Smart City Recommendations Using the TOPSIS Method

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Abstract. This study aims to recommend a city that is suitable as a Smart City on the island of Sumatera. This study uses a Decision Support System with the TOPSIS (Technique For Others Reference by Similarity to Ideal Solution) Method. The TOPSIS method is one method that is often used for ranking problems. The research data used are data from 10 major cities on the island of Sumatera, with the largest population in 2019 obtained from the Wikipedia Website (https://www.wikipedia.org/wiki/Sumatra) and the Central Statistics Agency website (https://www.bps.go.id/) as a reference in determining the assessment of each Alternative later. The 10 major cities are Medan, Palembang, Bandar Lampung, Pekanbaru, Batam, Padang, Jambi, Bengkulu, Banda Aceh, and Pematangsiantar. To be able to determine and recommend cities in the islands of Sumatera that are eligible to become Smart Cities, there are 4 criteria as an assessment of each Alternative, namely, Infrastructure, Population, Area, and Economic Level. Based on calculations using the TOPSIS method, the results obtained that the city of Medan has the highest value in the eligibility to become a Smart City.

1. Introducing

Smart City is an urban area environment that is made smart and smart by using ICT technology so that it can improve the quality of life of residents and the efficiency of urban infrastructure, and provide the best and ever-increasing services to its citizens. A Smart City usually has a physical cyber system that can improve urban behavior and capabilities by providing ICT-based facilities. Infrastructure for Smart City must be geographically and functionally expandable, this is needed to grow the shared physical environment and to meet the increasing needs and demands of users/residents of the city [1]–[4]. The term "Smart City" has spread and spread throughout the world and influenced government programs and strategies in city development. Many ideas and breakthroughs by the government are trying to create various services, ranging from smart transportation and smart energy to smart and educated people [5]. Future cities like that are expected to be able to use ICT technology effectively and efficiently in the structure of the urban environment that aims to improve and rationalize public services in the future [6]. However, things like this, however, often fail to guarantee safety and security as the main focus. This is important because it is not only one of the most fundamental principles in urban planning and management but also human welfare. Thus, safety and security are factors that are an integral part of human well-being and also of every Smart City design [7]. Smart City promotes a modern and advanced lifestyle. Infrastructure, innovation, and technology are components that make smart cities efficient and independent [8]. The level of smart city sustainability is measured based on a series of parameters, including public management, social cohesion, governance, technology, urban planning, environment, mobility and...
transportation, international projections, human capital, and the economy. Smart City has tons of applications to monitor and control each of these parameters [9].

In Indonesia, the central government helps prepare a strategic data storage facility and general applications to assist regions in building smart cities. The central government will provide a smart city development master plan for local governments. Therefore, the government does not arbitrarily choose cities that will be used as smart cities, special studies and assessments are needed, one of them is by building a system that can recommend cities that are worthy of being Smart Cities in Indonesia, especially on the island. Sumatera, the results of this system can later be used as a reference for the government in determining which regions are eligible to be selected as the next smart city. There are many branches in the field of computer science that can solve complex problems, this is evident from the many studies that have been done, such as research in the field of data mining [10]–[14], the field of artificial neural networks [15]–[25], and the field of decision support systems [26]–[33]. Based on this explanation, researchers used a decision support system to resolve the above problem. In this case, researchers use the TOPSIS method, because this method is one of the methods of decision support systems that are often used for ranking based on predetermined variables and criteria. Many previous studies discuss the smart city [34]–[36]. Based on this background, the research was conducted. It is expected that by using the TOPSIS method, the results will be obtained in the form of a Smart City recommendation on the island of Sumatera that can be used as a government reference in determining which cities in Sumatera are eligible to be used as Smart Cities.

2. Methodology

2.1. Method of collecting data

Data collection was carried out by observation contained on the Wikipedia Website (https://www.wikipedia.org/wiki/Sumatra) and the Central Statistics Agency website (https://www.bps.go.id/), not conduct research or surveys directly to cities that are alternative to obtain data.

2.2. Stages of the TOPSIS Method

At this stage, the workflow of the TOPSIS (Technique For Others Reference by Similarity to Ideal Solution) method used in recommending a city worthy of being a Smart City in Sumatera is based on alternatives and criteria that have been analyzed.

![Image](image.png)

Figure 1. Stages of the TOPSIS Method
3. Results and Discussion

Manual calculations using the TOPSIS method are based on assessments that have been carried out with data analysis based on 10 major cities in Sumatera island obtained from the Website of Wikipedia and the Website of the Indonesian Central Statistics Agency. Alternative Criteria value is given based on the Infrastructure, Population, Area and Economic Level criteria can be seen in the following table.

| No | Alternative     | Criteria |
|----|----------------|----------|
| 1  | Medan          | C1: 90   |
|    |                | C2: 90   |
|    |                | C3: 70   |
|    |                | C4: 85   |
| 2  | Palembang      | C1: 40   |
|    |                | C2: 85   |
|    |                | C3: 75   |
|    |                | C4: 45   |
| 3  | Bandar Lampung | C1: 75   |
|    |                | C2: 80   |
|    |                | C3: 60   |
|    |                | C4: 60   |
| 4  | Pekan Baru     | C1: 85   |
|    |                | C2: 75   |
|    |                | C3: 80   |
|    |                | C4: 70   |
| 5  | Batam          | C1: 45   |
|    |                | C2: 70   |
|    |                | C3: 90   |
|    |                | C4: 65   |
| 6  | Padang         | C1: 80   |
|    |                | C2: 65   |
|    |                | C3: 85   |
|    |                | C4: 80   |
| 7  | Jambi          | C1: 70   |
|    |                | C2: 60   |
|    |                | C3: 65   |
|    |                | C4: 50   |
| 8  | Bengkulu       | C1: 65   |
|    |                | C2: 45   |
|    |                | C3: 60   |
|    |                | C4: 60   |
| 9  | Banda Aceh     | C1: 55   |
|    |                | C2: 55   |
|    |                | C3: 40   |
|    |                | C4: 40   |
| 10 | Pematangsiantar| C1: 60   |
|    |                | C2: 40   |
|    |                | C3: 45   |
|    |                | C4: 75   |

Furthermore, the valuation of each Alternative based on the value of the weight that has been determined based on the assessment of the criteria of Infrastructure, Population, Area and Economic Level can be seen in the following table.

| No | Alternative     | Criteria |
|----|----------------|----------|
| 1  | Medan          | C1: 4   |
|    |                | C2: 4   |
|    |                | C3: 3   |
|    |                | C4: 4   |
| 2  | Palembang      | C1: 1   |
|    |                | C2: 4   |
|    |                | C3: 3   |
|    |                | C4: 1   |
| 3  | Bandar Lampung | C1: 3   |
|    |                | C2: 3   |
|    |                | C3: 2   |
|    |                | C4: 2   |
| 4  | Pekan Baru     | C1: 4   |
|    |                | C2: 3   |
|    |                | C3: 3   |
|    |                | C4: 3   |
| 5  | Batam          | C1: 1   |
|    |                | C2: 3   |
|    |                | C3: 4   |
|    |                | C4: 2   |
| 6  | Padang         | C1: 3   |
|    |                | C2: 2   |
|    |                | C3: 4   |
|    |                | C4: 3   |
| 7  | Jambi          | C1: 3   |
|    |                | C2: 2   |
|    |                | C3: 2   |
|    |                | C4: 1   |
| 8  | Bengkulu       | C1: 2   |
|    |                | C2: 1   |
|    |                | C3: 1   |
|    |                | C4: 4   |
| 9  | Banda Aceh     | C1: 2   |
|    |                | C2: 1   |
|    |                | C3: 1   |
|    |                | C4: 1   |
| 10 | Pematangsiantar| C1: 2   |
|    |                | C2: 1   |
|    |                | C3: 3   |
|    |                | C4: 2   |

The following is a manual calculation of the TOPSIS (Technique For Others Reference by Similarity to Ideal Solution) method in recommending cities that are worthy of being Smart cities in Sumatera.

a. Normalized decision matrix

\[
X'_1 = \sqrt{4^2 + 1^2 + 3^2 + 4^2 + 1^2 + 3^2 + 3^2 + 2^2 + 2^2 + 2^2} = \sqrt{73} = 8,5440
\]

\[
R_{11} = \frac{4}{8,5440} = 0,4682
\]

\[
R_{21} = \frac{1}{8,5440} = 0,1170
\]

\[
R_{31} = \frac{3}{8,5440} = 0,3511
\]

\[
R_{41} = \frac{4}{8,5440} = 0,4682
\]

\[
R_{51} = \frac{2}{8,5440} = 0,2341
\]

For \( X_2, X_3 \) and \( X_4 \) done in the same way based on the values of C2, C3 and C4. From the normalization calculation, the value of R is obtained:

\[
0,4682 0,4682 0,3586 0,4781
0,1170 0,4682 0,3586 0,1195
0,3511 0,3511 0,2390 0,2390
0,4682 0,3511 0,3586 0,3586
0,1170 0,3511 0,4781 0,2390
0,3511 0,2341 0,4781 0,3586
0,3511 0,2341 0,2390 0,1195
\]
b. Normalized weight value. Matrix R Normalized W = 4, 3, 2, 3

\[
Y_{11} = 0.4682 \times 4 = 1.8727 \\
Y_{21} = 0.1170 \times 4 = 0.4682 \\
Y_{31} = 0.3511 \times 4 = 1.4045 \\
Y_{41} = 0.4682 \times 4 = 1.8727 \\
Y_{51} = 0.1170 \times 4 = 0.4682 \\
Y_{61} = 0.2341 \times 4 = 0.9363 \\
Y_{71} = 0.2341 \times 4 = 0.9363 \\
Y_{81} = 0.2341 \times 4 = 0.9363 \\
Y_{91} = 0.2341 \times 4 = 0.9363 \\
Y_{101} = 0.2341 \times 4 = 0.9363
\]

Next, the calculation is done in the same way to get the results from \(Y_{ij} = W_i \cdot R_{ij}\)

\[
1.8727, 1.4045, 0.7171, 1.4343 \\
0.4682, 1.4045, 0.7171, 0.3586 \\
1.4045, 1.0534, 0.4781, 0.7171 \\
1.8727, 1.0534, 0.7171, 1.0757 \\
0.4682, 1.0534, 0.9562, 0.7171 \\
1.4045, 0.7022, 0.9562, 1.0757 \\
1.4045, 0.7022, 0.4781, 0.3586 \\
0.9363, 0.3511, 0.2390, 1.4343 \\
0.9363, 0.3511, 0.2390, 0.3586 \\
0.9363, 0.3511, 0.2390, 1.0757
\]

c. The Positive Ideal Solution \((A^+\)\)

\[
Y_i^+ = \max \{ 1.8727, 0.4682, 1.4045, 1.8727, 0.4682, 1.4045, 1.4045, 0.9363, 0.9363, 0.9363 \} \\
= \max \{ 1.8727 \} \quad \text{(And so on until } Y_i^+ \text{)}
\]

Solusi Ideal Positif \((A^+)\)

\[
Y_i^- = \min \{ 1.8727, 0.4682, 1.4045, 1.8727, 0.4682, 1.4045, 1.4045, 0.9363, 0.9363, 0.9363 \} \\
= \min \{ 0.4682 \} \quad \text{(And so on until } Y_i^- \text{)}
\]

d. The alternative distance is weighted with a positive ideal solution.

\[
D_i^+ = \sqrt{(1.8727 - 1.8727)^2 + (1.4045 - 1.4045)^2 + (0.7171 - 0.9562)^2 + (1.4343 - 1.4343)^2} \\
= \sqrt{(-0.2391)^2} \\
= 0.2391 \quad \text{(And so on until getting results } D_{10}^+ = 1.6214)\]

e. The alternative distance is weighted with a negative ideal solution.

\[
D_i^- = \sqrt{(1.8727 - 0.4682)^2 + (1.4045 - 0.3511)^2 + (0.7171 - 0.2390)^2 + (1.4343 - 0.3586)^2} \\
= \sqrt{(1.4045)^2 + (0.4782)^2 + (1.0757)^2} \\
= \sqrt{1.9726 + 0.2285 + 1.1571} \\
= \sqrt{4.4478} \\
= 2.1137 \quad \text{(And so on until getting results } D_{10}^- = 0.8563)\]

Result of \(D_i^+\): 0.2391; 1.7851; 1.0417; 0.5551; 1.6153; 0.9170; 1.4484; 1.5813; 1.7439; 1.6214

Result of \(D_i^-\): 2.1137; 1.1567; 1.2472; 1.7912; 1.0658; 1.2041; 1.0280; 1.1731; 0.5850; 0.8563

f. Preference value for each alternative

| Alternative | \(V_i\) | \(D_i^+\) | \(D_i^-\) |
|-------------|--------|--------|--------|
| 1           | 2.1137 | 0.8983 |       |
| 2           | 2.1137 | 0.3931 |       |
| 3           | 2.1137 | 0.5448 |       |
| 4           | 2.1137 | 0.7634 |       |
| 5           | 2.1137 | 0.3975 |       |
| 6           | 2.1137 | 0.6083 |       |
| 7           | 2.1137 | 0.4151 |       |
| 8           | 2.1137 | 0.4259 |       |
4. Conclusion

The TOPSIS method can recommend cities that are worthy of being Smart City. This study results that the city of Medan (Alternative 1) has the highest value in the feasibility of being a Smart City based city that is equal to 0.8983 or the highest compared to other alternatives.

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