Optimization of Sei Mangkei special economic zone (SEZ) industrial land based on user needs

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Abstract: Sei Mangkei Special Economic Zone (SEZ) is an industrial area with a total land area of 1,933.8 hectares, which is distributed into 18 (eighteen) zoning areas. This industrial land zone has a 1 (one) type single plot, which is 1: 1 (200 m x 200 m) size or 4 hectares. With a single size pattern will result in high land residuals and cannot serve the needs of diverse users (markets) especially investors who need less than 4 (four) hectares of land. The pattern of size and variety of lots requires a redesign to be able to produce effective land use and provide optimal benefits for the company. In accordance with Permenperin No. 40 of 2016 that the pattern and size of industrial land is divided into 3 (three) sizes, i.e. plots of land ready to be built with small sizes ranging from 300 - 3,000 m² per lot, medium size 3,000 - 30,000 m² per lot and large sizes above 3 Ha per lot. The method of optimizing the size and variety of lots uses a model of dynamic programming and linear programming with the help of POM-QM software.

1. Introduction

Sei Mangkei Special Economic Zone (SEZ) is an industrial area with a total land area of 1,933.8 hectares distributed in 18 (eighteen) zoning areas of which ten zones are allocated to industrial lots which have the largest proportion of 69.78%. The rest is used for green open space zones of 10.60%, facilities of 10.04% and road infrastructure zones of 9.58%, shown in Figure 1.1. This proportion is in accordance with the provisions of Regulation of the Minister of Industry No. 40 of 2016 which sets a maximum proportion of the use of industrial lots by 70%, roads and canals by 8-10%, minimum green open space by 10% and other infrastructure by 8-10% [1].

The results of further observations have been carried out by PT KawasanIndustri Nusantara as a subsidiary of PT Perkebunan Nusanatara III (Persero) which has been given authority in the management of the area including conducting a pattern of mapping 1 (one) type (single pattern), namely 1: 1 size (200 m x 200 m) or an area of 4 hectares per plot. This plot pattern is certainly not optimal, both in terms of land use and marketing. With a single size pattern will result in high land residuals or land that cannot be utilized optimally and will not be able to serve the needs of diverse users (markets), especially investors who need lots less than 4 hectares. This pattern certainly has an impact on losses for the company or the achievement of profits will not be optimal.

Permenperin No. 40 of 2016 regulates the pattern of industrial lot size with a ratio of width (L) and length (P) 2: 3, or 1: 2, or the minimum lot width outside the provisions of the left and right GSB is a multiple of 18 m. Plot size based on land area is divided into 3 (three) groups, namely plots ready to build with small land sizes ranging from 300 - 3,000 m² per lot, medium size 3,000 - 30,000 m² per lot and large sizes above 3 Ha per lot.

Based on the background of the problem and Permenperin No. 40 of 2016 for variations in the size patterns and categories of plots above, a review of the Sei Mangkei industry plots is needed to produce optimal land use and profits.
Problem Formulation
The problem examined is how to optimize company profits by managing the SeiMangkei SEZ industrial plot in terms of the effect of variations in the size of the industrial plot based on land area categories.

2. First research
Some of the previous studies that have been carried out before on optimizing land use include [2] conducting research by raising the topic of research: "Optimizing the Use of Empty Land in the Baturiti District for Commercial Properties with the Highest and Best Use Principles". The analytical method used is linear programming. [3] conducted a research by raising the research topic: "Optimizing Land Use to Maximize the Revenue of Sidoarjo Regency (Case Study: Waru District)". Data analysis method used is the Linear Programming method. [4] examined Optimization of
Agricultural Land Use with the Linier Program (Study Location: J.I. SumberBuntu, Jabung District, Malang Regency).

[5] conducted a study with the title: "Optimization of Housing Development Using the Simplex Method (Case Study: UD. GriyaCempakaAlam Housing)". [6] examined by setting the title of the study: "Optimization of Housing Development Benefits Based on the Number of Houses of Each Type Using Particle Swarm Optimization (PSO)". [7] and U conducted a study with the title: "Modeling of Land Area Allocation in Highest and Best Use Analysis, Land on Jl. Kahuripan Raya Kav 30-34 Sidoarjo, East Java ". The analytical method used is linear programming.

3. Research method
This research was conducted in a Special Economic Zone located at Kelapa Sawit street No. 1. Bosar Maligas District, Simalungun Regency, North Sumatra. This research is scheduled to take place within a period of five months, from January 2019 to May 2019.

a. The research conceptual framework is seen in Figure 2.

![Figure 2. Research conceptual framework.](image)

b. Hypothesis
Based on the problems formulated in this study, a hypothesis is proposed: "Variation in the size of industrial lots based on land area categories has a significant positive effect in optimizing the profitability of PT Perkebunan Nusantara III (Persero) for managing the SeiMangkei Special Economic Zone (SEZ) industrial estate".

c. Data Collection
After identifying the data needs in the analysis, this stage is intended to collect appropriate and appropriate data. Data collected at this stage includes:
- The benefits of each plot are derived from calculations
- The area of land is obtained from the conditions on the ground

The variables used are:
- Type of lots
- Land area of each type of land
- Land area of each type of industrial plot
- The benefits of each land parcel in certain land area categories
- Maximum limit of land area

d. Data Analysis
With the data collected, the results of this study will only be obtained after processing the data with the analytical framework used in this research. The steps taken in processing data here are:
- Making alternative composition of the selection of variations in parcel size based on certain categories
- Makes possible dimensions patterns of industrial lots
- Make a mathematical model of the problem.
- Finding optimal solutions from existing models with the help of the POM-QM software for Windows.
4. Analysis and discussion
In general, the production process in making ready-to-sell industrial lots is fence preparation / fencing, block planner / determination of block plan, wide project variation / extent of project variation, cut & fill / leveling, lot block planner, utility support / supporting facilities. At the fence preparation stage, around the project area a perimeter fence will be built around the area. Next in the block planner phase or the determination of the block is carried out mapping of areas with a fairly large size which is often called the block plan, after the blocks have been formed then the wide project variation stage is the determination of the area of each project to be built. Next, it enters the cut & fill stage, which is the leveling of the land in the formed blocks, then plots according to the desired plot area at the lot block planner / plotting stage and then enters the utility support stage or the supporting facilities, namely the construction of facilities regional support.

4.1 Determination of the area of the kavling development project zone ready to build
The total land area of SeiMangkei Special Economic Zone is 1,933.80 hectares distributed in 18 (eighteen) zoning areas, 10 of which are allocated to industrial lots that have the largest proportion of 69.78%, and the remainder is allocated to zoning 10.60% of green open space, facilities of 10.04% and road zoning of 9.58%.

Of the 1933.8 hectares of land, 210 hectares have been filled, consisting of several zones. In accordance with marketing needs (investors / users) for the industrial zone will be divided into 3 sizes of plots ready to build, namely plots ready to build with a small land size, plots ready to build with a medium land size and plots ready to build with large land sizes. For each size of land ready to be built, they have different infrastructure needs and for each different land size, the value of benefits is different. In this study the size of each plot is adjusted to Permenperin No. 40 of 2016. Wide variation and profit according to data obtained from PT KawasanIndustri Nusantara.

| No | Small lots | Medium lots | Large lots |
|----|------------|-------------|------------|
|    | Surface area (ha) | Profit (IDR) | Surface area (ha) | Profit (IDR) | Surface area (ha) | Profit (IDR) |
| 0  | 0          | 0           | 0          | 0           | 0          | 0           |
| 1  | 10         | 13,000      | 10         | 37,166      | 10         | 47,002      |
| 2  | 20         | 26,000      | 20         | 74,332      | 20         | 94,044      |
| 3  | 30         | 39,000      | 30         | 111,498     | 30         | 141,066     |
| 4  | 40         | 148,664     | 40         | 188,088     |
| 5  | 50         | 185,830     | 50         | 235,110     |
| 6  | 60         | 222,996     | 60         | 282,132     |
| 7  | 70         | 260,162     | 70         | 329,154     |
| 103| ……         | ……          | ……         | ……          | 1,030      | 4,843,266   |

4.2 Pattern of industrial land grading
Each block with a certain length dimension may be cut / divided to various width dimensions of the plot size. In this case what is cut / divided is the length dimension of the block while the width dimension is not cut / divided so that the width dimension of the block will later be the length dimension of the industrial land lot. The entire size of the block can be cut as desired with various sizes of certain plot widths called the plotting pattern. For example a block with dimensions of 50m. x 160m can be divided into 2 lots with an area of 4,000 m² so that the pattern of plot results in the remaining land area of 0m². The remaining maximum plotting in determining the plotting pattern is the same as the smallest plot area.
4.3 Benefits of each plot
To be able to look for the maximum profit that can be obtained by the company, first the amount of profit must be sought for each area of industrial land produced by the company. Each plot has a different advantage. The large profit is the selling price less the cost of goods sold so that the profit per m2 of land is as follows:

Industrial land sales per m2 IDR 850,000
The cost of land for Rp 380,779
Profit land lots per m2 IDR 470,221
For the excess of land for industrial lots sold for IDR 180,799 resulting in a residual land loss of IDR 200,000.00. To find the value of cost of goods sold (COGS) is as shown in Table 2 as follows.

Table 2. Calculation of cost of land sold.

| No | Type of Investment                  | Period 2012-2031 (IDR) |
|----|------------------------------------|------------------------|
| A  | Infrastructure job                 |                        |
| 1  | Earthworks                         | 467,358,822,500        |
| 2  | ROW 62                             | 223,553,458,800        |
| 3  | ROW 43                             | 216,252,414,000        |
| 4  | ROW 34                             | 901,981,617,600        |
| 5  | ROW 30                             | 34,398,903,000         |
| 6  | ROW 28                             | 217,274,501,511        |
| 7  | Sal environment and parent         | 387,721,602,000        |
| 8  | Regional office                    | 108,000,000,000        |
| 9  | Dryport building                   | 169,500,000,000        |
| 10 | Train                              | 73,350,000,000         |
| 11 | Landscaping                        | 106,315,000,000        |
| 12 | Golf course                        | 145,980,000,000        |
| 13 | Area fence                         | 46,150,000,000         |
| 14 | Dam & intake                       | 21,737,500,000         |
|    | Total (A)                          | 3,119,573,819,400      |
| B  | Network work                       |                        |
| 1  | TM electricity network             | 423,958,972,000        |
| 2  | Electricity system                 | 9,111,700,000          |
| 3  | IT system                          | 2,660,736,000          |
| 4  | Street lighting                    | 73,301,932,220         |
|    | Total (B)                          | 509,033,340,220        |
| C  | WTP, WWP & Channel job            |                        |
| 1  | WTP                                | 790,916,603,541        |
| 2  | WWTP                               | 591,901,561,524        |
| 3  | Hidrant                            | 126,830,023,269        |
|    | Total (C)                          | 1,509,648,188,344      |
| Land Investment (Total)(A+B+C)     | 5,138,255,347,954      |
| Land for industry (Total)          | 13,494,056             |
| Cost of Goods Sold/Cost of industrial land sale on average per m² | 380,779 |

4.4 Optimum area of each development project zone
To solve the problem using the Linear Programming method, it is first necessary to change the existing problem into a mathematical form. This mathematical form is also needed so that existing problems can be solved using the help of software.

In calculating the optimum area determination using Dynamic Programming modeling, the data is a variation of the area with different benefits according to the data obtained from PT Kawasan Industri Nusantara. In the calculation of maximizing company profits by determining the optimum size of industrial ready-to-build lots, namely ready-to-build lots with small land sizes, ready-to-build lots with medium land size and ready-to-build lots with large land sizes, there are three stages namely the first stage n = plots ready to build with a small land size; second stage n = lot ready to build with medium
size; and the third stage \( n = \text{lots ready to build with a large land size} \). For \( n = \text{plot ready to build with a small land size} \), as shown in Table 5.1, the largest profit value is IDR 111,498, - million, with an area of planned plot ready to build with a small land size of 30 hectares allocated for land ready to build with size 10 hectares of small land. For \( n = \text{plot ready to build with medium land size} \) is the second stage where the second stage is the decision taken based on the first stage, according to Table 5.1 the largest profit value is IDR 631,822 million, with the area of the planned plot of land ready to build with size 170 hectares of land are allocated for land ready to build with a size of 170 hectares of land. For \( n = \text{plot ready to build with large land size} \) is the third stage where the third stage of the decision taken based on the second stage, the largest profit value is IDR 4,843,266 million with the planned area of the 1,030 hectare industrial land project allocation allocated for land plots. ready to build with a small land size of 10 hectares, allocated for land ready to build with a medium land size of 170 hectares and allocated land ready to build with a large land size of 1030 hectares. The decision used is the decision on the third stage because it is the last stage.

4.5 Determination of industrial land acceleration patterns

From the previous calculation it was found that the optimum area is the area of industrial plot development projects with an area of 1200 hectares with block size as in Table 3.

| 3. Size of industrial plot land plans. |
|----------------------------------------|
| **No.** | **Block Size** | **No.** | **Block Size** |
| 1 | 50m x 160m | 7 | 130m x 420m |
| 2 | 60m x 200m | 8 | 150m x 480m |
| 3 | 80m x 260m | 9 | 180m x 560m |
| 4 | 90m x 300m | 10 | 220m x 680m |
| 5 | 100m x 340m | 11 | 260m x 800m |
| 6 | 120m x 380m | 12 | 300m x 1000m |

In this research, the area of lots to be considered is 4,000m², 6,000m², 10,400m², 13,500m², 17,000m², 22,800m², 27,300m², 36,000m², 50,400m², 74,800m², 104,000m², and 150,000m², while the dimensions of the block are considered are numbers 1 through 6 in table 3. With this data, it is possible to calculate the pattern of classification for each block to cover the entire plot size.

Industrial plot zones which can be plotted in a pattern are Industrial Diversity Zones and Electronic Zones. Other industrial plot zones cannot be redesigned because there is already available infrastructure inside that is not possible to be demolished again. The description is as follows.

| 4. Industry zone. |
|-------------------|
| **No** | **Land Area** | **Small** | **Medium** | **Large** |
| 1 | Palm Industry Zone | 246 |  |  
| 2 | Rubber Industry Zone | 84 |  |  
| 3 | Saprodi Zone | 85 |  |  
| 4 | Industrial Electricity | 38 |  |  
| 5 | SFB Zone | 19 |  |  
| 6 | IKM Zone | 13 |  |  
| **Optimized Zone** |  |  |  |
| 7 | Various Industrial | 125 | 435 |  
| 8 | Electronic Zone | 20 | 135 |  
| **Total** | **13** | **164** | **1023** |


4.6 Purpose function of industrial land plots

The objective function is a function of the decision variable that will be maximized / minimized. In this problem, the objective to be achieved in this mathematical model is to maximize the total profit that can be generated in the industrial land development project by determining the block plot planning pattern that can maximize profits with effective plot size and with the least amount of residual plot, the objective function can be written as follows.

Maximize:

$$
\text{Maximize: } 1.486.640.000X_{1.1} + 2.229.960.000X_{2.1} + 3.865.264.000X_{3.1} + 5.017.410.000X_{4.1} + 6.318.220.000X_{5.1} + 8.473.848.000X_{6.1} + 10.146.318.000X_{7.1} + 16.927.956.000X_{8.1} + 23.699.840X_{9.1} + 35.172.530.800X_{10.1} + 48.902.984.000X_{11.1} + 70.533.150.000X_{12.1} + 16.927.956.000X_{8.2} + 23.699.840X_{9.2} + 35.172.530.800X_{10.2} + 48.902.984.000X_{11.2} + 70.533.150.000X_{12.2} + 2.217.616.530.000X_{13.2} - 200.000C_1 - 200.000C_2
$$

The parameter for each variable is obtained from the profit value of each plot multiplied by the amount of each plot then subtracted by the remaining land multiplied by the ground loss per m².

4.7 Constraint function

To complete this mathematical modeling, the circumstances that limit the achievement of a goal or commonly called a constraint must first be identified because a mathematical model can only be answered if the model has certain limitations or constraints. Model constraints that will be prepared in solving Linear Programming problems in this problem include:

- Demand constraints / Demand
- Mutually exclusive constraints
- Grouping lot constraints.

4.7.1 Demand constraints.

In the provision of industrial land, in general the developer only provides the land after the buyer has made an order of lots of a certain plot. So as if the developer only provides land based on orders. In this research a number of industrial plots of various sizes and sizes are provided first and then offered to buyers. In accordance with an analysis from PT Kawasan Industri Nusantara that the demand for industrial land lots with a certain size as shown in Table 5 follows.

| Size of Industrial Land Plot | Minimum Amount of Demand |
|-----------------------------|--------------------------|
| 4.000 m²                    | 6 lot                    |
| 6.000 m²                    | 7 lot                    |
| 10.400 m²                   | 6 lot                    |
| 13.500 m²                   | 5 lot                    |
| 17.000 m²                   | 6 lot                    |
| 22.800 m²                   | 7 lot                    |
| 27.300 m²                   | 6 lot                    |
| 36.000 m²                   | 5 lot                    |
| 50.400 m²                   | 7 lot                    |
| 74.800 m²                   | 6 lot                    |
| 104.000 m²                  | 5 lot                    |
| 150.000 m²                  | 5 lot                    |

The form of the demand constraint equation is as follows:

$$
\sum_{j=1}^{n} \sum_{k=1}^{\alpha_{ijk}} X_{ijk} \geq d_i \quad i = 1,2,\ldots,m
$$  (1)
\( \alpha_{ijk} \) = The number of lots \( i \), on a block that is cut with a cut pattern \( k \)

\( d_i \) = Demand lot \( i \)

Based on demand data in each plot area, then:

Plots of various sizes in various industrial zones are:

4.000X1.1+6.000X2.1+10.400X3.1+13.500X4.1+17.000X5.1+22.800X6.1+27.300X7.1+36.000X8.1
+50.400X9.1+74.800X10.1+104.000X11.1+150.000X12.1-C1=6.020.000

Plots of various electronic zone sizes are:

4.000X1.2+6.000X2.2+10.400X3.2+13.500X4.2+17.000X5.2+22.800X6.2+27.300X7.2+36.000X8.2
+50.400X9.2+74.800X10.2+104.000X11.2+150.000X12.2-C2=1.552.000

4.7.2 Mutually exclusive constraints.

In this research, if the path / pattern of industrial land plotting in a block plan has been determined / selected, then the block plan can no longer be made / selected for the pattern of industrial land with another pattern. So the mathematical function formulation is as follows.

\[
\sum_{j=1}^{n} x_{jk} \leq 1 \quad j = 1,2,\ldots,n
\]

Based on data on the pattern of industrial land plotting in the blocks in accordance with the charting pattern table is as follows:

X1.1+X1.2 \geq 6

X2.1+X2.2 \geq 7

X3.1+X3.2 \geq 6

X4.1+X4.2 \geq 5

X5.1+X5.2 \geq 6

X6.1+X6.2 \geq 7

X7.1+X7.2 \geq 6

X8.1+X8.2 \geq 5

X9.1+X9.2 \geq 6

X10.1+X10.2 \geq 7

X11.1+X11.2 \geq 6

4.7.3 Grouping problem obstacle.

In this grouping it is intended to minimize the variation of industrial land plotting on various block plots or grouping of industrial land lots based on the dimensions and area of plots on various blocks, because this relates to the determination of supporting or utility installations such as water, electricity, telephone installations and others. This constraint is formulated mathematically as follows.

\[
\sum_{j=1}^{n} x_{jk} - c_i = 1 \quad i = 1,2,\ldots,m
\]

\( K_{\text{small}} \) is a part (subset) of \( K_{\text{large}} \)

\( c_i \) = Variables that limit price order

\[
\sum_{j=1}^{n} x_{jk} \text{ close to } 1, c_i \text{ positive valuable is avoided by giving a penalty to the objective function.}
\]
Based on data on the pattern of industrial land plotting in the blocks according to the charting pattern table is as follows.

Medium lots are:
\[4.000 \times 1.1 + 6.000 \times 2.1 + 10.400 \times 3.1 + 13.500 \times 4.1 + 17.000 \times 5.1 + 22.800 \times 6.1 + 27.300 \times 7.1 + 4.000 \times 1.2 + 6.000 \times 2.2 + 10.400 \times 3.2 + 13.500 \times 4.2 + 17.000 \times 5.2 + 22.800 \times 6.2 + 27.300 \times 7.2 + 190.000 \leq 1640.000\]

Large lots are:
\[36.000 \times 8.1 + 50.400 \times 9.1 + 74.800 \times 10.1 + 104.000 \times 11.1 + 150.000 \times 12.1 + 36.000 \times 8.2 + 50.400 \times 9.2 + 74.800 \times 10.2 + 104.000 \times 11.2 + 150.000 \times 12.2 + 4.530.000 \leq 10.230.000\]

By considering the results of the calculation of the optimal area of each zone of the development project, the next step is to look for the pattern of plotting, in this research considered only in the zone of the projected plot of industrial development. So that for other development project zones ignored.

4.8 Area of development project zone

By using Dynamic Programming modeling to solve the problem of optimal area of the project zone of development of an industrial plot of land, a warehousing development project zone and a housing development project zone that can produce optimal area and maximum profit, the following calculation results can be obtained:

- The land development project zone is ready to be built with a small land size of 13 hectares.
- The land development project zone is ready to build with a medium land size of 164 hectares.
- The land development project zone is ready to build with a large land area of 1023 hectares.
- Total profit of Rp 5,453,683,400,000.

Then the area of the project area for the development of an industrial plot of land covering an area of 1200 hectares is considered as a cut zone or a plot of a certain size and a certain pattern of land acquisition.

4.9 Pattern of industrial land grading

The mathematical model consisting of objective functions and some constraint functions is then inputted to be analyzed using POM-QM software.

From the results obtained as listed in Table 6, it can be seen that the maximum profit that can be achieved by the company for the industrial land development project zones in the 12 planned blocks, namely various industrial zones and electronic zones with a total profit of IDR 5,453,683,400,000, - while the value is only valued at integer numbers, chosen as a pattern of classification.

| Variabel | Value | Variabel | Value |
|----------|-------|----------|-------|
| X1.1     | 13    | X7.1     | 7     |
| X1.2     | 6     | X7.2     | 1     |
| X2.1     | 13    | X8.1     | 17    |
| X2.2     | 6     | X8.2     | 6     |
| X3.1     | 9     | X9.1     | 13    |
| X3.2     | 4     | X9.2     | 6     |
| X4.1     | 9     | X10.1    | 12    |
| X4.2     | 3     | X10.2    | 4     |
| X5.1     | 9     | X11.1    | 13    |
| X5.2     | 2     | X11.2    | 2     |
| X6.1     | 7     | X12.1    | 13    |
| X6.2     | 1     | X12.2    | 2     |
From Table 6 we get the integer variables as follows:
- X1.1 is a plot of (1) 50m x 80m divided by a pattern of mapping 1 (various industrial zones) so that according to Table 6, there are 13 industrial land lots with a size of 4,000 m².
- X1.2 is a plot of (2) 50m x 80m divided by a 2-plot (electronic zone) so that according to Table 6, 6 industrial land lots with an area of 4,000 m² are obtained.
- X12.1 is a plot of (12) 300m x 500m plot with a plotting pattern 1 (various industrial zones to the right) so that according to Table 6, there are 6 industrial plots of land with an area size of 150,000m².
- X12.2 is a plot of (12) 300m x 500m plot with a pattern of plotting (electronic zone) so that according to Table 6, 2 plots of industrial land with an area of 150,000m² are obtained.

Figure 3. Proposed new masterplan SEZ Sei Mangkei.

5. **Conclusion**
The conclusions that can be obtained after data processing and problem solving analysis are as follows:
1. The results obtained by using Dynamic Programming to determine the extent of each development project the results obtained are; the 13 hectares small industrial zone, 164 small medium industrial zone and the large 1023 hectares industrial plot zone. Total profit of IDR 5,453,683,400,000.
2. The results obtained by using Linear Programming to determine the pattern of plotting in the industrial land development project and the pattern of selected plots indicate a very large difference or difference in profit compared to the projected benefits obtained from the feasibility study of PT KawasanIndustri Nusantara conducted by consultant AmbaraPuspita in the amount of IDR 5,210,000,000,000.

Suggestions that can be given in this study and can be used for improvement in future studies are as follows:
1. The company should be able to consider using a model for determining the extent of each development project zone and the pattern of industrial land parceling as in this research by considering the profit and market share of the industry.

2. The company needs to improve its classification method so that market needs are met and the resulting infrastructure costs can be minimized.

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