Smart City Recommendations Using the TOPSIS Method

by Nurliana Nasution

Smart City Recommendations Using the TOPSIS Method

Smart City Recommendations Using the TOPSIS Method

Nurliana Nasution [1], Gita Widi Bhawika [2], Anjar Wanto [3], Ni Luh Wiwik Sri Rahayu Ginantra [4], Teuku Afriliansyah [5]

[1] Universitas Lancang Kuning, Pekanbaru - Indonesia
[2] Institut Teknologi Sepuluh Nopember, Surabaya - Indonesia
[3] STIKOM Tunas Bangsa, Pematangsiantar - Indonesia
[4] STMIK STIKOM Indonesia, Denpasar - Indonesia
[5] STKIP Bumi Persada Lhokseumawe, Aceh - Indonesia

* nurliananst@unilak.ac.id

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.

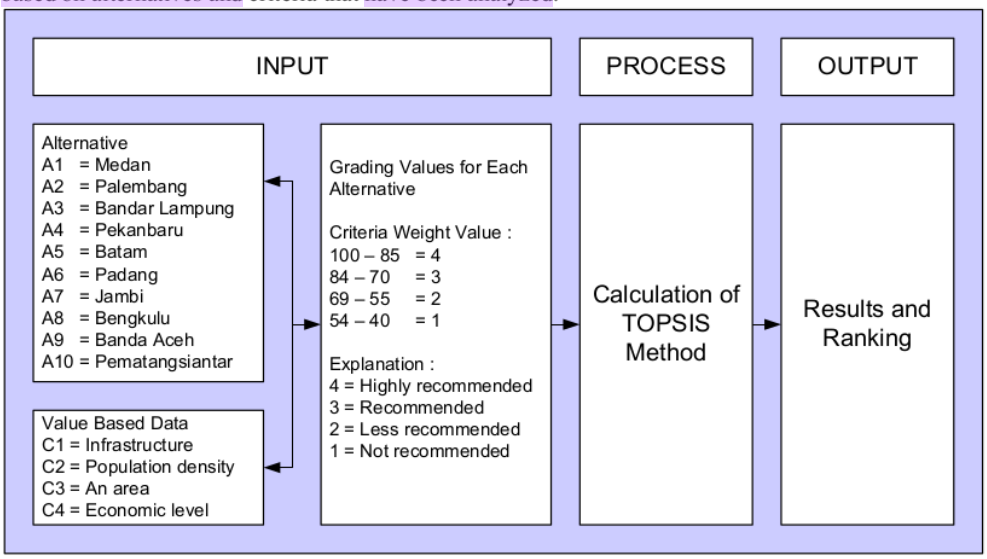

Figure 1. Stages of the TOPSIS Method

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.

Table 1. Alternative Value Criteria

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

Table 2. Alternative Criteria Weight Value

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

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

$X_1 = \sqrt{4^2 + 1^2 + 3^2 + 4^2 + 1^2 + 3^2 + 3^2 + 2^2 + 2^2 + 2^2} = \sqrt{73} = \mathbf{8,5440}$

$R_{1\,1} = \frac{4}{8,5440} = \mathbf{0,4682}$ $\quad R_{6\,1} = \frac{3}{8,5440} = \mathbf{0,3511}$

$R_{2\,1} = \frac{1}{8,5440} = \mathbf{0,1170}$ $\quad R_{7\,1} = \frac{3}{8,5440} = \mathbf{0,3511}$

$R_{3\,1} = \frac{3}{8,5440} = \mathbf{0,3511}$ $\quad R_{8\,1} = \frac{2}{8,5440} = \mathbf{0,2341}$

$R_{4\,1} = \frac{4}{8,5440} = \mathbf{0,4682}$ $\quad R_{9\,1} = \frac{2}{8,5440} = \mathbf{0,2341}$

$R_{5\,1} = \frac{1}{8,5440} = \mathbf{0,1170}$ $\quad R_{10\,1} = \frac{2}{8,5440} = \mathbf{0,2341}$

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

0,2341	0,1170	0,1195	0,4781
0,2341	0,2341	0,1195	0,1195
0,2341	0,1170	0,1195	0,3586

b. Normalized weight value. Matrix R Normalized W = 4, 3, 2, 3

$Y_{11} = 0{,}4682 \times 4 = \mathbf{1{,}8727}$ $Y_{61} = 0{,}3511 \times 4 = \mathbf{1{,}4045}$
$Y_{21} = 0{,}1170 \times 4 = \mathbf{04682}$ $Y_{71} = 0{,}3511 \times 4 = \mathbf{1{,}4045}$
$Y_{31} = 0{,}3511 \times 4 = \mathbf{1{,}4045}$ $Y_{81} = 0{,}2341 \times 4 = \mathbf{0{,}9363}$
$Y_{41} = 0{,}4682 \times 4 = \mathbf{1{,}8727}$ $Y_{91} = 0{,}2341 \times 4 = \mathbf{0{,}9363}$
$Y_{51} = 0{,}1170 \times 4 = \mathbf{04682}$ $Y_{101} = 0{,}2341 \times 4 = \mathbf{0{,}9363}$

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

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	0,7022	0,2390	0,3586
0,9363	0,3511	0,2390	1,0757

c. The Positive Ideal Solution (A^+)

Y_1^+ = Max { 1,8727, 0,4682, 1,4045, 1,8727, 0,4682, 1,4045, 1,4045, 0.9363, 0.9363, 0.9363 }
= Max {1,8727} (And so on until Y_4^+)

Solusi Ideal Positif (A^-)

Y_1^- = Min { 1,8727, 0,4682, 1,4045, 1,8727, 0,4682, 1,4045, 1,4045, 0.9363, 0.9363, 0.9363 }
= Min {0,4682} (And so on until Y_4^-)

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

$$D_1^+ = \sqrt{(1{,}8727 - 1{,}8727)^2 + (1{,}4045 - 1{,}4045)^2 + (0{,}7171 - 0{,}9562)^2 + (1{,}4343 - 1{,}4343)^2}$$
$$= \sqrt{(-0{,}2391)^2}$$
$$= \sqrt{0{,}0571}$$
$$= \mathbf{0{,}2391}$$ (And so on until getting results $D_{10}^+ = \mathbf{1{,}6214}$)

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

$$D_1^- = \sqrt{(1{,}8727 - 0{,}4682)^2 + (1{,}4045 - 0{,}3511)^2 + (0{,}7171 - 0{,}2390)^2 + (1{,}4343 - 0{,}3586)^2}$$
$$= \sqrt{(1{,}4045)^2 + (1{,}0534)^2 + (0{,}4782)^2 + (1{,}0757)^2}$$
$$= \sqrt{1{,}9726 + 1{,}1096 + 0{,}2285 + 1{,}1571}$$
$$= \sqrt{4{,}4678}$$
$$= \mathbf{2{,}1137}$$ (And so on until getting results $D_{10}^- = \mathbf{0{,}8563}$)

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; 1,4241; 1,0280; 1,1731; 0,5850; 0,8563

f. Preference value for each alternative

Alternative 1 $V_1 = \frac{2{,}1137}{2{,}1137 + 0{,}2391} = \frac{2{,}1137}{2{,}3528} = \mathbf{0{,}8983}$

Alternative 2 $V_2 = \frac{1{,}1567}{1{,}1567 + 1{,}7851} = \frac{1{,}1567}{2{,}9418} = \mathbf{0{,}3931}$

Alternative 3 $V_3 = \frac{1{,}2472}{1{,}2472 + 1{,}0417} = \frac{1{,}2472}{2{,}2889} = \mathbf{0{,}5448}$

Alternative 4 $V_4 = \frac{1{,}7912}{1{,}7912 + 0{,}5551} = \frac{1{,}7912}{2{,}3463} = \mathbf{0{,}7634}$

Alternative 5 $V_5 = \frac{1{,}0658}{1{,}0658 + 1{,}6153} = \frac{1{,}0658}{2{,}6811} = \mathbf{0{,}3975}$

Alternative 6 $V_6 = \frac{1{,}4241}{1{,}4241 + 0{,}9170} = \frac{1{,}4241}{2{,}3411} = \mathbf{0{,}6083}$

Alternative 7 $V_7 = \frac{1{,}0280}{1{,}0280 + 1{,}4484} = \frac{1{,}0280}{2{,}4764} = \mathbf{0{,}4151}$

Alternative 8 $V_8 = \frac{1{,}1731}{1{,}1731 + 1{,}5813} = \frac{1{,}1731}{2{,}7544} = \mathbf{0{,}4259}$

Alternative 9 $V_9 = \frac{0,5850}{0,5850+1,7439} = \frac{0,5850}{2,3289} = \mathbf{0,2511}$

Alternative 10 $V_{10} = \frac{0,8563}{0,8563+1,6214} = \frac{0,8563}{2,4777} = \mathbf{0,3456}$

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.

References

[1] A. Monzon, "Smart Cities Concept and Challenges," *2015 International Conference on Smart Cities and Green ICT Systems (SMARTGREENS)*, pp. 1–11, 2015.
[2] K. R. Kunzmann, "Smart cities: A new paradigm of urban development," *Crios*, vol. 7, pp. 9–19, 2014.
[3] F. Cicirelli, A. Guerrieri, G. Spezzano, and A. Vinci, "An edge-based platform for dynamic Smart City applications," *Future Generation Computer Systems*, vol. 76, pp. 106–118, 2017.
[4] A. Sharifi, *A typology of smart city assessment tools and indicator sets*, vol. 53. Elsevier B.V., 2020.
[5] J. Laufs, H. Borrion, and B. Bradford, "Security and the smart city: A systematic review," *Sustainable Cities and Society*, vol. 55, p. 102023, 2020.
[6] M. Berry, "Technology and organised crime in the smart city: an ethnographic study of the illicit drug trade," *City, Territory and Architecture*, vol. 5, no. 1, pp. 1–11, 2018.
[7] A. G. Reddy, D. Suresh, K. Phaneendra, J. S. Shin, and V. Odelu, "Provably Secure Pseudo-Identity Based Device Authentication for Smart Cities Environment," *Sustainable Cities and Society*, vol. 41, pp. 878–885, 2018.
[8] P. Chamoso, A. González-Briones, F. De La Prieta, G. K. Venyagamoorthy, and J. M. Corchado, "Smart city as a distributed platform: Toward a system for citizen-oriented management," *Computer Communications*, vol. 152, no. December 2019, pp. 323–332, 2020.
[9] C. Richter, S. Kraus, and P. Syrjä, "The Smart City as an opportunity for entrepreneurship," *International Journal of Entrepreneurial Venturing*, vol. 7, no. 3, pp. 211–226, 2015.
[10] R. Rahim *et al.*, "C4.5 Classification Data Mining for Inventory Control," *International Journal of Engineering & Technology*, vol. 7, pp. 68–72, 2018.
[11] I. Parlina *et al.*, "Naive Bayes Algorithm Analysis to Determine the Percentage Level of visitors the Most Dominant Zoo Visit by Age Category," *Journal of Physics: Conference Series*, vol. 1255, no. 1, 2019.
[12] I. S. Damanik, A. P. Windarto, A. Wanto, Poningsih, S. R. Andani, and W. Saputra, "Decision Tree Optimization in C4.5 Algorithm Using Genetic Algorithm," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–7, 2019.
[13] D. Hartama, A. Perdana Windarto, and A. Wanto, "The Application of Data Mining in Determining Patterns of Interest of High School Graduates," *Journal of Physics: Conference Series*, vol. 1339, no. 1, pp. 1–6, 2019.
[14] M. Widyastuti, A. G. Fepdiani Simanjuntak, D. Hartama, A. P. Windarto, and A. Wanto, "Classification Model C.45 on Determining the Quality of Custumer Service in Bank BTN Pematangsiantar Branch," *Journal of Physics: Conference Series*, vol. 1255, no. 012002, pp. 1–6, 2019.
[15] E. Siregar, H. Mawengkang, E. B. Nababan, and A. Wanto, "Analysis of Backpropagation Method with Sigmoid Bipolar and Linear Function in Prediction of Population Growth," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.
[16] G. W. Bhawika *et al.*, "Implementation of ANN for Predicting the Percentage of Illiteracy in Indonesia by Age Group," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.
[17] W. Saputra, J. T. Hardinata, and A. Wanto, "Resilient method in determining the best architectural model for predicting open unemployment in Indonesia," *IOP Conference Series: Materials Science and Engineering*, vol. 725, no. 1, pp. 1–7, 2020.
[18] A. Wanto and J. T. Hardinata, "Estimations of Indonesian poor people as poverty reduction efforts

facing industrial revolution 4 . 0," *IOP Conference Series: Materials Science and Engineering*, vol. 725, no. 1, pp. 1–8, 2020.

[19] A. Wanto *et al.*, "Model of Artificial Neural Networks in Predictions of Corn Productivity in an Effort to Overcome Imports in Indonesia," *Journal of Physics: Conference Series*, vol. 1339, no. 1, pp. 1–6, 2019.

[20] A. Wanto *et al.*, "Analysis of the Accuracy Batch Training Method in Viewing Indonesian Fisheries Cultivation Company Development," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.

[21] I. S. Purba *et al.*, "Accuracy Level of Backpropagation Algorithm to Predict Livestock Population of Simalungun Regency in Indonesia Accuracy Level of Backpropagation Algorithm to Predict Livestock Population of Simalungun Regency in Indonesia," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.

[22] A. Wanto *et al.*, "Analysis of the Backpropagation Algorithm in Viewing Import Value Development Levels Based on Main Country of Origin," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.

[23] S. Setti, A. Wanto, M. Syafiq, A. Andriano, and B. K. Sihotang, "Analysis of Backpropagation Algorithms in Predicting World Internet Users," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.

[24] M. K. Z. Sormin, P. Sihombing, A. Amalia, A. Wanto, D. Hartama, and D. M. Chan, "Predictions of World Population Life Expectancy Using Cyclical Order Weight / Bias," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.

[25] A. Wanto *et al.*, "Forecasting the Export and Import Volume of Crude Oil , Oil Products and Gas Using ANN," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–6, 2019.

[26] P. P. P. A. N. . F. I. R.H Zer, Masitha, A. P. Windarto, and A. Wanto, "Analysis of the ELECTRE Method on the Selection of Student Creativity Program Proposals," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–7, 2019.

[27] A. P. W. Budiharjo and A. Muhammad, "Comparison of Weighted Sum Model and Multi Attribute Decision Making Weighted Product Methods in Selecting the Best Elementary School in Indonesia," *International Journal of Software Engineering and Its Applications*, vol. 11, no. 4, pp. 69–90, 2017.

[28] D. R. Sari, N. Rofiqo, D. Hartama, A. P. Windarto, and A. Wanto, "Analysis of the Factors Causing Lazy Students to Study Using the ELECTRE II Algorithm," *Journal of Physics: Conference Series*, vol. 1255, no. 012007, pp. 1–6, 2019.

[29] K. Fatmawati *et al.*, "Analysis of Promothee II Method in the Selection of the Best Formula for Infants Under Three Years," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–7, 2019.

[30] P. Alkhairi, L. P. Purba, A. Eryzha, A. P. Windarto, and A. Wanto, "The Analysis of the ELECTREE II Algorithm in Determining the Doubts of the Community Doing Business Online," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–7, 2019.

[31] S. Sundari, Karmila, M. N. Fadli, D. Hartama, A. P. Windarto, and A. Wanto, "Decision Support System on Selection of Lecturer Research Grant Proposals using Preferences Selection Index," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–7, 2019.

[32] S. R. Ningsih, R. Wulansari, D. Hartama, A. P. Windarto, and A. Wanto, "Analysis of PROMETHEE II Method on Selection of Lecturer Community Service Grant Proposals," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–7, 2019.

[33] T. Imandasari, M. G. Sadewo, A. P. Windarto, A. Wanto, H. O. Lingga Wijaya, and R. Kurniawan, "Analysis of the Selection Factor of Online Transportation in the VIKOR Method in Pematangsiantar City," *Journal of Physics: Conference Series*, vol. 1255, no. 1, pp. 1–7, 2019.

[34] C. Zheng, J. Yuan, L. Zhu, Y. Zhang, and Q. Shao, "From Digital to Sustainable : A Scientometric Review of Smart City Literature between 1990 and 2019," *Journal of Cleaner Production*, pp. 1–51, 2020.

[35] M. W. Wathne and H. Haarstad, "The smart city as mobile policy: Insights on contemporary urbanism," *Geoforum*, vol. 108, no. February 2019, pp. 130–138, 2020.

[36] M. Lom and O. Pribyl, "International Journal of Information Management Smart city model based on systems theory," *International Journal of Information Management*, no. February 2019, pp. 1–11, 2020.

Smart City Recommendations Using the TOPSIS Method

ORIGINALITY REPORT

20%	14%	23%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universitas Negeri Semarang Student Paper	6%
2	Ni Luh Wiwik Sri Rahayu Ginantra, Gita Widi Bhawika, Ahmad Zamsuri, Fadjar Budianto, GS Achmad Daengs. "Decision Support System in Recommending Climbing Tourism Destinations with Profile Matching Method", IOP Conference Series: Materials Science and Engineering, 2020 Publication	5%
3	www.mdpi.com Internet Source	3%
4	iopscience.iop.org Internet Source	3%
5	Franco Cicirelli, Antonio Guerrieri, Giandomenico Spezzano, Andrea Vinci. "An edge-based platform for dynamic Smart City applications", Future Generation Computer Systems, 2017 Publication	3%

Exclude quotes	On	Exclude matches	< 3%
Exclude bibliography	On		