantitative Method .QM for Windows* is software that is developed and accompanies textbooks about operations management published by Prentice-Hall's. There are three similar software that they publish namely *DS for Windows*, *POM for Windows* and *QM for Windows* .These software are *user friendly* in their use to help process the technical calculation of quantitative decision making.*POM for Windows* a package intended for management operations, *QM for Windows* is a package that is intended for quantitative methods for business and *DS for Windows* contains a combination of the two previous packages.
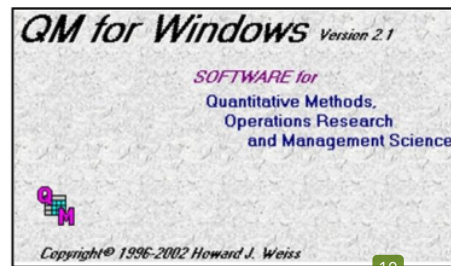

Fig 1:- *QM for Windows* version 2.1

III. RESEARCH METHODS

The method used in this study is a case study, namely in-depth exploration of the bound system (for example, activities, events, processes, or individuals) based on extensive data collection. Case studies involve investigating cases that can be defined as an entity or object of study that is limited or separate for research in terms of time, place, or physical boundaries. After the case is clearly defined, researchers investigate in depth, usually using several methods of data collection, namely, interviews, field observations, and documentation.

This research first carried out several stages, starting from the initial preparation, survey and investigation of the

locations to be studied, in order to obtain complete and accurate data. Calculation of land optimization needs a good and correct methodology, because the methodology is a reference to determine the steps of activities that need to be taken in the calculation.

The data used for this calculation is secondary data. Secondary data is data obtained by looking for information scientifically in agencies and institutions related to case studies. Analysis is carried out to determine the optimal number of types of houses that can be built on available land by using linear programs requiring appropriate data input so that results can be optimal. The data needed to perform calculations include data on land area or location to be built housing, data on type of house planned and data on the price of each type of house planned.

The purpose of this analysis is to obtain the optimal composition of the number of houses of each type of house that will be built on the construction of Wongkaditi Permai III Earth Housing to maximize company profits. The analysis steps are as follows.

- Determine the decision variable
  X_1 = Number of type 42 houses
  X_2 = Number of type 45 houses
  X_3 = Number of type 54 houses
- Determine the purpose
  Maximizing Z = Profit X_1 + Profit X_2 + Profit X_3
- Determining borders

➤ *Purpose Function*
The objective function is shown to calculate the maximum sales price that can be obtained by the developer, the profit data from sales are as follows.

Type House	Cost Development	House Selling Prices	Profit
Type 42	Rp. 146,800,000	Rp.175,000,000	Rp. 28,200,000
Type 45	Rp. 148,000,000	Rp. 200,000,000	Rp.52,000,000
Type 54	Rp. 175,200,000	Rp.275,000,000	Rp.99,800,000

Table 1:- Data on Profit from Sales Results (Source: Wongkaditi Permai III Earth Housing in Gorontalo City)

From Table 1 the profit data from the sale of each type of house is.
- Type 42 house = Rp.28,200,000
- Type 45 house = Rp.52,000,000
- Type 54 house = Rp.99,800,000

The next step to simplify the calculation process, the price of the benefits of each type of simplified house in tens of millions of rupiah, is explained as below.
- Type 42 house Rp.28,200,000 = 2.82
- Type 45 house Rp.52,000,000 = 5.20
- Type 54 house Rp.99,800,000 = 9.98

So that the objective function can be written as follows.

$$Z = 2.28 X_1 + 5.20 X_2 + 9.98 X_3$$
$$\rightarrow Z - 2.28 X_1 - 5.20 X_2 - 9.98 X_3 = 0$$

The area of land used for building consists of three types: type 42, type 45 and type 54. The land area devoted entirely to buildings that will be sold is an area of 29 806 M^2 of the total land area is 50000 M^2 sehingga did a pat first restriction function.
Land area X_1 + Land area X_2 + Land area $X_3 \leq$ 29806 M^2

- Comparison of the number of house type plans
  Data obtained from companies that will plan the number of each type of house to be built, with the number X_1 unit for type 42 houses, X_2 units for type 45 houses, and X_3 units for type 54 houses, so that comparisons can be written of the three types of houses being .
  $X_1 : X_2 : X_3$

IV. RESULTS AND DISCUSSION

A. Optimization Using Linear Programs
The purpose of this study is to obtain the optimal number of house types for that calculation using a simplex method.The formulation of the linear program is as follows.

➤ *Decision Variable*
The decision variable for this study uses the type of house that will be built on the construction of Bumi Wongkaditi Permai III Housing.
X_1 = Number of type 42 houses
X_2 = Number of type 45 houses
X_3 = Number of type 54 houses

➤ *Limitation or Limiting Functions*
Limitation function is the equation of various variables which can reduce the maximum profit obtained by the developer.
- Limitation on land area
  The total land area used only for housing construction is 2 9806 M^2 with the area of each type of house.Type 42 house land area 108 M^2 , type 45 house land area 108 M^2 , and house type 54 land area 120 M^2 .From the land area data the first limitation function can be written as follows:
  $$108 X_1 + 108 X_2 + 120 X_3 \leq 29806 M^2 \quad \ldots (1)$$
- Comparison of the number of house type plans
  Based on the planned data the number of each type of house that will be built is, 134 units for type 42 houses, 90 units for type 45 houses, 45 units for type 54 houses, so the comparison of the three types of houses becomes:
  $X_1 : X_2 : X_3$ = 134 : 90 : 45
  From the results of the above comparison can be simplified by dividing all variables with the smallest

number then the results of simplifying comparisons are obtained.

$X_1 : X_2 : X_3 = 2.97778 : 2 : 1$

So that the second and third boundary functions equation is obtained as follows.

$$\frac{X_1}{X_2} = \frac{2.97778}{2}$$

$2X_1 \leq 2.97778 X_2 \rightarrow 2X_1 - 2.97778 X_2 \leq 0 \ ...(2)$

$$\frac{X_2}{X_3} = \frac{2}{1}$$

$X_2 \leq 2X_3 \rightarrow X_2 - 2X_3 \leq 0 \qquad ...(3)$

B. Calculation with the Simplex Method

In detail the steps to solve a linear program problem using the simplex table method are.

- Turn linear program problems into mathematical forms.

Purpose function : $Z \qquad = 2.28 X_1 + 5.20 X_2 + 9.98 X_3$

- Creates a simplex table and includes all the objective function coefficients, limiting functions, *slack variables* and right hand side constraints.

Limit / limit: (1) $= 108 X_1 + 108 X_2 + 120 X_3 \leq 29806$

(2) $= 2 X_1 - 2.97778 X_2 \leq 0$
(3) $= X_2 - 2X_3 \leq 0$

Change the mathematical model from a linear program problem to a standard form. The way to convert a linear program to a standard form is to add an additional variable, namely the base variable (S_1, S_2, S_3) to each of the constraints, then the standard form of the linear program is as follows.

Purpose function: $Z = 2.28 X_1 + 5.20 X_2 + 9.98 X_3 + 0S_1 + 0S_2 + 0S_3$

$Z - 2.28 X_1 - 5.20 X_2 - 9.98 X_3 - 0S_1 - 0S_2 - 0S_3 = 0$

Limit / limit: (1) $= 108 X_1 + 108 X_2 + 120 X_3 + S_1 \leq 29806$
(2) $= 2 X_1 - 2.97778 X_2 + S_2 \leq 0$
(3) $= X_2 - 2 X_3 + S_3 \leq 0$

Basic Variable	Z	X1	X2	X3	S1	S2	S3	NK
Z	1.00	-2.82	-5.20	-9.98	0.00	0.00	0.00	0.00
S 1	0.00	108.00	108.00	120.00	1.00	0.00	0.00	29806.00
S 2	0.00	2.00	-2.98	0.00	0.00	1.00	0.00	0.00
S 3	0.00	0.00	1.00	-2.00	0.00	0.00	1.00	0.00

Table 2:- Initial Simplex Tables (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

After entering all the equations in the simplex table, the next step is to determine the key column, key row and *cell element*.

- Specifies the key column

The key column is the column whose decision variables and coefficients are based. The key column is determined by the value of Z which has the least negative value, so the key column is column X_3.

- Specifies the key row

A key line is a line whose base variable and base variable exits the base. The key line is determined by the

"minimum comparison result" value in the NK column with the value in the key column (X_3).

- First line (R_1) $= \frac{X_1}{X_2} = \frac{29806}{120} = 248,383$
- Second line (R_2) $= \frac{X_1}{X_2} = \frac{0}{0} = \infty$
- Third line (R_3) $= \frac{X_1}{X_2} = \frac{0}{2} = 0$

$R_i = \min (243,383, \infty, 0) = 0$, then the key row is located in the third row.

- Determines *cell elements*

Cell element is the value of intersection between the key column and the key row, thus *the cell element* is 3.

Basic Variable	Z	X1	X2	X3	S1	S2	S3	NK
Z	1.00	-2.82	-5.20	-9.98	0.00	0.00	0.00	0.00
S 1	0.00	108.00	108.00	120.00	1.00	0.00	0.00	29806.00
S 2	0.00	2.00	-2.98	0.00	0.00	1.00	0.00	0.00
S 3	0.00	0.00	1.00	-2.00	0.00	0.00	1.00	0.00

Table 3:- Column Selection Key, Key Row and *Elemen* First *Cell* (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

Information:

The table above shows the values that are key columns, key rows and *cell elements*, of all functions ready for the iteration process.

C. Iteration Stage

The iteration process is carried out continuously until an optimal solution is obtained. The optimal solution can be

said to have been obtained if the value of Z is not possible to increase.

Termination of the iteration process is applied by looking at the coefficient of the non-base variable, if all the coefficients have been marked positive, the iteration process can be terminated because an optimal solution has been obtained. Following are the iterative stages.

A. Create a new key line
New key line (X_3) =

Old key line	0.00	0.00	1.00	-2	0.00	0.00	1.00	0.00
Cell element	- 2							
New key line	0.00	0.00	-0.5	1.00	0.00	0.00	-0.5	0.00

Table 4:- New Key Row (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

B. Make a new Z line

Old Z line (i)	1.00	-2.82	-5.20	-9.98	0.00	0.00	0.00	0.00
New key line	0.00	0.00	-0.5	1.00	0.00	0.00	-0.5	0.00
The number in the old Z row key column	-9.98							
Multiplying the new key row with the number in the old Z row key column (ii)	0.00	0.00	4.99	-9.98	0.00	0.00	4.99	0.00
New Line Z (i) - (ii)	1.00	-2.82	-10. 19	0.00	0.00	0.00	-4.99	0.00

Table 5:- New Z lines (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

C. Make new numbers first row (S_1)

Old first line (S_1) (i)	0.00	108.00	108.00	120.00	1.00	0.00	0.00	29806 .00
New key line	0.00	0.00	-0.5	1.00	0.00	0.00	-0.5	0.00
The number in the first row key column is long	120.00							
Multiplying new key lines with numbers in the old first row key column (ii)	0.00	0.00	-60	120.00	0.00	0.00	-60	0.00
The first line is new (i) - (ii)	0.00	108.00	168	0.00	1.00	0.00	60	29806 .00

Table 6:- New Numbers First Line (S_1) (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

D. Make a new number of the second row (S_2)

Old second line (S_1) (i)	0.00	2	-2.97778	0.00	0.00	1.00	0.00	0.00
New key line	0.00	0.00	-0.5	1.00	0.00	0.00	-0.5	0.00
The number in the second row key column is long	0.00							
Multiplying new key lines with numbers in the old second row key column (ii)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
The second line is new (i) - (ii)	0.00	2	-2.97778	0.00	0.00	1.00	0.00	0.00

Table 7:- New Numbers Second Line (S_2) (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

The results of the translation of the above iteration process are obtained a new key value or number (X_3), new Z line, new row S_1 and S_2.

Basic Variable	Z	X1	X2	X3	S1	S2	S3	NK
Z	1.00	-2.82	-10.19	0.00	0.00	0.00	-4.99	0.00
S 1	0.00	108.00	168.00	0.00	1.00	0.00	60.00	29806.00
S 2	0.00	2.00	-2.98	0.00	0.00	1.00	0.00	0.00
X3	0.00	0.00	-0.50	1.00	0.00	0.00	-0.50	0.00

Table 8:- Table Simplex Iteration 1 (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

The table above shows that the first key column is the variable X_3, the key row value becomes the value of X_3. The next step is to re-determine the second key column, the second key line and the second cell element because the columns X_2 and X_3 are still negative. The second iteration process will be shown in table 9.

Basic Variable	Z	X1	X2	X3	S1	S2	S3	NK
Z	1.00	-2.82	-10.19	0.00	0.00	0.00	-4.99	0.00
S 1	0.00	108.00	168.00	0.00	1.00	0.00	60.00	29806.00
S 2	0.00	2.00	-2.98	0.00	0.00	1.00	0.00	0.00
S 3	0.00	0.00	- 0.50	1.00	0.00	0.00	-0.50	0.00

Table 9:- Selection Key Column, Line Lock and Elemen Cell Second (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

Information:

After determining the value of the second key column, the second key row and *the* second *cell element*, these values are used for the second iteration process which will be shown in table 10.

Basic Variable	Z	X1	X2	X3	S1	S2	S3	NK
Z	1.00	-9.66	0.00	0.00	0.00	-3.42	-4.99	0.00
S_1	0.00	220.84	0.00	0.00	1.00	56.42	60.00	29806.00
X2	0.00	-0.67	1.00	0.00	0.00	-0.34	0.00	0.00
X3	0.00	-0.34	0.00	1.00	0.00	-0.17	-0.50	0.00

Table 10:- Simplex Iteration Table 2 (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

The table above shows that the second key column is the variable X_2, the key row value becomes the value of X_2. The next step is to re-determine the third key column, the third key row and *the* third *cell element* because column X_1 is still negative. The third iteration process will be shown in table 11.

Basic Variable	Z	X1	X2	X3	S1	S2	S3	NK
Z	1.00	-9.66	0.00	0.00	0.00	-3.42	-4.99	0.00
S_1	0.00	220.84	0.00	0.00	1.00	56.42	60.00	29806.00
X2	0.00	-0.67	1.00	0.00	0.00	-0.34	0.00	0.00
X3	0.00	-0.34	0.00	1.00	0.00	-0.17	-0.50	0.00

Table 11:- Column Selection Key, Key Row and *Elemen* Third *Cell* (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

Information:

After determining the value of the third key column, the third key row and *the* third *cell element* , these values are used for the third iteration process that will be shown in table 12 .

The number in the solution column is obtained from the value of NK minus the value in column X_1 multiplied by the value of NK in the new key row.

Basic Variable	Z	X1	X2	X3	S1	S2	S3	NK
Z	1.00	0.00	0.00	0.00	0.04	-0.95	-2.36	1304,345
X1	0.00	1.00	0.00	0.00	0.00	0.26	0.27	134.9691
X2	0.00	0.00	1.00	0.00	0.00	-0.16	0.18	90,6508
X3	0.00	0.00	0.00	1.00	0.00	-0.08	-0.41	45.3254

Table 12:- Optimal Results from the Third Simplex Iteration Table (Source: Thesis Processed Data Andriany Saputri Rauf, 2017)

The table above shows the final results of calculations on the simplex method which is done manually. The results shown in the table are $X_1 : X_2 : X_3$ = 134,9691: 90,6508: 45,3254 is an optimization value of the number of types of houses to be built.

V.   CONCLUSION

➢ *Conclusion*

Based on the results of research and discussion can be concluded from the results of the study are as follows.The results of optimization of residential land from the calculations that have been made using the Linear Simplex Table Method Program obtained optimal results of 29808m^2 from the total available land of 29806 m ^{2} . Based on the size of the land, the number of houses that will be built type 42, 45 and 54 are 135, 91 and 45 housing units respectively. Land optimization obtained from the calculation of sales profit of Rp.41 27000 000.5. The price is derived from the selling price of the house minus the production costs of each type of house.

➢ *Suggestion*

Suggestions that can be taken into consideration for housing developers are in the early stages of planning a housing development so that the previous research will be conducted so that the number of houses and types of houses to be built can produce optimal amount and profit from the amount of land available. *Qm for Windows is* also not the only program or alternative optimization and controller calculation that can be used for research like this, housing developers can use Lingo software or other programs that are easier and easier to understand.

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