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TOPSIS Technique for Selecting of Property Development Location

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Abstract: The selection of the location of property development becomes an important thing for the property company. The location must match the company's target. Locations that do not meet the criteria will pose problems such as large costs incurred in development, long construction completion time and marketing difficulties where low consumer interest in property so that the firm must lower the selling price. Therefore the location is selected based on several criteria. Typically, property firms have different location criteria. However, the criteria used concern the structure of the soil to the completeness of the correspondence. In this study, the selection of 3 locations of property development, A, B and C, through a decision support system. A total of 32 predefined criteria are processed using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. TOPSIS is one of the decision support methods that can solve multi criteria problems and can produce decisions quickly and precisely. Land data, criteria, alternatives, weighting criteria, survey results and criteria values are internal data used in this system. TOPSIS results show that location A is the best location because it has the highest preference value of 0.6. That is, location A has the shortest distance from the positive ideal solution and the furthest distance from the negative ideal solution.

Keywords: Property, Location, Decision Support System, Multicriteria, TOPSIS

1. Introduction

The selection of the location of property development becomes an important thing for the property company. The location must match the company's target. Property Company always prioritizes the quality of the building to maintain customer satisfaction with the product. One way that is done to maintain customer satisfaction is to conduct a survey to find a strategic location before building a project.

Locations that do not meet the criteria will pose problems such as large costs incurred in development, long construction completion time and marketing difficulties where low consumer interest in property so that the firm must lower the selling price. Therefore the location is selected based on several criteria and typically, property firms have different location criteria. The criteria used involve the structure of the soil to the circumstances surrounding the site.

In this study, the selection of 3 locations of property development, A, B and C, through a decision support system with predetermined criteria. A total of 32 predefined criteria are processed using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. TOPSIS is one of the multi-criteria decision making (MCDM) methods [23]. This method evaluates the alternatives based on two rules: one is close to the ideal solution; the other is far away from negative ideal solution [15]. TOPSIS has been applied to many fields such as risk evaluation, performance evaluation, and suppliers' selection since it was proposed by [9]. In practice, TOPSIS has been successfully applied to solve selection/evaluation problems with a finite number of alternatives [11] because it is intuitive and easy to understand and implement.

TOPSIS method was initially presented by Hwang and Yoon [9]. It has been deemed one of the major decision making methods within the world [20]. In recent years, it has been successfully applied to the health care sector [2], human resources selection [7], market for expansion [5], human resources management [4], location analysis [25], quality control [24], water management [22], manufacturing [1, 16, 17], product design [13], purchasing and outsourcing [12, 21], financial performance measurement [8] and transportation [10]. In addition, the concept of TOPSIS has also been connected to multi-objective decision making [14] and group decision making [19]. The basic idea of TOPSIS is rather simple. It originates from the concept of a displaced ideal point from which the compromise solution has the shortest distance [3, 14, 26, 27]. TOPSIS is also developed into a new method [6]. A relative advantage of TOPSIS is its ability to identify the best alternative quickly [18]. Hwang and Yoon [9] proposed that the ranking of alternatives will be based on the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS) to determine the best alternative.

Land data, criteria, alternatives, weighting criteria, survey results and criteria values are internal data used in this system. TOPSIS processing is predicted to result in varying preference values. The highest preference value is a location recommendation that can be chosen by the firm because it has the shortest distance from the positive ideal solution and the furthest distance from the negative ideal solution.

2. Methodology

This research is included in experimental research using TOPSIS method to assist decision making. TOPSIS process is done through the steps as below.

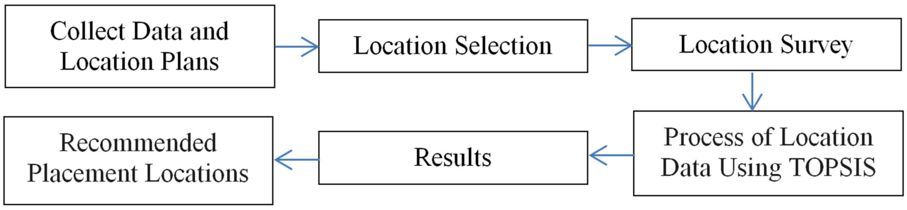

Figure 1. *Research Phase Site Determination Using TOPSIS.*

1) Collect Data and Location Plans
   At this stage, data collection and site plans are deemed to be in accordance with company regulations.
2) Location Selection
   The complete location with the data is selected and selected which is closest to the company's terms. In this study, selected 3 locations A, B and C are considered to represent all the criteria that have been determined.
3) Location Survey
   In the selected locations then conducted a survey to ensure compliance with existing data and plans.
4) Process of Location Data Using TOPSIS
   At this stage, all the surveyed location data is processed using TOPSIS. This stage shows the process of 32 criteria by TOPSIS algorithm as follows:
   1. Ranking of Each Alternative
      TOPSIS requires performance ranking of each alternative Ai on each of the normalized Cj criteria:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

      Where i=1, 2,....m; dan j=1, 2,......n;
   2. Construct the weighted Normalized Decision Matrix

$$y_{ij} = w_i r_{ij};$$

      Where i=1, 2,..., m dan j=1, 2,..., n
   3. Determine the Positive Ideal and Negative Ideal Solution
      The Positive Ideal Solution and The Negative Ideal Solution can be determined based on the normalized weight ranking (y_{ij}) as follows:

$$A^- = (y_1^-, y_2^-, \ldots, y_n^-);$$

$$A^- = (y_1^+, y_2^+, \ldots, y_n^+);$$

      Where:
      y_j^+ is: - max y_{ij}, if j is gain attribute
      - min y_{ij}, if j cost attribute
      y_j^- is: - min y_{ij}, if j is gain attribute
      - max y_{ij}, if j cost attribute
   4. Distance with Ideal Solution
      Distance is an alternative Ai with a positive ideal solution, formulated as:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(y_i^+ - y_{ij}\right)^2};i=1,2,\ldots,m$$

      Distance is an alternative Ai with a positive ideal solution, formulated as:

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(y_{ij} - y_j^-\right)^2};i=1,2,\ldots,m$$

   5. Preference Value for Any Alternative
      Preference value for any alternative (V_i) as follows:

$$V_i = \frac{D_i^-}{D_i^- + D_i^+}; \qquad i=1,2,\ldots,m$$

      V_i larger value indicates that an alternative is preferred.
5) Results
   This stage shows the results of several location tests

using TOPSIS

6) Recommendation of Construction Site

TOPSIS gives the highest preference result at the tested locations.

3. Result and Discussion

3.1. Result

The decision-making process begins with preparing the data for the three locations of property development followed by determining the value of each alternative used in the assessment of decision support systems. The alternatives and values are shown in the following table.

Table 1. *Alternative and Value.*

Alternative	Value
Very Good	4
Good	3
Enough	2
Less	1

Next is to prepare the criteria used as the basis for selecting the location of property development. Selection criteria are accompanied by alternative choice of the 32 criteria as shown in table 2 below.

Table 2. *Criteria and Alternative Option.*

No	Assessment Criteria	Alternative Options			
		Very Good	Good	Enough	Less
1	Soil Texture	Sand	Clay Sandy	Clay Sandy	Clay
2	Hard Ground Depth (m)	2.5-3.5	3.5-5	5-7	>7
3	Slope of the Ground	Flat	Flat Wavy	Hilly	Steep
4	Temperature	24-26	26-30	30-34	>34
5	Flood	No Flood	Rarely Flood	Often Flooded	Flood Areas
6	Atmosphere	Quiet and Comfortable	Less Calm	Noisy	Very Noisy
7	View	Very Interesting	Interesting	Less Attractive	Not Attractive
8	Water Quality	Clear	Yellowish	Yellowish and Smelly	Murky and Smelly
9	Level of Air Pullution	15	15-30	31-70	>70
10	Means of Cleanliness	Very Close	Close	Far	Not Available
11	Education Facility	Very Close	Close	Far	Not Available
12	Health Facility	Very Close	Close	Far	Not Available
13	Sport Facilities	Very Close	Close	Far	Not Available
14	Place of Worship	Very Close	Close	Far	Not Available
15	Recreational Facilities	Very Close	Close	Far	Not Available
16	Means of Government	Very Close	Close	Far	Not Available
17	Road Conditions	Asphalt	Hardening	Damaged Asphalt	Dirt Road
18	Width of Road	>4	3-4	2-3	1
19	Distance to City Centre (km)	1-3	3-5	5-8	>8
20	Availability of Transportation	Complete	Pretty Complete	Incomplete	Not Available
21	Distance to the Shopping Centre	1-2	2-4	4-6	>6
22	Population Density (%)	>81	51-80	35-50	<35
23	Crime Rate	<20	21-50	51-75	>75
24	Purchasing Power (%)	>80	61-80	40-60	<40
25	Economic Community	Upper	Middle to Upper	Middle	Middle to Lower, Lower
26	Level of Demand	>75	55-75	45-55	<45
27	Flexibility	>80	61-80	30-60	<30
28	Price of Land	Cheap	Standard	Pretty Expensive	Expensive
29	Level of Land Letters	Freehold Title	Districts Level	Rural Level	Do Not Have
30	Ownership Rights	Ownership	Behalf of Some People	Dispute	Not Certified
31	Drainage	Very Smooth	Pretty Smooth	Little Obstructed	Obstructed
32	Rock Content	Very	Many	Not Many	Little

Based on table 2 above, the data of three selected locations are converted into value form representing an alternative assessment. The conversion results are shown in table 3.

Table 3. *Conversion Results.*

No	Assessment Criteria	Location		
		A	B	C
1	Soil Texture	3	2	3
2	Hard Ground Depth (m)	2	1	4
3	Slope of the Ground	2	2	4
4	Temperature	4	3	4
5	Flood	4	3	3
6	Atmosphere	4	2	4
7	View	4	3	4
8	Water Quality	4	3	4
9	Level of Air Pullution	4	3	3
10	Means of Cleanliness	3	2	4
11	Education Facility	2	1	3
12	Health Facility	3	2	4
13	Sport Facilities	3	1	4
14	Place of Worship	3	2	4

No	Assessment Criteria	Location		
		A	B	C
15	Recreational Facilities	4	3	4
16	Means of Government	4	3	3
17	Road Conditions	3	2	3
18	Width of Road	3	2	4
19	Distance to City Centre (km)	4	3	4
20	Availability of Transportation	4	3	4
21	Distance to the Shopping Centre	3	2	3
22	Population Density (%)	4	3	4
23	Crime Rate	4	3	3
24	Purchasing Power (%)	4	1	4
25	Economic Community	4	3	4
26	Level of Demand	3	2	1
27	Flexibility	4	3	2
28	Price of Land	4	3	3
29	Level of Land Letters	4	2	4
30	Ownership Rights	4	3	4
31	Drainage	3	3	4
32	Rock Content	3	3	4

The next stage is to run the first TOPSIS algorithm by calculating the normalized decision matrix (r_{ij}). The results of the normalized decision matrix can be seen in table 4 of the decision matrix (X_{ij}) and the normalized decision matrix (r_{ij}).

Table 4. *Decision Matrix and Normalized Decision Matrix.*

X_{ij}	Rij		
	A	B	C
4,69	0,64	0,43	0,64
4,58	0,44	0,22	0,87
4,9	0,41	0,41	0,82
6,4	0,63	0,47	0,63
5,83	0,69	0,51	0,51
6	0,67	0,33	0,67
6,4	0,63	0,47	0,63
6,4	0,63	0,47	0,63
5,83	0,69	0,51	0,51
5,39	0,56	0,37	0,74
3,74	0,53	0,27	0,8
5,39	0,56	0,37	0,74
5,1	0,59	0,2	0,78
5,39	0,56	0,37	0,74
6,4	0,63	0,47	0,63
5,83	0,69	0,51	0,51
4,69	0,64	0,43	0,64
5,39	0,56	0,37	0,74
6,4	0,63	0,47	0,63
6,4	0,63	0,47	0,63
4,69	0,64	0,43	0,64
6,4	0,63	0,47	0,63
5,83	0,69	0,51	0,51
5,74	0,7	0,17	0,7
6,4	0,63	0,47	0,63
3,74	0,8	0,53	0,27
5,39	0,74	0,56	0,37
5,83	0,69	0,51	0,51
6	0,67	0,33	0,67
6,4	0,63	0,47	0,63
5,83	0,51	0,51	0,69
5,83	0,51	0,51	0,69

Here is the process of calculating the normalized decision matrix.

a. Alternative Roots

1. Soil Texture

$$X_{ij} = \sqrt{\left((m_{11})^2 + (m_{21})^2 + (m_{31})^2\right)}$$

$$X_1 = \sqrt{\left((3)^2 + (2)^2 + (3)^2\right)}$$

= √(9+4+9)

= √(22)

= 4,69

2. Hard Ground Depth

$$X_{ij} = \sqrt{\left((m_{12})^2 + (m_{22})^2 + (m_{32})^2\right)}$$

$$X_2 = \sqrt{\left((2)^2 + (1)^2 + (4)^2\right)}$$

= √(4+1+16)

= √(21)

= 4,58

For the 3rd criterion and up to 32, the calculation is the same as above.

b. Ranking of Each Alternative

1. Soil Texture

$$rA_1 = \frac{m_{11}}{x_1} = \frac{3}{4.69} = 0.64$$

$$rB_1 = \frac{m_{21}}{x_1} = \frac{2}{4.69} = 0.43$$

$$rC_1 = \frac{m_{31}}{x_1} = \frac{3}{4.69} = 0.64$$

2. Hard Ground Depth

$$rA_2 = \frac{m_{12}}{x_2} = \frac{2}{4.58} = 0.44$$

$$rB_2 = \frac{m_{22}}{x_2} = \frac{1}{4.58} = 0.22$$

$$rC_2 = \frac{m_{32}}{x_2} = \frac{4}{4.58} = 0.87$$

For the 3rd criterion and up to 32, the calculation is the same as above.

After obtaining the result of a normalized decision matrix, the next step is a weighted normalized decision matrix. The weighted normalized decision matrix is the multiplication between the normalized decision matrix (r_{ij}) and the criterion weight (W). The weight of criteria is the value of each criterion determined by the decision maker. The result of calculation can be seen in table 5. The following is calculation process of weighted normalized decision matrix.

$YA_1 = rA_1 * w_1 = 0{,}64 * 3 = 1{,}92$

$YB_1 = rB_1 * w_1 = 0{,}43 * 3 = 1{,}29$

$YC_1 = rC_1 * w_1 = 0{,}64 * 3 = 1{,}92$

YA_2...etc.

The next step is a positive ideal solution (A+) and a negative ideal solution (A-). The maximized normalized (A

+) maximized decision matrix is determined by the rank of the normalized decision matrix with the greatest value, while the minimum weighted normalized decision matrix (A-) is determined based on a normalized matrix decision ranking with the smallest value. The following matrix decisions are normalized maximum (A +) and minimum (A-)

Table 5. *Positive and Negative Ideal Solution.*

Solusi ideal	
A+	**A-**
1,92	1,29
2,61	0,66
3,28	1,64
1,26	0,94
2,07	1,53
1,34	0,66
1,26	0,94
1,89	1,41
2,07	1,53
2,22	1,11
2,4	0,81
2,96	1,48
1,56	0,4
2,22	1,11
1,89	1,41
1,38	1,02
2,56	1,72
2,96	1,48
2,52	1,88
1,26	0,94
1,92	1,29
2,52	1,88
2,76	2,04
2,8	0,68
2,52	1,88
3,2	1,08
2,22	1,11
2,04	2,76
2,68	1,32
2,52	1,88
2,07	1,53
2,07	1,53

After obtaining a positive ideal solution and a negative ideal solution, the next step is a weighted value distance to the positive ideal solution (D +) and the negative ideal solution (D-). The weighted value distance to the positive ideal solution is determined based on the root of the sum of squared values of the weighted normalized decision matrix minus the positive ideal solution, while the weighted value spacing of the ideal solution is determined based on the root of the sum of squared values of the weighted normalized decision matrix minus the ideal negative solution.

Here is the process of calculating the distance of weighted values against a positive ideal solution:

$$DA+ = \sqrt{((YA_1-A1+)^2+(YA2-A2+)^2+(YA3-A3+)^2+(YA4-A4+)^2+(YA5-A5+)^2)}$$

$$= \sqrt{((2.76-2.76)^2+(1.92-1.92)^2+(2.96-2.96)^2+(0.99-2.01)^2+(1.53-2.07)^2)}$$

$$= 1.15$$

$$DB+ = \sqrt{((YB_1-A1+)^2+(YB2-A2+)^2+(YB3-A3+)^2+(YB4- A4+)^2+(YB5-A5+)^2)}$$

$$= \sqrt{((2.04-2.76)^2+(1.92-1.92)^2+(1.48-2.96)^2+(2.01-2.01)^2+(1.53-2.07)^2)}$$

$$= 1.73$$

$$DC+ = \sqrt{((YC_1-A1+)^2+(YC2-A2+)^2+(YC3-A3+)^2+(YC4-A4+)^2+(YC5-A5+)^2)}$$

$$= \sqrt{((2.04-2.76)^2+(1.29-1.92)^2+(2.24-2.96)^2+(2.01-2.01)^2+(2.07-2.07)^2)}$$

$$= 1.2$$

Here is the process of calculating the distance of weighted values against a negative ideal solution:

$$DA- = \sqrt{((YA_1-A_1-)^2+(YA2-A2-)^2+(YA3-A3-)^2+(YA4-A4-)^2+(YA5-A6-)^2)}$$

$$= \sqrt{((2.76-2.04)^2+(1.92-1.29)^2+(2.96-1.48)^2+(0.99-0.99)^2+(1.53-1.53)^2)}$$

$$= 1.76$$

$$DB- = \sqrt{((YB_1-A_1-)^2+(YB2-A2-)^2+(YB3-A6-)+(YB4-A4-)^2+(YB5-A5-)^2)}$$

$$= \sqrt{((2.04-2.04)^2+(1.29-1.29+)^2+(1.48-1.48)+(2.01- 0.99)^2+(1.53-1.53)^2)}$$

$$= 1.2$$

$$DC- = \sqrt{((YC_1-A_1-)^2+(YC2-A2-)^2+(YC3-A3-)+(YC4-A4-)^2+(YC5-A5-)^2)}$$

$$= \sqrt{((2.04-2.04)^2+(1.29-1.29+)^2+(2.24-1.48)+(2.01- 0.99)^2+(2.07-1.53)^2)}$$

$$= 1.38$$

Here is a table of weighted value distances against a positive ideal solution and a negative ideal solution:

Table 6. *The Distance Between of Weighted Value with Positive and Negative Ideal Solutions.*

Di					
D1+	**D2+**	**D3+**	**D1-**	**D2-**	**D3-**
2,81	5,32	2,64	4,34	1,39	5,12

The next step is to determine the preference value (V_i). Values V_i are determined by dividing the weighted value spacing of the ideal solution to the sum of the weighted value spacing of the negative ideal solution with the distance of the weighted value of the positive ideal solution. Here is the process of calculating the determination of preference values.

$$V_A = \frac{D^-}{D^- + D^+}$$
= 1.76/(1.76 + 1.15)
=0.6

$$V_B = \frac{D^-}{D^- + D^+}$$
= 1.2/(1.2 + 1.73)
=0.41

$$V_C = \frac{D^-}{D^- + D^+}$$
= 1.38/(1.38 + 1.2)
=0.53

3.2. Discussion

The calculations of the three preferences show different results but are not far adrift. The sum of the weighted value spacing of a negative ideal solution with a weighted value spacing of an increasingly positive ideal solution will result in a smaller preference value. Table 7 shows the preference values for each location where location A has the highest preference value of the 3 tested locations. Location A is selected because it has the criteria with the best alternative option as well, as shown in table 8.

Table 7. *Preference Values.*

V_i		
A	**B**	**C**
0,6	0,41	0,53

Table 8. *Criteria of Location A.*

No	Assessment Criteria	Alternative Options
1	Soil Texture	Clay
2	Hard Ground Depth (m)	5-7
3	Slope of the Ground	Hilly
4	Temperature	24-26
5	Flood	No Flood
6	Atmosphere	Quiet and Comfortable
7	View	Very Interesting
8	Water Quality	Clear
9	Level of Air Pullution	<15
10	Means of Cleanliness	Close
11	Education Facility	Far
12	Health Facility	Close
13	Sport Facilities	Close
414	Place of Worship	Close
15	Recreational Facilities	Very Close
16	Means of Government	Very Close
17	Road Conditions	Hardening
18	Width of Road	3-4
19	Distance to City Centre (km)	1-3
20	Availability of Transportation	Complete
21	Distance to the Shopping Centre	2-4
22	Population Density (%)	>81
23	Crime Rate	<20
24	Purchasing Power (%)	>80
25	Economic Community	Upper
26	Level of Demand	55-75
27	Flexibility	>80
28	Price of Land	Cheap
29	Level of Land Letters	Freehold Title
30	Ownership Rights	Ownership
31	Drainage	Pretty Smooth
32	Rock Content	Many

Some criteria from location A get enough weight there are the depth of hard soil, the slope of the soil, and the means of education. However, because TOPSIS determines the best object of the highest preference value, then all three criteria are ignored, although at location C, these three criteria get better weight.

4. Conclusion

Effective location selection for property development is a strategic decision that affects company performance. Mistakes can pose problems such as large costs incurred in development, long construction completion time and marketing difficulties where low consumer interest in property so that the firm must lower the selling price. Despite the difficulties in using TOPSIS, we noted no ambiguity in final results. Therefore the results of the analysis shows that the first ranking among the locations based on property criteria belongs to location A because it has the highest preference value or has the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. Testing using TOPSIS is highly determined by the weight value given by the decision maker. This can give different preference results.

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