Fuzzy AHP TOPSIS Method Based TrFN for New Normal Problem

Eko Y Utomo, Titi Udjiani, Bambang Irawanto and Bayu Surarso

November 21, 2020

Fuzzy AHP TOPSIS Method based TrFN for New Normal Problem

E Y Utomo, T Udjiani, B Irawanto and B Surarso

Matematika FSM, Universitas Diponegoro
Jl. Prof. H. Soedarto, S.H, Tembalang, Semarang

ekoyunantoutomo@students.undip.ac.id

bsurarso@gmail.com

Abstract. The Corona virus disease (Covid-19) pandemic is a multi-dimensional crisis that attacks a country in various fields, such as health and the economy. This is also felt by Indonesia, which has carried out an emergency response period for handling Covid. The Indonesian government is working on the New Normal program. However, to ensure the success of the program, the readiness of each region is needed to implement it. Research on the readiness of an area was conducted using the Fuzzy Analytical Hierarchy Process (AHP) and Fuzzy Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method. Fuzzy AHP is used to calculate the weight for each criterion, while fuzzy TOPSIS is used to examine the readiness and safety of an area to implement the new normal. Both of these methods use Trapezoidal Fuzzy Number (TrFN). The case study in this research is Central Java Province, with the alternative regency and city. The criteria used are the number of positive patients who recover, are treated, died and suspect. The result can be seen that the more patients who recover, the area will be ready to implement the new normal program.

1. Introduction

The Covid-19 pandemic is a multidimensional crisis that comes fast and attacks a country in various fields, such as health and the economy [1]. This is also felt by Indonesia, as one of the countries with the largest population in the world. Indonesia has implemented an emergency response period for handling covid since early March 2020, then modified the regional quarantine policy to become Large-Scale Social Restrictions. After 3 months, the new normal program was started [2]. The new normal program aims to run the wheels of the economy, but still pay attention to existing health protocols. However, an obstacle arises from this program, namely the readiness of each region. Readiness was assessed based on the number of positive patients who were treated, died, recovered, and residents suspected of being exposed to Covid 19. Then these four things were used as the criteria for this study. While the methods used are Fuzzy Analytic Hierarchy Process (AHP) and Fuzzy Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) to assist in decision making whether an area is ready to carry out the new normal.

There are several methods for finding weights, but AHP has several advantages. One of its advantages is based on binary comparisons (pairwise) [3]. The use of conventional AHP is not sufficient to provide the right solution in this weighting problem [4]. By adding fuzzy to the AHP method, the relative importance is represented by fuzzy numbers and can reflect uncertainty as accurately as possible [5]. Finding the weight value of each criterion using Fuzzy AHP has been carried out in previous studies [6-9]. So that AHP can be used to find the weight of this problem. Whereas TOPSIS is a method that has two alternatives which are defined as a positive ideal solution and a negative ideal [10]. This method is based on the concept that the positive ideal alternative has the best level for all attributes, while the negative ideal is the alternative with all the worst attribute values [11]. The weakness of this method appears ambiguity, uncertainty and ambiguity in decision making which cannot be resolved only with the value of crips [12]. Adding fuzzy set theory to the TOPSIS method can help the taker to calculate better results and free from errors due to obscurity [13]. So that the combination of Fuzzy AHP and Fuzzy TOPSIS will be used for new normal problems.

In [14], Zhu et al used fuzzy rough numbers in the AHP and TOPSIS methods to determine the product design concept in an uncertain environment. In [15], Yousefzadeh et all compared five hydrometallurgical processes to recover copper from PCB by adopting a central composite design using Fuzzy AHP and TOPSIS methods. In [16], Sirisawat et al classified the constraints of reverse logistic and obstacle ranking using Fuzzy AHP and Fuzzy TOPSIS methods. In [17], Vinodh et all used the AHP-TOPSIS fuzzy method to select the best plastic recycling method. In [18], Chang et al used the AHP-TOPSIS hybrid method to determine protection priorities for the coastal environment in the Miaoli Coast, Taiwan. In [19], Barrios et all used Multi Criteria Decision Making (MCDM) to evaluate the readiness of hospitals to deal with disasters. In [20], Albahri et al used MCDM to determine the best healing plasma transfusion in most critically ill patients. In [21], we discussed the new normal program using the Fuzzy AHP and Fuzzy TOPSIS methods. We used the Triangular Fuzzy Number (TFN), while in the current study using Trapezoidal Fuzzy Number (TrFN). We expect that by using TrFN will get results that are close to the actual conditions. So based on previous research, TrFN in the MCDM method can be used to assist the decision maker in New Normal problem.

2. Method

In this study, the variables used are the number of positive Covid-19 patients who recovered, died, and are still being treated and the number of residents suspected of Covid-19 was added. The data used are obtained from the corona.jatengprov.go.id website and the data used is on October 20, 2020. From Figure 1 it can be seen the steps to carry out the calculations as follows:

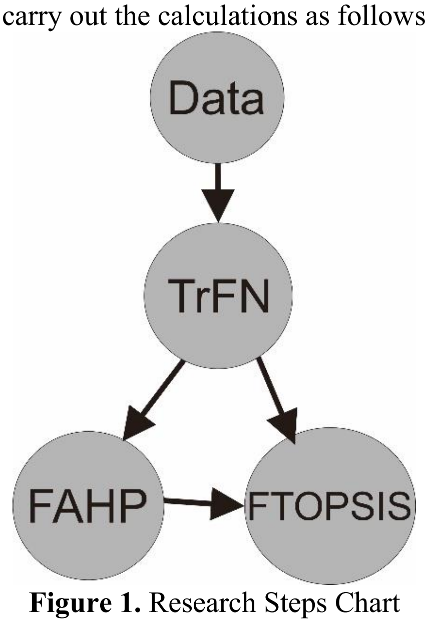

Figure 1. Research Steps Chart

2.1. Trapezoidal Fuzzy Number

A trapezoidal fuzzy number $\tilde{A}$ can be define as $\tilde{A} = \{a, b, c, d\}, 0 \leq a \leq b \leq c \leq d$, if the membership function $\mu_{\tilde{A}}: R \to [0,1]$ is defined as follows [22]:

$$\mu_{\tilde{A}} = \begin{cases} \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \\ 0, & others \end{cases} \quad (1)$$

2.2. Fuzzy AHP

The following are the calculation steps to find the weight of each criterion for the new normal problem [17,22]:

2.2.1. Step 1. Determine the best alternative among existing alternatives by considering the criteria to be used. The selection of the best alternative will be based on the construction of a hierarchical system.

2.2.2. Step 2. Determination of the weight that will use the trapezoidal fuzzy number. With fuzzy linguistics, namely "equal", "moderate", "strong", "very strong" and "extremely strong". With the values as follows*: (1,1,2,3);(2,3,4,5);(4,5,6,7);(6,7,8,9);(8,9,9,9).*

2.2.3. Step 3. Determines weights for each criterion used. Determination of the weights for each criterion involves the following steps 1) A matrix of pairwise comparisons showing the preference of one criterion over another is constructed by entering the values judged by the decision maker. Because the value is linguistic, it will be entered into a trapezoidal fuzzy number. 2) The synthetic pairwise comparison matrix calculated using the geometric mean method r_i is defined as follows

$$r_i = \left(a_{ij}^1 \times a_{ij}^2 \times a_{ij}^3 \times a_{ij}^4\right)^{1/4} \quad (2)$$

2.2.4. Step 4. Weights for each criterion are determined. This is done by normalizing the matrix

$$w_i = r_i \times (r_1 + r_2 + r_3 + \cdots + r_n)^{-1} \quad (3)$$

2.3. Fuzzy TOPSIS

The following are the calculation steps using the Fuzzy TOPSIS method [23,24,25]:

2.3.1. Step 1. Determine suitable alternatives, to evaluate criteria and establish a group of decision makers. Assume that there are alternatives, criteria and decision makers.

2.3.2. Step 2. Determine the appropriate linguistic variables for each criterion weight ($\widetilde{W}_j = a_{ij}, b_{ij}, c_{ij}, d_{ij}$) dan and linguistic rankings for alternatives related to the criteria $\tilde{X}_{ij}$ as a trapezoidal fuzzy number.

2.3.3. Step 3. Gabungkan bobot kriteria untuk mendapatkan bobot fuzzy agregat $\widetilde{w}_j$ dari kriteria C_j dan agregat peringkat fuzzy dari alternatif A_i dengan kriteria C_j yang telah dievaluasi dengan menggunakan fuzzy AHP

$$\tilde{X}_{ij} = \frac{1}{k}\left[\tilde{X}_{ij}^1 + \tilde{X}_{ij}^2 + \cdots + \tilde{X}_{ij}^k\right] \quad ; i = 1,2, \dots, m ; j = 1,2, \dots, n \quad (4)$$

$$\widetilde{W}_j = \frac{1}{k}\left[\widetilde{W}_j^1 + \widetilde{W}_j^2 + \cdots + \widetilde{W}_j^k\right] \quad ; j = 1,2, \dots, n \quad (5)$$

2.3.4. Step 4. Perform fuzzy decision matrix construction.

$$.\ \tilde{D} = \begin{bmatrix} \tilde{X}_{11} & \tilde{X}_{12} & \dots & \tilde{X}_{1n} \\ \tilde{X}_{21} & \tilde{X}_{22} & \dots & \tilde{X}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{X}_{m1} & \tilde{X}_{m2} & \dots & \tilde{X}_{mn} \end{bmatrix} \tilde{W} = [\tilde{w}_1 . \tilde{w}_2, \dots, \tilde{w}_n] \quad (6)$$

2.3.5. Step 5. Normalizing the fuzzy decision matrix ($\bar{R}$).

$$\bar{R} = \left[\bar{r}_{ij}\right]_{mxn}, i = 1,2, \dots, m\, ; j = 1,2, \dots, n \quad (7)$$

The formula can be written more clearly as follows:

$$\bar{r}_{ij}^{*} = \left(\frac{a_{ij}}{U_j^*}, \frac{b_{ij}}{U_j^*}, \frac{c_{ij}}{U_j^*}, \frac{d_{ij}}{U_j^*}\right), when\ U_j^* = max\ d_{ij} \quad (8)$$

$$\bar{r}_{ij}^{-} = \left(\frac{U_j^-}{d_{ij}}, \frac{U_j^-}{c_{ij}}, \frac{U_j^-}{b_{ij}}, \frac{U_j^-}{a_{ij}}\right), when\ U_j^* = min\ a_{ij} \quad (9)$$

2.3.6. Step 6. Normalize the weighting of the fuzzy decision matrix.

$$\bar{V} = \left[\tilde{V}_{ij}\right]_{mxn}, i = 1,2, \dots, m;\ j = 1,2, \dots, n \quad (10)$$

When $\tilde{V}_{ij} = \tilde{r}_{ij} . \tilde{w}_j, i = 1,2, \dots, m; j = 1,2, \dots, n$

2.3.7. Step 7. Looking for a positive ideal solution value *(S^+)* and fuzzy negative ideal solution *(S^-).*

$$S^+ = (\tilde{V}_1^+, \tilde{V}_2^+, \dots, \tilde{V}_n^+) \quad (11)$$

$$S^- = (\tilde{V}_1^-, \tilde{V}_2^-, \dots, \tilde{V}_n^-) \quad (12)$$

When $\tilde{V}_j^+ = max\{v_{ij4}\}$ dan $\tilde{V}_j^- = \min(v_{ij1})$ with $\tilde{V}_j$ is the weighting normalization for Trapezoidal Fuzzy Number.

$$i = 1,2, \dots, m;\ j = 1,2, \dots, n$$

2.3.8. Step 4. Perform distance calculation for each alternative from the fuzzy positive ideal solution *(d^+)* and fuzzy negative ideal solution *(d^-).*

$$d(A_1, A_2) = \sqrt{\frac{1}{6}[(a_1 - a_2)^2 + 2(b_1 - b_2)^2 + 2(c_1 - c_2)^2 + +(d_1 - d_2)^2]} \quad (13)$$

$$d_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^+), i = 1,2, \dots, m$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), i = 1,2, \dots, m$$

2.3.9. Step 9. Calculation the Closeness Coefficient (CC_i) and find a rating for each alternative.

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, i = 1,2, \dots, m \quad (14)$$

Based on the value of the proximity coefficient for each alternative, the highest coefficient of proximity is the best for this method.

3. Result and Discussion

In this study, the data were processed using the Fuzzy Analytical Hierarchy Process (AHP) method to find the weight value for each criterion. By using step 1 of the Fuzzy AHP method, the criteria to be studied are positive patients who are recover, treated, died and suspected. To perform calculations using this method, the data must first be equivalent to the following three criteria:

$$Recover = \frac{Number\ of\ Heal}{Total\ Positive\ Patients}$$

$$Dead = \frac{Number\ of\ Dead}{Total\ Positive\ Patients}$$

$$Treated = \frac{Number\ of\ Treated}{Total\ Positive\ Patients}$$

with total positive patients is the number of patients recovered, patients died and patients who are still being treated. In step 2, determine the initial weight values using TrFN and fuzzy language. Furthermore, using step 3, paired comparisons were carried out for each criterion which can be seen in Table 1.

Table 1. Pairwise Comparison of Each Criterion

Criteria	Treated	Recover	Dead	Suspect
Treated	(1,1,2,3)	(0.11,0.125,0.14,0.16)	(0.14,0.16,0.2,0.25)	(0.2,0.25,0.33,0.5)
Recover	(6,7,8,9)	(1,1,2,3)	(2,3,4,5)	(4,5,6,7)
Dead	(4,5,6,7)	(0.2,0.25,0.33,0.5)	(1,1,2,3)	(2,3,4,5)
Suspect	(2,3,4,5)	(0.14,0.16,0.2,0.25)	(0.2,0.25,0.33,0.5)	(1,1,2,3)

Next look for value r_i by using (2). Then on Step 4 we will look for weights for each criterion by substituting the value r_i to (3), so that the value is obtained as in Table 2.

Table 2. Weights of Each Criteria for Fuzzy AHP Calculation Results

Criteria	Weight
Treated	(0.0245,0.035,0.0678,0.1114)
Recover	(0.2721,0.4186,0.8114,1.2369)
Dead	(0.1162,0.182,0.445,0.6005)
Suspect	(0.0504,0.0776,0.1562,0.2076)

Furthermore, the weight value will be used in the Fuzzy TOPSIS method to find areas that are safe or ready to implement the New Normal program. The data to be used is data on Covid-19 patients on October 20, 2020 and there are 35 alternatives which are districts and cities in Central Java Province. The first step is to determine fuzzy linguistics for each criterion and its weight value. This is done to change the crisp value to the Trapezoidal Fuzzy Number form. The trapezoidal Fuzzy Number used is divided into 5 levels of membership degrees, namely, very low (1,1,2,3), low (2,3,4,5), medium (4,5,6,7), high (6 , 7,8,9), and very high (8,9,9,9). After knowing the value for each criterion, it will be continued using (7). Before doing normalization, it is necessary to determine the criteria including the benefits or costs. The criteria included in the cost are Treated, Dead and Suspect, normalized using (9), while Recover is included in the benefit criteria so that normalization is carried out using (8).

Next, multiplying the weight of the Fuzzy AHP calculation with the normalized results using (10). From this product, the value of the ideal positive solution (S^+) and the ideal solution (S^-) will be sought for each criterion. The positive ideal solution is the highest value of a criterion, while the negative ideal solution is the lowest value of the criterion. So that then the distance from each alternative will be sought on each criterion of the positive and negative ideal solutions by using (13). The alternative distance with a positive ideal solution is denoted by d_i^+ and the distance with a positive ideal solution is denoted by d_i^-. In this case the distance is written in the form of a crisp number. Next, we will look for the Closeness Coefficient (CC) value using (14), so that the results are obtained in Table 3.

Table 3. CC Value

District/City	CC Value	District/City	CC Value	District/City	CC Value
Kota Semarang	0,673188	Kota Magelang	1	Kota Pekalongan	0,797204
Kudus	0,729395	Sragen	0,797204	Pemalang	0,729395
Jepara	0,867094	Cilacap	0,510847	Brebes	0,669419
Demak	0,732171	Purworejo	0,867094	Pekalongan	0,797204
Kendal	0,732171	Kota Surakarta	0,797204	Banjarnegara	0,797204
Semarang	0,729395	Karanganyar	0,669419	Tegal	0,732171
Kebumen	0,669419	Temanggung	0,729395	Kota Tegal	0,857575
Wonosobo	0,606144	Blora	0,729395	Purbalingga	0,797204
Boyolali	1	Banyumas	0,797204	Wonogiri	0,732171
Sukoharjo	0,729395	Pati	0,438197	Rembang	1
Magelang	0,857575	Grobogan	0,729395	Kota Salatiga	0,867094
Klaten	0,867094	Batang	0,797204		

From Table 3, it can be seen that there are 3 regions that have a CC = 1 value, which means that these areas are ready to implement the new normal program with the health protocol. For example, the city of Magelang is one of the areas that is ready. Because, Magelang has a small number of positive patients treated, namely only 11 people from the total positive patients is 238 people. As well as the large number of positive patients who recovered with a percentage of 88.23% of the total positive patients. Meanwhile, for CC values above 0.8, the New Normal program can be implemented but further supervision and consideration is still needed. For areas with a CC value below 0.8, it is not recommended to implement the New Normal program, and it is more advisable to implement restrictions on activities outside the home. Pati had the lowest CC value, this was due to the large percentage of positive patients who died, namely 16.07% and had quite a lot of suspects, namely 178 people. More and more positive patients died, indicating that the area is still not ready to handle the Covid-19 problem, so it is better not to carry out a new normal.

4. Conclusion

This research has provided information about districts or cities that are feasible to implement the new normal program using the Fuzzy AHP and Fuzzy TOPSIS methods. The results of the Fuzzy TOPSIS method show that only 3 regions are ready to implement the program based on data on October 20, 2020, as well as several regions that are still under consideration. This consideration can be seen from the CC calculation on the following day. From the results it can be seen that if the cost criterion has a large value, then the area is not ready to implement the new normal program. Meanwhile, the benefit criteria, namely positive patients who recovered, had a major influence in making this decision. This is because the large percentage of recovered patients shows that the local government and medical personnel are able to handle the spread of Covid-19.

References

[1] Modjo M I 2020 Memetakan jalan penguat ekonomi pasca pandemi *The Indonesian Journal of Development Planning* **4** 103-116

[2] Muhyuddin 2020 Covid-19, New normal dan perencanaan pembangunan di Indonesia *The Indonesian Journal of Development Planning* **4** 240-252

[3] Dadras M, Shafri H Z M, Ahmad N, Pradhan B and Safarpour S 2014 A combined fuzzy MCDM approach for identifying the suitable lands for urban development: An example from Bandar Abbas, Iran *Journal of Urban and Environmental* **8** 11-27

[4] Singh A K, Avikal S, Kumar N K C, Kumar Manish and Thakura P 2020 A fuzzy AHP and M-TOPSIS based approach for selection of composite materials used in structural applications

Materials Today: Proceedings **26** 3119-3123
[5] Lyu H M, Zhou W H, Shen S L and Zhou A N 2020 Inundation risk assessment of metro system using AHP and TFN-AHP in Shenzhen *Sustainable Cities and Society* **56** 102103
[6] Khan A A, Shameem M, Kumar R R, Hussain S and Yan X 2019 Fuzzy AHP based prioritization and taxonomy of software process improvement success factors in global software development *Applied Soft Computing Journal* **83** 105648
[7] Liu R, Wang Y and Qian Z 2019 Hybrid SWOT-AHP analysis of strategic decisions of coastal tourism a case study of Shandong Peninsula blue economic zone *Journal of Coastal Research* **94** 671-676
[8] Achu A L, Thomas J and Reghunath R 2020 Multi criteria decision analysis for delineation of ground potential zones in tropical river basin using remote sensing, GIS and analytical hierarchy process (AHP) *Groundwater for Sustainable Development* **10** 100365
[9] Teng Y M, Wu K S and Wang M J 2020 Using the analytic hierarchy process (AHP) and delphi analysis to evaluate key factors in the development of the Taiwan cruise tourism industry *Journal of Coastal Research* **36** 828-833
[10] Rouyendegh B D and Saputro T E 2014 Supplier selection using integrated fuzzy TOPSIS and MCGP: a case study *5th World Conference on Educational Sciences WCES 2013* **116** 3957-3970
[11] Lee G, Min B I and Jun K S 2016 Multi criteria surge vulnerability assessment with long-term reanalysis *Journal of Coastal Research* **75** 1172-1176
[12] Rajak M and Shaw K 2019 Evaluation and selection of mobile health (mHealth) applications using AHP and fuzzy TOPSIS *Technology in Society* **59** 101186
[13] Mathew M, Chakrabority R K and Ryan M J 2020 A novel approach integrating AHP and TOPSIS under spherical fuzzy sets for advanced manufacturing system selection *Engineering Applications of Artificial Intelligence* **96** 103988
[14] Zhu G N, Hu J, and Ren H 2020 A fuzzy rough number based AHP-TOPSIS for design concept evaluation under uncertain environments *Applied Soft Computing Journal* **91** 106228
[15] Yousefzadeh S, Yaghmaeian K, Mahvi A H, Nasseri S, Alavi N and Nabizadeh R 2020 Comparative analysis of hydrometallurgical methods for the recovery of Cu from circuit boards: Optimization using response surface and selection of the best technique by two step fuzzy AHP-TOPSIS method *Journal of Cleaner Production* **249** 119401
[16] Sirisawat P and Kiatcharoenpol T 2018 Fuzzy AHP-TOPSIS approaches to prioritizing solutions for reverse logistics barriers *Computers & Industrial Engineering* **117** 303-318
[17] Vinodh S, Prasanna M and Prakash N H 2014 Integrated fuzzy AHP-TOPSIS for selecting the best plastic recycling method: A case study *Applied Mathematical Modelling* **38** 4662-4672
[18] Chang H K, Liou J C and Chen W W 2012 Protection priority in the coastal environment using a hybrid AHP-TOPSIS method on the Miaoli Coast, Taiwan *Journal of Coastal Research* **28**
[19] Barrios M O, Gul M, Meza P L, Yucesan M and Jimenez E 2020 Evaluation of hospital disaster preparedness by a multi criteria decision making approach: The case of Turkish hospitals *International Journal of Disaster Risk Reduction* **49** 101748
[20] Albahri O S, Al-Obaidi J R, Zaidan A A, Albahri A S, Zaidan B B, Salih M M, Qays A, Dawood K A, Mohammed R T, Abdulkareem K H, Aleessa A M, Alamoodi A H, Chyad M A and Zulkifli C Z 2020 Helping doctor hasten COVID-19 treatment: Towards a rescue framework for the transfusion of best convalescent plasma to the most critical patients based on biological requirements via ml and novel MCDM methods *Computer Methods and Programs in Biomedicine* **196** 105617
[21] Utomo E Y, Udjiani T and Surarso B 2020 Application of fuzzy AHP and fuzzy TOPSIS methods for the new normal problem *ISNPINSA* **10**
[22] Li G, Kou G, Lin C, Xu L and Liao Y 2015 Multi attribute decision making with generalized fuzzy numbers *Journal of the Operational Research Society* **46** 1793-1803
[23] Wang Y M and Elhag T M S 2006 Fuzzy TOPSIS method based on alpha level sets with an

application to bridge risk assessment *Expert Systems with Application* **31** 309-319
[24] Malakouti M, Faizi M, Hosseini S B and Maleki S N 2019 Evaluation of flexibility components for improving housing quality using fuzzy TOPSIS method *Journal of Building Engineering* **22** 154-160
[25] Dong J Y and Wan S P 2016 Virtual enterprise partner selection integrating LINMAP and TOPSIS *Journal of the Operational Research Society* **67** 1288-1306