Fuzzy logic algorithm and analytic network process (ANP) for boarding houses searching recommendations

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Abstract
Finding a boarding house is usually done manually or by visiting the boarding house in person. Several choices of boarding houses make boarding house seekers have to make choices according to the desired criteria, so it takes quite a long time. A decision support system is a system that can be used to help make decisions based on existing criteria for determining several alternatives to be selected. The methods used in this research are the Analytic Network Process (ANP) and the Fuzzy Logic method. This study employed several criteria in providing recommendations, including distance, price, facilities, security, number of spaces, parking space and convenience. The weighting of these criteria used the fuzzy logic method based on the priority scale determined by the boarding house seekers. This system has provided a recommendation for boarding houses based on the results of the calculation process using the ANP method and weighting using fuzzy logic. The result of calculations shows that the highest value was obtained by Munawar kos (boarding house) with a value of 6.55% and followed by Diding kos with a value of 6.52%.

Keywords: Analytic Network Process; Fuzzy Logic; DSS; Boarding house; Recommendation

Introduction
Currently, many employees and students from outside the city live in boarding houses because it can save time and transportation costs. It will be exhausting for them to go back and forth from their hometown to their workplaces and schools. The problem occurs when they want to find a boarding house that fits the criteria, as they have to search from one boarding house to another [1]. There are certain criteria for boarding house seekers to get the right and appropriate boarding house [2] [3]. However, limited information regarding the location, price, facilities and contact of the boarding house owner is the common problem often faced by them.

A study used the SAW (Simple Additive Weighting) method using 3 criteria, namely a) price; b) location; c) facilities and using 3 alternatives, obtained the best alternative output value of 3.99 [4]. Another study used the Analytic Network Process (ANP) method for the selection of boarding houses using 3 criteria, namely a) distance; b) price; c) facilities and using 30 alternative boarding houses obtained the result of 3,714 for Kos Putri (female boarding house) and then 3,702 for Asenkar boarding house [5].

In addition, a study using Fuzzy Sugeno employed 6 criteria, namely price, rooms, location of the market, nearby dining places, places of worship, and parking lots [6]. To obtain the result in this study, four stages of data collection were conducted; they included the formation of fuzzy sets, the formation of rules, application of implication functions and rule inference as well as defuzzification. Some of the main components in choosing the ideal house are accessibility and flooding avoidance [7], safety and convenience standards, i.e., parking availability, safe neighbourhood (from thefts and sexually immoral acts), adequate lighting, good air circulation, provision of clean water and windows [8] [9].

In addition, there are several health requirements for housing needed by humans such as oxygen, availability of clean water, air circulation, density of occupancy, disposal of waste, environmental facilities, and infrastructure as well as reforestation [10]. Referring to previous research in finding boarding houses that used 3 criteria, namely distance, price, and bathroom facilities, this study adds several criteria such as price, facilities, security [11], distance, convenience, parking space, and the number of spaces. [12]. It is hoped that the addition of the criteria can produce a system that is able to overcome the problems mentioned above.
Method

A. Fuzzy Logic

The weighting of the criteria to be used is based on the priority determined by the boarding house seekers so that the weight can be determined using fuzzy logic. In this study, 7 criteria were proposed, and the boarding house seekers could choose all of these criteria, or it could be less than 7 criteria, depending on their needs.

In this study, the criteria used include rental prices, available facilities, security, distance, convenience, parking space and the number of spaces. These criteria can be selected by the seekers based on the order of priority, whether the main priority is based on distance, or based on price, and so on. The priority can be described as in Figure 1.

Figure 1. Fuzzy logic weighting

\[
\text{Weighting} = ((\text{count} - n) + 1)x(1/\text{count})x100
\]  

Count = number of priority  
N = priority order

B. Analytic Network Process (ANP)

The Analytic Network Process (ANP) method is a qualitative approach developed to improve the weaknesses of the Analytical Hierarchy Process (AHP) method in the form of the ability to recommend linkages to the ANP method [13]. The Analytical Network Process (ANP) method is a mathematical theory that is able to analyze an effect by using an assumption approach to solve problems. This method is used with consideration of adjusting the complexity of the problem by means of a synthesis decomposition accompanied by a priority scale that produces the greatest priority effect. In the AHP network there are levels of objectives, criteria, sub-criteria, and alternatives, each of which has elements. Whereas in the ANP network, the level in AHP is called a cluster which can have criteria and alternatives in it [14]

The advantage of the ANP method when compared to AHP is in solving more complex problems [15]. Research using the Analytic Network Process (ANP) method is the right solution in determining priority road handling based on the level of road service. The study shows a correlation value between -1 to 1 with a value of 0.867 which has been validated using the Spearman Rank for 10 roads in the city of Cirebon [16]. The steps used to solve this problem are:

1. Identify problems and determine solution criteria.
2. Determine the weighting of the criteria by the user
3. Create a Comparison Matrix

Comparison matrix is done by making comparisons in pairs for each hierarchical sub-system, then transforming it in the form of a matrix for a numerical analysis process (n x n matrix). Comparison matrix is shown in Table 1.

| A | B1 | B2 | B3 | ... | Bn |
|---|----|----|----|-----|----|
| B1 | B1 | B12 | B13 | ... | B1n |
| B2 | B21 | B22 | B23 | ... | B2n |
| B3 | B31 | B32 | B33 | ... | B3n |
| ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... |
| Bn | Bn1 | Bn2 | Bn3 | ... | Bnn |

4. Calculating the Eigenvector Value
To calculate the eigenvector value, we added up the values in each column of the matrix then divided each value in the column cell by the total column, then added up the values for each row and divide by the value of n. The calculation of the eigenvector value can be seen in equation (2).

\[
X = \sum \left( \frac{W_i}{\sum W_i} \right)
\]

\(X\) = eigenvector  
\(W_i\) = single row column cell value \((i = 1 \ldots n)\)  
\(\sum W_i\) = total number of columns

5. Checking Consistency Ratio
   a. Looking for the value of \(\lambda_{\text{maks}}\) shown in equation (3)

\[
\lambda_{\text{maks}} = (\text{eigenvector value 1} \times \text{number of columns 1}) + (\text{eigenvector value 2} \times \text{number of columns 2}) \ldots n
\]

\(\lambda_{\text{maks}}\) = the largest eigenvector value
\(n\) = number of comparison matrices

b. Calculating the Consistency Index (CI), with equation (4).

\[
\text{CI} = \frac{(\lambda_{\text{maks}} - n)}{(n - 1)}
\]

Where:
\(\text{CI}\) = Consistency Index  
\(\lambda_{\text{maks}}\) = the largest eigenvector value  
\(n\) = number of comparison matrices

c. Determining Consistency Ratio (CR)

\[
CR = \frac{CI}{RI}
\]

6. Making Supermatrix
   a. Unweight supermatrix, the eigenvector generated from the whole pairwise comparison matrix in the network.
   b. Weighted supermatrix, multiplying the contents of the unweighted supermatrix with the cluster weight.
   c. Limit supermatrix, performing the weighted supermatrix continuously until the number in each column in one row is the same then normalize.

7. Ranking
   It is the final value in the ANP method that has been carried out by the normalization process to find out the final value of the calculation. The best alternative is generated from the highest alternative score [16].

C. Methodology
   In this study, our methodology is as shown in Figure 2.
This research was conducted with the following stages:

1. Interview
   The interview was conducted to know the business process in searching for boarding houses manually by conducting questions and answers to employees and students in order to get precise and accurate results.

2. Observation
   The researcher collected data based on predetermined criteria for several boarding houses in Tangerang area.

3. Literature/Library Studies
   The data was further analyzed by studying several journals related to the search for boarding houses including the criteria used [17].

Results and Discussion

A. Design

In this study, the boarding house seekers used 7 selected criteria with top priority starting from the price offered, the facilities provided, the security of the boarding house whether security was available or not, the distance from the boarding house to the place of activity, the convenience of the boarding house, the availability of parking lot both car parking and motorbike parking, and the last priority is the number of rooms in the boarding house. Based on equation 1, the weights for each criterion were obtained as shown in Table 3.

| Priority | Code | Criteria       | Weight |
|----------|------|----------------|--------|
| 1        | H    | Price          | 100    |
| 2        | F    | Facility       | 86     |
| 3        | KA   | Security       | 71     |
| 4        | J    | Distance       | 57     |
| 5        | KN   | Convenience    | 43     |
| 6        | P    | Parking lot    | 29     |
| 7        | R    | Number of rooms| 14     |

After the weight value was determined by the user, then the researcher made a pairwise comparison matrix as shown in Table 4.

| Criteria | H  | F  | KA | J  | KN | P  | R  |
|----------|----|----|----|----|----|----|----|
| H        | 1.00 | 1.16 | 1.41 | 1.75 | 2.33 | 3.45 | 7.14 |
| F        | 0.86 | 1.00 | 1.21 | 1.51 | 2.00 | 2.97 | 6.14 |
The next step was to determine the eigenvector value using the equation (2) by adding up the value of each row from the matrix and then dividing each value of the number of row cells by the total column. The eigenvector value is shown in Table 5.

Furthermore, after the eigenvector value is obtained, the next step was to check the consistency ratio using the formula in equation 3, if the value is < 0.1 then results are consistent.

\[ \lambda_{max} = (0.25 \times 4.00) + (0.22 \times 4.65) + (0.18 \times 5.63) + (0.14 \times 7.02) + (0.11 \times 9.30) + (0.07 \times 13.79) + (0.04 \times 28.57) \]
\[ = 7 \]

Next was calculating CI with the number of orders using 7 criteria. To calculate CI the equation (4) was used.

\[ CI = (\lambda_{max} – n) / (n – 1) \]
\[ = (7 – 7) / (7 – 1) \]
\[ = 0.00 \]

The Random Index (RI) used is 1.32 based on the value specified in table 2. The calculation of the CR value can use equation (5).

\[ CR = CI / RI \]
\[ = 0.00 / 1.32 \]
\[ = 0.00 \]

Because the CR result is 0.00 less than 0.10 (CR<0.1), the eigenvector value is considered consistent.

The next step was to calculate the eigenvector price using the equation (2). The first step was to calculate the reverse value. The reverse price value is to reverse the value by subtracting the total price value by the price value of each Kos (boarding house). After that, the eigenvector value was obtained by dividing each reserve value of Kos by the total reverse price. Table 6 is the result of the eigenvector price calculation.
The second criterion is that the facility that used equation (2) without using the reverse process, because the higher the facility value, the better. The calculation process is the value of each facility divided by the total value of all Kos facilities. Table 7 is the result of the calculation of the eigenvector facility.

### Table 7. Eigenvector Facility

| No | Alternative   | Facility value | Eigen vector |
|----|---------------|----------------|--------------|
| 1  | Mariyam Kos   | 4              | 0.0727       |
| 2  | Hariyono Kos  | 4              | 0.0727       |
| 3  | Deni Kos      | 1              | 0.0182       |
| 4  | Budi Kos      | 1              | 0.0182       |
| 5  | Sinta Kos     | 1              | 0.0182       |
| 6  | Aldian Kos    | 1              | 0.0182       |
| 7  | Doni Kos      | 4              | 0.0727       |
| 8  | Munawar Kos   | 4              | 0.0727       |
| 9  | Andreas Kos   | 1              | 0.0182       |
| 10 | Harry Kos     | 4              | 0.0182       |
| 11 | Rika Kos      | 1              | 0.0182       |
| 12 | Riski Kos     | 4              | 0.0727       |
| 13 | Dedi Kos      | 1              | 0.0182       |
| 14 | Dede Kos      | 1              | 0.0182       |
| 15 | Anang Kos     | 1              | 0.0182       |
| 16 | Mariya Kos    | 4              | 0.0727       |
| 17 | Slamet Kos    | 4              | 0.0727       |
| 18 | Diding Kos    | 7              | 0.1273       |
| 19 | Yanto Kos     | 4              | 0.0727       |
| 20 | Nurul Kos     | 3              | 0.0545       |
The third criterion is security using equation (2). The calculation process is the same as finding the eigenvector facility where the higher the security value, the better, so the calculation process is the value of each security divided by the total security value of all Kos. Table 8 is the result of the calculation of the eigenvector security.

| No | Alternative  | Facility value | Eigen vector |
|----|--------------|----------------|--------------|
| Σ  |              | 55             | 1            |

### Table 8. Eigenvector Security

| No | Alternative  | Security Value | Eigen vector |
|----|--------------|----------------|--------------|
| 1  | Mariyam Kos  | 1              | 0.0435       |
| 2  | Hariyono Kos | 1              | 0.0435       |
| 3  | Deni Kos     | 1              | 0.0435       |
| 4  | Budi Kos     | 1              | 0.0435       |
| 5  | Sinta Kos    | 2              | 0.0870       |
| 6  | Aldian Kos   | 1              | 0.0435       |
| 7  | Doni Kos     | 1              | 0.0435       |
| 8  | Munawar Kos  | 2              | 0.0870       |
| 9  | Andreas Kos  | 1              | 0.0435       |
| 10 | Harry Kos    | 1              | 0.0435       |
| 11 | Rika Kos     | 1              | 0.0435       |
| 12 | Riski Kos    | 1              | 0.0435       |
| 13 | Dedi Kos     | 1              | 0.0435       |
| 14 | Dede Kos     | 1              | 0.0435       |
| 15 | Anang Kos    | 1              | 0.0435       |
| 16 | Mariya Kos   | 2              | 0.0870       |
| 17 | Slamet Kos   | 1              | 0.0435       |
| 18 | Diding Kos   | 1              | 0.0435       |
| 19 | Yanto Kos    | 1              | 0.0435       |
| 20 | Nurul Kos    | 1              | 0.0435       |
| Σ  |              | 23             | 1            |

The fourth criterion is the distance using the equation (2). The calculation process is the same as finding the eigenvector price by calculating the reverse value by subtracting the total value of the distance by the value of the distance of each Kos. After that, to find the eigenvector value, we divided the value of each reverse Kos distance by the total reverse distance. Table 9 is the result of calculating the eigenvector distance.

| No | Alternative  | Distance value | Reverse distance | Eigen vector |
|----|--------------|----------------|------------------|--------------|
| 1  | Mariyam Kos  | 10,000         | 253,700          | 0.05063569   |
| 2  | Hariyono Kos | 8,800          | 254,900          | 0.050875197  |
| 3  | Deni Kos     | 10,000         | 253,700          | 0.05063569   |
| 4  | Budi Kos     | 9,900          | 253,800          | 0.050655649  |
| 5  | Sinta Kos    | 9,300          | 254,400          | 0.050775403  |
| 6  | Aldian Kos   | 79,000         | 184,700          | 0.03686406   |
| 7  | Doni Kos     | 9,500          | 254,200          | 0.050735485  |
| 8  | Munawar Kos  | 10,000         | 253,700          | 0.05063569   |
| 9  | Andreas Kos  | 10,000         | 253,700          | 0.05063569   |
| 10 | Harry Kos    | 10,000         | 253,700          | 0.05063569   |
| 11 | Rika Kos     | 10,000         | 253,700          | 0.05063569   |

Gunawan (Fuzzy logic algorithm and analytic network process (ANP) for boarding houses searching recommendations)
The fifth criterion is the convenience, using the equation (2), the calculation process is the same as finding the facility eigenvector. The result is in Table 10.

Table 10. Eigenvector convenience

| No | Alternative  | Convenience Value | Eigen vector |
|----|--------------|-------------------|-------------|
| 1  | Mariyam Kos  | 3                 | 0.05        |
| 2  | Hariyono Kos | 3                 | 0.05        |
| 3  | Deni Kos     | 3                 | 0.05        |
| 4  | Budi Kos     | 3                 | 0.05        |
| 5  | Sinta Kos    | 3                 | 0.05        |
| 6  | Aldian Kos   | 3                 | 0.05        |
| 7  | Doni Kos     | 3                 | 0.05        |
| 8  | Munawar Kos  | 3                 | 0.05        |
| 9  | Andreas Kos  | 3                 | 0.05        |
| 10 | Harry Kos    | 3                 | 0.05        |
| 11 | Rika Kos     | 3                 | 0.05        |
| 12 | Riski Kos    | 3                 | 0.05        |
| 13 | Dedi Kos     | 3                 | 0.05        |
| 14 | Dede Kos     | 3                 | 0.05        |
| 15 | Anang Kos    | 3                 | 0.05        |
| 16 | Mariya Kos   | 3                 | 0.05        |
| 17 | Slamet Kos   | 3                 | 0.05        |
| 18 | Diding Kos   | 3                 | 0.05        |
| 19 | Yanto Kos    | 3                 | 0.05        |
| 20 | Nurul Kos    | 3                 | 0.05        |
| ∑  |              | 60                | 1           |

The sixth criterion is the parking lot using the equation (2). The calculation process is the same as finding the facility eigenvector. The result is in Table 11.

Table 11. Eigenvector Parking Lot

| No | Alternative  | Parking lot Value | Eigen vector |
|----|--------------|-------------------|-------------|
| 1  | Mariyam Kos  | 2                 | 0.0909      |
| 2  | Hariyono Kos | 1                 | 0.0455      |
The seventh criterion is the amount of space using the equation (2). The calculation process is the same as searching for the eigenvector of facilities where the higher the value of the number of spaces, the better, so the calculation process is the value of each number of rooms divided by the total value of the total number of rooms for all Kos. Table 12 is the result of the calculation of the eigenvector of the number of spaces.

Table 12. Eigenvector Number of Spaces

| No | Alternative    | Parking lot Value | Eigen vector |
|----|----------------|-------------------|--------------|
| 3  | Deni Kos       | 1                 | 0.0455       |
| 4  | Budi Kos       | 1                 | 0.0455       |
| 5  | Sinta Kos      | 1                 | 0.0455       |
| 6  | Aldian Kos     | 1                 | 0.0455       |
| 7  | Doni Kos       | 1                 | 0.0455       |
| 8  | Munawar Kos    | 2                 | 0.0909       |
| 9  | Andreas Kos    | 1                 | 0.0455       |
| 10 | Harry Kos      | 1                 | 0.0455       |
| 11 | Rika Kos       | 1                 | 0.0455       |
| 12 | Riski Kos      | 1                 | 0.0455       |
| 13 | Dedi Kos       | 1                 | 0.0455       |
| 14 | Dede Kos       | 1                 | 0.0455       |
| 15 | Anang Kos      | 1                 | 0.0455       |
| 16 | Mariya Kos     | 1                 | 0.0455       |
| 17 | Slamet Kos     | 1                 | 0.0455       |
| 18 | Diding Kos     | 1                 | 0.0455       |
| 19 | Yanto Kos      | 1                 | 0.0455       |
| 20 | Nurul Kos      | 1                 | 0.0455       |
| Σ  |                | 22                | 1            |
After obtaining each priority criterion, the eigenvector value of each cost was obtained, and the unweighted supermatrix was compiled from all the eigenvector values from the previous calculation. After that the value of the unweighted supermatrix was multiplied by the eigenvector from the results of the pairwise comparison matrix of criteria weights to produce the weighted supermatrix value. The final step was to iterate over the weighted supermatrix with itself so that the same value was obtained in each row for the limiting supermatrix process. To generate a global priority value, we calculated the alternative data of the Kos multiplied by the global eigenvector criteria using equation (6).

Global priority = (alternative eigenvector criteria 1 x eigencriteria 1) + (alternative eigenvector criteria 2 x eigencriteria 2)..n

(6)

To calculate the global priority for each Kos, first we collected the eigen values of the criteria in the alternative like in the eigen values of the criteria in the Mariyam Kos alternative. See Table 13.

| No | Alternative | Number of Spaces Value | Eigen vector |
|----|-------------|------------------------|--------------|
| 19 | Yanto Kos   | 3                      | 0.0811       |
| 20 | Nurul Kos   | 1                      | 0.0270       |
| ∑  |             | 37                     | 1            |

The calculation process used equation 6.
Mariyam kos Priority Value
\[
= (0.0495 \times 0.25) + (0.0727 \times 0.22) + (0.0435 \times 0.18) + (0.0506 \times 0.14) + (0.0909 \times 0.07) + (0.0811 \times 0.04)
\]
\[
= 0.05721082
\]
So, the priority value on the Mariyam Kos alternative is 0.05721082.

The results of calculations using global priorities can be seen in Table 14.

| No | Alternative | H   | F   | KA  | J   | KN  | P   | R   | Eigen | Prioritas |
|----|-------------|-----|-----|-----|-----|-----|-----|-----|-------|-----------|
| 1  | Mariyam Kos | 0.0495 | 0.0727 | 0.0435 | 0.0506 | 0.05 | 0.0909 | 0.0811 | 0.25   | 0.05721082 |
| 2  | Hariyono Kos| 0.0497 | 0.0727 | 0.0435 | 0.0509 | 0.05 | 0.0455 | 0.0811 | 0.22   | 0.05401479 |
| 3  | Deni Kos   | 0.0499 | 0.0182 | 0.0435 | 0.0506 | 0.05 | 0.0455 | 0.0541 | 0.18   | 0.043366705 |
| 4  | Budi Kos   | 0.0502 | 0.0182 | 0.0435 | 0.0507 | 0.05 | 0.0455 | 0.0270 | 0.14   | 0.042504853 |
| 5  | Sinta Kos  | 0.0501 | 0.0182 | 0.0870 | 0.0508 | 0.05 | 0.0455 | 0.0270 | 0.11   | 0.048690892 |
| 6  | Aldian Kos | 0.0504 | 0.0182 | 0.0435 | 0.0369 | 0.05 | 0.0455 | 0.0270 | 0.07   | 0.039084642 |
| 7  | Doni Kos   | 0.0497 | 0.0727 | 0.0435 | 0.0507 | 0.05 | 0.0455 | 0.0541 | 0.04   | 0.05303392 |
| 8  | Munawar Kos| 0.0497 | 0.0727 | 0.0870 | 0.0506 | 0.05 | 0.0909 | 0.0811 | 0.063446024 |
| 9  | Andreas Kos| 0.0505 | 0.0182 | 0.0435 | 0.0506 | 0.05 | 0.0455 | 0.0270 | 0.042555236 |

Gunawan (Fuzzy logic algorithm and analytic network process (ANP) for boarding houses searching recommendations)
After obtaining the global priority, we then sorted the values from the highest to the lowest value, then normalized them in the form of a percent so that the difference in values between alternative costs is more visible. The ranking results can be seen in Table 15.

Table 15. Alternative calculation

| No | Alternatif  | Nilai       | Normalisasi |
|----|-------------|-------------|-------------|
| 1  | Munawar Kos | 0.063446024 | 6.3446024   |
| 2  | Diding Kos  | 0.062751032 | 6.2751032   |
| 3  | Mariya Kos  | 0.059279104 | 5.9279104   |
| 4  | Mariyam Kos | 0.05721082  | 5.721082    |
| 5  | Harryono Kos| 0.054014794 | 5.4014794   |
| 6  | Harry Kos   | 0.053915366 | 5.3915366   |
| 7  | Slamet Kos  | 0.053910742 | 5.3910742   |
| 8  | Yanto Kos   | 0.053891635 | 5.3891635   |
| 9  | Raski Kos   | 0.053108034 | 5.3108034   |
| 10 | Doni Kos    | 0.05303392  | 5.303392    |
| 11 | Nurul Kos   | 0.049033512 | 4.9033512   |
| 12 | Sinta Kos   | 0.048690892 | 4.8690892   |
| 13 | Deni Kos    | 0.043366705 | 4.3366705   |
| 14 | Rika Kos    | 0.042578967 | 4.2578967   |
| 15 | Anang Kos   | 0.042563146 | 4.2563146   |
| 16 | Andreas Kos | 0.042555236 | 4.2555236   |
| 17 | Dede Kos    | 0.042539415 | 4.2539415   |
| 18 | Dedi Kos    | 0.042521159 | 4.2521159   |
| 19 | Budi Kos    | 0.042504853 | 4.2504853   |
| 20 | Aldian Kos  | 0.039084642 | 3.9084642   |

B. Data Modelling
The table relations can be seen in Figure 3.

Gunawan (Fuzzy logic algorithm and analytic network process (ANP) for boarding houses searching recommendations)
Conclusion

Based on the results of tests and analysis, the following conclusions can be drawn: 1) The boarding house searching process using the Analytic Network Process (ANP) method is dynamic, which means that the total priority can be increased or decreased as needed. 2) The results of calculations show that the highest value is 6.55%, namely Munawar Kos and then Diding Kos with a value of 6.52%. 3) When viewed as the chosen priority, the prices and facilities owned by Munawar Kos and Doni Kos are the same. However, Munawar Kos was in first place, while Doni Kos was in tenth place. From these results, the level of security of the boarding house is the determinant factor. Munawar Kos has a better level of security when compared to Doni Kos, even though Doni Kos is closer than Munawar Kos.

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