IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Fuzzy TOPSIS Decision Making Model for the prevention of spreading diseases like COVID-19

[1]Sk Mustak Ahmed,
[1]Assistant Professor,
Department of Commerce,
[1]Bangabasi Morning College, Kolkata, India

Abstract : In the year 2020-2022, the Novel Coronavirus (COVID-19) has become a crucial health concern that causes serious health problems in human beings and has become a pandemic. So, preventing the spread of COVID-19 in the community is a very difficult task then. In this article, we propose the current COVID-19 prevention problem in India as a multi-criteria decision-making (MCDM) problem and implement the fuzzy TOPSIS method to solve the problem. In our study, for MCDM, we choose some states in India as alternatives and select a few measures to prevent the spread of COVID-19 as criteria. Based on the available data, we determine the best alternative to the proposed MCDM problem.

IndexTerms **-COVID-19, Prevention, TOPSIS, Fuzzy sets..**

I. INTRODUCTION

1.INTRODUCTION

A large family of viruses, called coronaviruses, is causing serious problems to human beings all over the world in that time. Since the discovery of the COVID-19 (one type of coronavirus) in the Chinese city Wuhan in the last month of 2019, it has been spreading rapidly. After that COVID-19 infection has been reported so far in more than 200 countries and territories around the word [1]. Coronavirus can cause cold and more serious diseases such as MERS and SARS [2]. COVID-19 is a new type of coronavirus which has never been found in human and animal before. Common symptoms of a person infected with COVID-19 include shortness of breath, fever, cough and dyspnea although in some cases the people infected with COVID-19 have no symptoms. In more severe cases, infection can lead to pneumonia, acute respiratory syndrome, kidney failure and even death [3]. The death rate of the patient infected with COVID-19 is very low, but it is spreading rapidly in many countries with a chain that is a cause of fear. In February 2020, a positive patient for COVID-19 was first found in India. After two months, a large number of people have been infected with COVID-19 in many states of India. COVID- 19 had created a pandemic situation in India because the population density of India is very high compared to other countries. Government of India had taken some steps to break the chain of spreading COVID-19 and prevent the disease. As an early measure to prevent the spread of the disease, the Government of India implemented a lockdown and people were not allowed to leave their homes unless it was extremely essential. All public transports including airports, trains, metro and public buses were stopped during lockdown. Government of India had also taken decision of rapid testing of COVID-19 cases and arranged to send positive COVID-19 patients to isolation and quarantine along with their family members to break the chain of spreading COVID-19. Following WHO,ICMR (Indian Council of Medical Research) published a guideline which states that every one should wear mask, maintain the social distancing and use sanitizer as much as possible to prevent COVID-19 transmission. For the front line workers like doctors, nurses, medial staffs, health workers and police forces, Government had provided PPE, maskand other medical kits for them. Needless to say, some states of India are performing better to control the spreading of COVID-19 while some states' performance not up to the mark. Hence, selecting the best measure for preventing the spreading of COVID-19 is an important and challenging task for the decision makers at that moment. In this study, we propose the COVID-19 prevention problem in India as a multi-criteria decision making (MCDM) problem and implement fuzzy TOPSIS method to solve the problem. In our study, for MCDM, we choose some states of India as alternatives and select a few measures such as 'lockdown', 'rapid testing', 'social distancing in gathering places', 'protection of frontline worke 'sanitization' and 'population density' for prevention of spreading of COVID-19 as criteria. Multi-criteria decision making (MCDM) is an important field of study in decision analysis. MCDM refers to making choice of the best alternative from a finite set of decision alternatives. MCDM problem is very common in Operations Research, Management Science, medical diagnosis, data mining, etc. There are many classical MCDM methods to determine the best alterative with respect to the criteria which are known precisely. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [4] is one of the accepted classical MCDMtechniques among other MCDM techniques like Preference Ranking Organization METHod for Enrichment of Evaluations (PROMETHEE) [5], VIKOR [6], ELimination Et Choix Traduisant la REalit´e (ELECTRE) [7] etc. The fundamental idea of

TOPSIS is that the chosen alternative should have the closest distance from the best ideal solution and the farthest distance from the worst ideal solution. There exist a huge literature based on TOPSIS theory and its application in many branches of science and technology. Lai et al. [8] proposed TOPSIS method for MODM problem. Abo-Sinna and Amer [9] developed TOPSIS method to solve multi-objective large scale non-linear problem. TOPSIS method has also been widely used in the literature for solving various multi-criteria decision making problems [10 – 14]. In TOPSIS method, the steps to find the optimal alternative involve distance measure of the relative important criteria, performance of each alternative to these criteria, etc. However, the criteria value may be difficult to determine since human judgement is often uncertain and incomplete under many conditions. Fuzzy theory can be useful in this regard. TOPSIS method has also been developed under fuzzy [15] environment. Fuzzy TOPSIS method is a natural generalization of TOPSIS method [16,17]. Recently TOPSIS method has been studied under generalized fuzzy sets like intutationistic fuzzy sets [18], neutrosophic sets [19], Pythagorean fuzzy sets, etc. [20], [21 – 25]. Chen and Taso [26] developed TOPSIS method under interval valued fuzzy sets. They applied fuzzy TOPSIS method for experimental analysis. Chen [16] extended the TOPSIS method for multicriteria group decision making problem under fuzzy environment. Wang and Elhg [27] extended fuzzy TOPSIS method on alpha level sets for bridge risk assessment. Chen [28] proposed fuzzy TOPSIS method with leniency reduction. Prabhu et al. [29] proposed the TOPSIS method with interval-valued triangular fuzzy number for segmenting the manufacturing industries and measuring the performance. In this paper, we use fuzzy TOPSIS method with triangular fuzzy number to solve the proposed MCDM problem. The originality of this research comes from prevention of COVID-19 problem which is treated as multi-criteria decision making problem. Since the criteria like 'lockdown', 'rapid testing', 'social distancing in gathering places', 'protection of frontline workers' like doctors, nurses and health workers have lot of uncertainties and incompleteness for appropriate application, so we use triangular fuzzy number as a criteria value and determine distance measure of triangular fuzzy number for TOPSIS method. The remainder of the article is organised as follows. Section 2 gives preliminaries of TOPSIS method and fuzzy sets. Section 3 formulated the proposed MCDM problem using fuzzy TOPSIS method. A numerical study is conducted in Section 4 followed by discussion in Section 5. Finally, in section 6, the paper is concluded with some remarks.

2 Preliminaries

2.1 TOPSIS method

TOPSIS (Technique for order preference by similarity to ideal solution) is one of the best acceptable MCDM techniques in crisp as well as uncertain environment. This method considers positive and negative ideal solutions. The best alternative is the one which is closest to the positive ideal solution and farthest from the negative ideal solution. Consider an MCDM problem in which A1,A2, ...,An are alternatives and each alternative has m criteria C1,C2, ...,Cm. All the rating values of the alternatives with respect to the criteria form a decision matrix given by X = (xij). Let the weights of the alternatives be { w1,w2, ...,wn } so that
Then the TOPSIS method can be described by the following steps:

Step 1. Normalize the decision matrix. The normalized value xij is calculated as follows:

$$\bar{x}_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n}(x_{ij})^2}},\ i = 1, 2, \ldots, n \text{ and } j = 1, 2, \ldots, m.$$

Step 2. Calculate the weighted normalized decision matrix. In the weighted normalized decision matrix, the modified ratings are calculated as given below:

$$r_{ij} = w_j \times \bar{x}_{ij} \text{ for } i = 1, 2, \ldots, n \text{ and } j = 1, 2, \ldots, m. \quad (1)$$

Step 3. Determine the positive and the negative ideal solutions. The positive ideal solution (PIS) and the negative ideal solution (NIS) are determined as follows:

$$\begin{aligned} \text{PIS} = A^+ &= \{r_1^+, r_2^+, \ldots r_m^+,\} \quad (2)\\ &= \left\{\left(\max_j r_{ij} | j \in J_1\right), \left(\min_j r_{ij} | j \in J_2\right) | j = 1, 2, \ldots, m\right\}; \\ \text{NIS} = A^- &= \{r_1^-, r_2^-, \ldots r_n^-,\} \\ &= \left\{\left(\min_j r_{ij} | j \in J_1\right), \left(\max_j v_{ij} | j \in J_2\right) | j = 1, 2, \ldots, m\right\}, \end{aligned}$$

Step 4. Calculate the separation measures for each alternative from the PIS and the
NIS. The separation values for the PIS can be measured using the n-dimensional Euclidean distance measure as follows

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (r_{ij} - r_j^+)^2} \quad i = 1, 2, \ldots n. \tag{3}$$

Similarly, the separation values for the NIS can be measured as

$$D_i^- = \sqrt{\sum_{j=1}^{m} (r_{ij} - r_j^-)^2} \quad i = 1, 2, \ldots n. \tag{4}$$

Step 5. Calculate the relative closeness coefficient to the positive ideal solution. The relative closeness coefficient for the alternative Ai with respect to A+ is calculated as

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \text{ for } \quad i = 1, 2, \ldots n. \tag{5}$$

Step 6. Rank the alternatives. According to relative closeness coefficient to the ideal alternative, the larger value of Ci reflects the better alternative Ai.

2.2 Fuzzy sets

In 1965, Zadeh introduced the concept of fuzzy set which is more useful to handle uncertaintyof almost every system in the universe.

Definition 1. [15] Let X be the universe of discourse. Then a fuzzy set S defined on X is of the from

$$S = \{< x, \mu(x) > | x \in X\}$$

Definition 2. [15, 30, 31] A triangular fuzzy number is denoted by A1 = (a, b, c) and is defined by a fuzzy subset of real number with membership function μ A1 where

$$\mu_{A_1} = \begin{cases} \frac{x-a}{b-a}, & a \le x < b \\ \frac{c-x}{c-b}, & b < x \le c \\ 0, & otherwise. \end{cases}$$

Definition 3. [15, 31] A trapezoidal fuzzy number is denoted by A2 = (a, b, c, d) and is defined by a fuzzy subset of real number with membership function μ A2 where

$$\mu_{A_2} = \begin{cases} \frac{x-a}{b-a}, & a \le x < b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c < x \le d \\ 0, & otherwise. \end{cases}$$

Definition 4. [16] Let α = (a1, b1, c1) and β = (a2, b2, c2) be two triangular fuzzy numbers. Then the Euclidean distance measure of two triangular fuzzy numbers α and β is defined by

$$d(\alpha, \beta) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]} \tag{6}$$

It can be easily seen that this distance measure satisfies following conditions:

1. $d(\alpha, \beta) \ge 0$
2. $d(\alpha, \beta) = d(\beta, \alpha)$
3. $d(\alpha, \gamma) \le d(\alpha, \beta) + d(\beta, \gamma) \quad \forall\, \alpha, \beta, \gamma \in X$

3. Formulation of the model

We treat the prevention problem of spreading of COVID-19 as a multi-criteria decision-making problem and discuss fuzzy TOPSIS method with triangular fuzzy number to solve the problem. We now put forward a model framework for determining the ranking order for a few possible alternatives for COVID-19 prevention measure under fuzzy environment. Suppose that A = (A1,A2, ...,An) is a discrete set of alternatives and C = (C1,C2, ...,Cn) is a discrete set of attributes. Suppose that D = [aij] is the decision matrix, where aij = (a1ij , a2 ij , a3 ij) is a triangular fuzzy number which assigns the alternative Ai with respect to criterion Cj . Then we have the following fuzzy decision matrix

$$D = (a_{ij})_{m\times n} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix} \end{array} \tag{7}$$

If fuzzy decision matrix D has the same dimension, then we need not to normalize it; otherwise, D has to be normalized. Consider the weight vector of the criteria as W = {w1,w2, ...,wn}

Step 1: Standardize the decision matrix. Transform dimensional criteria into non-dimensional criteria, which allows comparison across criteria because various criteria are usually measured in various units. There are two types of criteria - one is gain type criteria and another one is loss type criteria. In order to eliminate the influence of criteria type, we consider the following technique to get the normalized matrix R = (rij)m×n, where rij = (r1ij , r2 ij , r3 ij) is a TFN. Then we have

$$r_{ij} = \left(\frac{a^1_{ij}}{u^+_j}, \frac{a^2_{ij}}{u^+_j}, \frac{a^3_{ij}}{u^+_j}\right), \quad \text{for gain type criteria} \tag{8}$$

$$r_{ij} = \left(\frac{u^-_j}{a^3_{ij}}, \frac{u^-_j}{a^2_{ij}}, \frac{u^-_j}{a^1_{ij}}\right), \quad \text{for gain type criteria} \tag{9}$$

where $u^+_j = max\{a^3_{ij} : i = 1, 2, ..., m\}$ and $u^-_j = min\{a^1_{ij} : i = 1, 2, ..., m\}$ for $j = 1, 2, ..., n$.

Step 2: Determine the positive and negative ideal solutions. In this step, we determine the positive and negative ideal solutions from the normalized decision matrix R = (˜ rij)m×n in the triangular fuzzy number. The positive and negative ideal solutions are calculated as r+ = (r+1 , r+2 , . . . , r+n) and r− = (r−1 , r−2 , . . . , r−n) where,

$$r^+_j = (r^{1+}_j, r^{2+}_j, r^{3+}_j) = \left(\max_i(r^1_{ij}), \max_i(r^2_{ij}), \max_i(r^3_{ij})\right) \tag{10}$$

$$r^-_j = (r^{1-}_j, r^{2-}_j, r^{3-}_j) = \left(\min_i(r^1_{ij}), \min_i(r^2_{ij}), \min_i(r^3_{ij})\right) \tag{11}$$

Step 3: Determine the distance measure from ideal solutions. Now, using Eqs.(6), (10) and (11), we determine the distance measure d+i from positive ideal solution and d− i from negative ideal solution as

$$\begin{aligned} d^+_i &= \sum_{j=1}^{n} w_j d(r_{ij}, r^+_j) \\ &= \sum_{j=1}^{n} w_j \sqrt{\frac{1}{3}[(r^1_{ij} - r^{1+}_j)^2 + (r^2_{ij} - r^{2+}_j)^2 + (r^3_{ij} - r^{3+}_j)^2]} \end{aligned} \tag{12}$$

$$\begin{aligned} d^-_i &= \sum_{j=1}^{n} w_j d(r_{ij}, r^-_j) \\ &= \sum_{j=1}^{n} w_j \sqrt{\frac{1}{3}[(r^1_{ij} - r^{1-}_j)^2 + (r^2_{ij} - r^{2-}_j)^2 + (r^3_{ij} - r^{3-}_j)^2]} \end{aligned} \tag{13}$$

Step 4: Compute the relative closeness co-efficient. We calculate the relative closeness co-efficient of an alternative Ai with respect to the ideal alternative A+ as

$$RCC(A_i) = \frac{d_i^-}{d_i^+ + d_i^-}, \ for \ i = 1, 2, ..., n, \tag{14}$$

where $0 \leq RCC(A_i) \leq 1$. We then rank the best alternative according to RCC.

4 Numerical study

For numerical study, we consider COVID-19 situation of six states in India, viz. Maharastra, Delhi, West Bengal, Tamilnadu, Kerala and Gujrat and select the best state in terms of prevention of COVID-19. We assume prevention problem of spreading of COVID-19 as a multi-criteria decision-making problem in which the states are taken as the alternatives and each alternative has criteria like 'lockdown', 'rapid testing', 'social distancing', 'protection of frontline workers' like doctors, nurses and health workers, 'sanitization' and 'population density of the state'. Table 1 shows the number of rapid testing being done in different states. The number of infected cases, number of cured cases and number of deaths for COVID-19 of the above states of India are shown in Fig.1 and Table 2.

Table 1: Rapid testing (**ICMR** July 2020)

Name of the state	Test per million person
Maharastra	1778.6
Delhi	5736.2
West Bengal	533.4
Tamilnadu	3455.5
Kerala	1078.7
Gujrat	1844.6

Table 2: COVID-19 status (**ICMR** July 2020)

Name of the state	Cases	Active	Cured	Death
Maharastra	318695	131636	175029	12030
Delhi	125096	15288	106118	3690
West Bengal	47030	17813	28035	1182
Tamilnadu	180643	51347	126670	2626
Kerala	13994	8060	5890	44
Gujrat	50379	11760	36423	2196

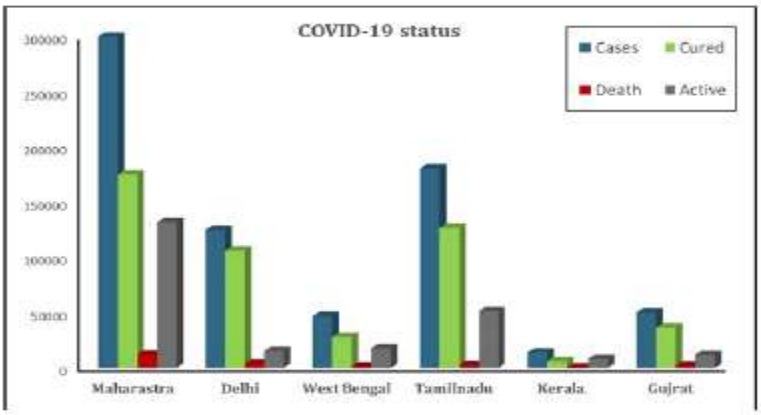


Figure 1: COVID-19 status

Table 3: Population Density (Census 2011 and updated 2019)

Name of the state	$/km^2$
Maharastra	365
Delhi	11297
West Bengal	1029
Tamilnadu	555
Kerala	859
Gujrat	308

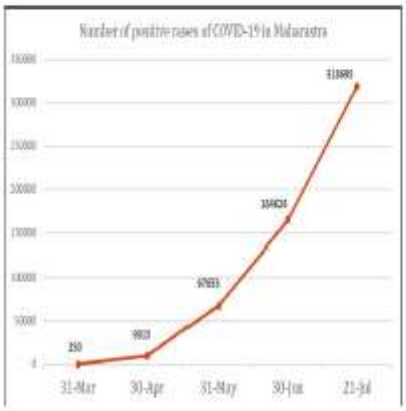
The population density of the states according to Census 2011 and updated Census 2019 is given in Table 3. We employ fuzzy TOPSIS method to find the solution i.e. identify the state which achieves the best performance in terms of prevention of COVID-19. In the prevention process, the effective criteria may have several uncertainties and incompleteness. So we use triangular fuzzy number for simplifying the criteria for prevention. The proposed technique is discussed in the following steps:

Step 1. For prevention of COVID-19, the following criteria are identified:
• Lockdown (C1)
• Rapid testing (C2)
• Social distancing (C3)
• Protection of frontline workers (C4)
• Population density (C5)

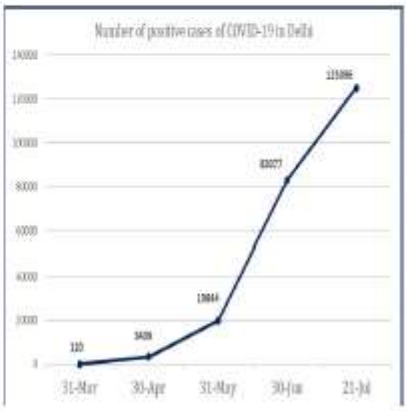
For our decision-making problem, the following states of India are considered as alternatives:
• West bengal (A1)
• Delhi (A2)
• Maharastra (A3)
• Tamilnadu (A4)
• Kerala (A5)
• Gujrat (A6)
We consider data from a five-month (March 2020 to July 2020) survey for the number of COVID positive cases in the above states as given in Table 4 and and following figure.

Table 4: Number of positive cases of COVID-19 since March 2020 (**ICMR**)

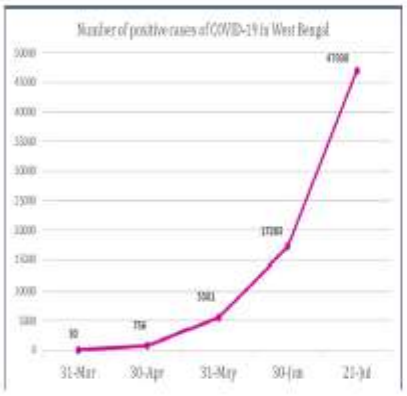
Name of the state	31 March	30 April	31 May	30 June	21 July
Maharastra	250	9915	67655	164626	318695
Delhi	120	3439	19844	83077	125096
West Bengal	30	756	5501	17283	47030
Tamilnadu	151	2162	22333	82275	180643
Kerala	222	496	1100	10321	13994
Gujrat	76	4082	16779	31320	50379



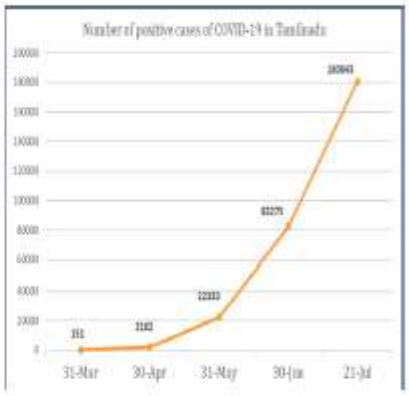
(1) COVID-19 status of Maharastra



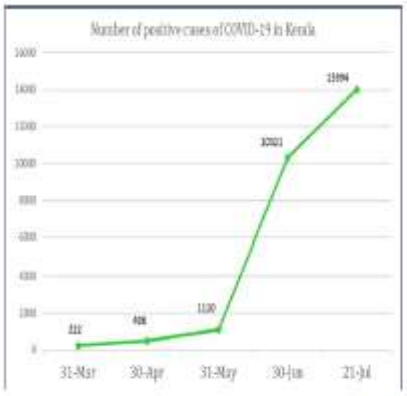
(2) COVID-19 status of Delhi



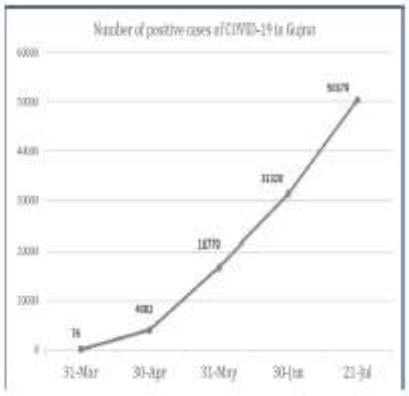
(3) COVID-19 status of West Bengal



(4) COVID-19 status of Tamilnadu



(5) COVID-19 status of Kerala



(6) COVID-19 status of Gujrat

We consider the criteria value as a triangular fuzzy number (TFN). The linguistic term and the corresponding TFN are shown in Table 5. We use 7-point linguistic rating scale

Table 5: The triangular fuzzy linguistic scale

Linguistic variable	Influence score	Corresponding TFN
Very low (AL)	0	(0,0,0.1)
Low (L)	1	(0,0.1,0.3)
Medium low (ML)	2	(0.1,0.3,0.5)
Medium (M)	3	(0.3,0.5,0.7)
Medium High (MH)	4	(0.5,0.7,0.9)
High (H)	5	(0.7,0.9,1.0)
Absolutely high (AH)	6	(0.9,1.0,1.0)

We consider three decision matrices D1, D2 and D3 for the months of March, May and July 2020, respectively as shown in Tables 6-8.

Table 6: Decision matrix D_1 for March 2020

	C_1	C_2	C_3	C_4	C_5
A_1	M	M	ML	L	M
A_2	M	H	L	ML	H
A_3	ML	VL	ML	M	MH
A_4	M	MH	L	ML	M
A_5	VH	MH	H	VH	M
A_6	L	M	ML	ML	ML

Table 7: Decision matrix D_2 for May 2020

	C_1	C_2	C_3	C_4	C_5
A_1	M	H	L	L	M
A_2	ML	VH	ML	L	H
A_3	L	ML	L	ML	MH
A_4	M	H	L	ML	M
A_5	VH	H	H	VH	M
A_6	L	ML	M	L	ML

Table 8: Decision matrix D_3 for July 2020

	C_1	C_2	C_3	C_4	C_5
A_1	L	L	ML	VL	M
A_2	ML	ML	L	M	H
A_3	L	VL	ML	L	MH
A_4	M	M	L	M	M
A_5	VH	H	H	H	M
A_6	L	M	ML	L	ML

Now, we calculate the aggregated fuzzy decision matrix. Let α 1 = (x1, y1, z1), α 2 = (x2, y2, z2),..., α n = (xn, yn, zn) be n TFNs. Then the aggregate TFN is given by

$$\alpha = \left(\frac{x_1 + x_2 + \ldots + x_n}{n}, \frac{y_1 + y_2 + \ldots + y_n}{n}, \frac{z_1 + z_2 + \ldots + z_n}{n}\right) \qquad (15)$$

We aggregate the matrices D1, D2 and D3 by using Eq. (15) and obtain the aggregate fuzzy decision matrix as given in Table 9.

Table 9: Aggregate fuzzy decision matrix

	C_1	C_2	C_3	C_4	C_5
A_1	(0.2,0.36,0.56)	(0.36,0.56,0.73)	(0.06,0.23,0.43)	(0,0.06,0.23)	(0.3,0.5,0.7)
A_2	(0.16,0.36,0.56)	(0.56,0.73,0.83)	(0.03,0.16,0.36)	(0.13,0.3,0.5)	(0.7,0.9,1.0)
A_3	(0.3,0.14,0.36)	(0.03,0.1,0.36)	(0.01,0.23,0.43)	(0.13,0.3,0.5)	(0.5,0.7,0.9)
A_4	(0.3,0.5,0.7)	(0.5,0.7,0.86)	(0,0.1,0.3)	(0.16,0.43,0.56)	(0.3,0.5,0.7)
A_5	(0.9,1.0,1.0)	(0.63,0.83,0.96)	(0.7,0.9,1.0)	(0.83,0.96,1.0)	(0.3,0.5,0.7)
A_6	(0,0.1,0.3)	(0.23,0.43,0.63)	(0.16,0.36,0.56)	(0.03,0.16,0.36)	(0.1,0.3,0.5)

Step 2. In this step, we normalize the aggregated fuzzy decision matrix. There are two types of criteria. We select 'lockdown' (C1), 'rapid testing' (C2), 'social distancing' (C3) and 'protection of frontline workers' (C4) as advantage type criteria, and 'population density' (C5) as disfavour type criteria. To normalize, we use equation (8) for the criteria C1, C2, C3, C4 and use Eq.(9) for the criteria C5. The normalized fuzzy decision matrix is given in Table 10.

Table 10: Normalized fuzzy decision matrix

	C_1	C_2	C_3	C_4	C_5
A_1	(0.2,0.36,0.56)	(0.375,0.583,0.76)	(0.06,0.23,0.43)	(0,0.06,0.23)	(0.142,0.2,0.33)
A_2	(0.16,0.36,0.56)	(0.583,0.76,0.864)	(0.03,0.16,0.36)	(0.13,0.3,0.5)	(0.1,0.11,0.142)
A_3	(0.3,0.14,0.36)	(0.031,0.104,0.3375)	(0.01,0.23,0.43)	(0.13,0.3,0.5)	(0.11,0.142,0.2)
A_4	(0.3,0.5,0.7)	(0.52,0.729,0.89)	(0,0.1,0.3)	(0.16,0.43,0.56)	(0.142,0.2,0.33)
A_5	(0.9,1.0,1.0)	(0.656,0.86,1.0)	(0.7,0.9,1.0)	(0.83,0.96,1.0)	(0.142,0.2,0.33)
A_6	(0,0.1,0.3)	(0.239,0.447,0.656)	(0.16,0.36,0.56)	(0.03,0.16,0.36)	(0.2,0.33,1.0)

Step 3. In this step, we determine the positive and the negative ideal solutions from the normalized fuzzy decision matrix using Eqs.(10) and (11). Fuzzy positive and negative ideal solutions are given in the following:

$$A^+ = \begin{pmatrix} (0.9, 1.0, 1.0) \\ (0.65, 0.86, 1.0) \\ (0.7, 0.9, 1.0) \\ (0.83, 0.96, 1.0) \\ (0.20, 0.33, 1.0) \end{pmatrix} \qquad A^- = \begin{pmatrix} (0, 0.1, 0.3) \\ (0.031, 0.104, 0.375) \\ (0, 0.1, 0.3) \\ (0, 0.06, 0.23) \\ (0.1, 0.11, 0.142) \end{pmatrix}$$

Step 4. We consider the weight w = (0.25, 0.30, 0.10, 0.25, 0.10) for the criteria C1, C2, C3, C4 and C5, respectively. Note that we have given more importance to the criteria rapid testing (C2). The normalized weight of this criteria is taken as 0.30. Using Eqs. (12) and (13), we calculate the separation measure from the positive ideal solution (d+) and the negative ideal solution (d− i) as given in Table 11.

Table 11: Distance measure from positive and negative ideal solutions

$d^+(A_i)$	value	$d^+(A_i)$	value
d_1^+	0.537	d_1^-	0.205
d_2^+	0.462	d_2^-	0.289
d_3^+	0.632	d_3^-	0.120
d_4^+	0.405	d_4^-	0.477
d_5^+	0.039	d_5^-	0.582
d_6^+	0.574	d_6^-	0.205

Step 5. In this step, using (14), we determine the relative closeness coefficient as shown in Table 12.

Table 12: Relative closeness co-efficient

$RCC(A_i)$	value
$RCC(A_1)$	0.276
$RCC(A_2)$	0.384
$RCC(A_3)$	0.160
$RCC(A_4)$	0.540
$RCC(A_5)$	0.936
$RCC(A_6)$	0.162

From Table 12, we see that the alternative A5 is the best alternative. It appears that the state "Kerala" is better than other states for prevention of COVID-19 spreading and A3 i.e. the state Maharastra has the worst condition for COVID-19. Rank of the states for the prevention of spreading COVID-19 is obtained as

$$A5 \succ A4 \succ A2 \succ A1 \succ A6 \succ A3$$

i.e. Kerala ≻ Tamilnadu ≻ Delhi ≻ Westbengal ≻ Gujrat ≻ Maharastra

5. Discussion

This study considers five criteria as ‘lockdown’, ‘rapid testing’, ‘social distancing’, ‘protection of frontline workers’ and ‘population density’. From weight of the criteria, we see that ‘rapid testing’, ‘lockdown’, and ‘protection of the frontline workers’ has been paid more attention. As maintained by our model, if a state pays more importance to ‘rapid testing’ then that state gives better prevention and the same thing will happen for the criteria ‘lockdown’ and ‘protection of frontline workers. Further, ‘population density’ is a constant type criterion and we see that the ‘population density’ of the state Delhi is very high but Delhi gets third position in the rank for prevention of COVID-19, after the Kerala and Tamilnadu because Delhi government gives more attention to ‘rapid testing’ and ‘lockdown’ for prevention of COVID-19 which is not properly happened in Gujrat and Maharastra. One can see that the triangular fuzzy number used in this model easily handles the uncertainty and incomplete information of different criteria and the proposed fuzzy TOPSIS method provided the best alternative. As a result, Kerala is found to be the best state for better prevention for COVID-19.

6. Concluding Remarks

TOPSIS is one of the classical methods for solving MCDM problem with crisp number as well as fuzzy number. In this paper, we have considered TOPSIS method with TFN and applied to determine the best alternative for prevention of Novel coronavirus (COVID- 19) spreading in India. The proposed model considers the prevention of spreading of COVID-19 as a MCDM problem and selects a few states of India like West Bengal, Delhi, Maharastra, Kerala, Tamilnadu and Gujrat as alternatives. The necessary measures to avoid spreading of COVID-19 like ‘lockdown’, ‘rapid testing’, ‘social distancing in gathering places ‘protection of frontline workers’ like doctors, nurses and health workers and ‘population density’ of the state are treated as the criteria of MCDM problem. Since each criterion contains uncertain and vagueness information, so we have considered TFN as a criteria value. The research idea introduced in this paper can be applied in different areas of forecasting and decision making.

References

References

[1] Singer, H.M., (2020), Short-term predictions of country-specific Covid-19 infection rates based on power law scaling exponents, arXiv preprint arXiv:2003.11997.

[2] Coleman, C.M., Sisk, J.M., Mingo, R.M., Nelson, E.A., White, J.M. and Frieman, M.B, (2016), Abelson kinase inhibitors are potent inhibitors of severe acute respiratory syndrome coronavirus and Middle East respiratory syndrome coronavirus fusion, Journal of virology., 90(19),pp.8924–8933.

[3] Schuller, B,W., Schuller, D.M., Qian, K., Liu, J., Zheng, H., and Li, X., (2020), Covid-19 and computer audition: An overview on what speech and sound analysis could contribute in the SARS-CoV-2 Corona crisis., arXiv preprint arXiv:2003.11117.

[4] Hwang, C.L., and Yoon, K., (1981), Methods for multiple attribute decision making. In Multiple attribute decision making., pp. 58-191, Springer, Berlin, Heidelberg.

[5] Brans, J.P., Vincke, P., Mareschal, B., (1986), How to select and how to rank projects: The PROMETHEE method, European journal of operational research, 24(2), pp.228–238.

[6] Opricovic, S. and Tzeng, G.H, (2004), Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS, European journal of operational research, 156(2), pp.445–455.

[7] Roy, B., (1991), The outranking approach and the foundations of ELECTRE methods, Theory and decisions, 31(1), pp. 49–73.

[8] Lai, Y.J., Liu, T.Y. and Hwang, C.L., (1994), TOPSIS for MODM, European journal of operational research, 76(3), pp.486–500.

[9] Abo-Sinna, M.A. and Amer, A.H., (2005), Extensions of TOPSIS for multi-objective large-scale nonlinear programming problems, Applied Mathematics and Computation, 162(1), pp.243–256.

[10] Agrawal, V.P, Kohli, V. and Gupta, S., (1991), Computer aided robot selection: the ‘multiple attribute decision making’approach, The International Journal of Production Research, 29(8), pp.1629–1644.

[11] Cheng, S., Chan, C.W. and Huang, G.H., (2003), An integrated multi-criteria decision analysis and inexact mixed integer linear programming approach for solid waste management, Engineering Applications of Artificial Intelligence, 16, pp.543–554.

[12] Deng, H., Yeh, C.H and Willis, R.J, (2000), Inter-company comparison using modified TOPSIS with objective weights, Computers and Operations Research, 27(10), pp. 963–973.

[13] Feng, C.M. and Wang, R.T, (2001), Considering the financial ratios on the performance evaluation of highway bus industry, Transport reviews, 21(4), pp.449–467.

[14] Tong, L.I. and Su, C.T., (1997), Optimizing multi-response problems in the Taguchi method by fuzzy multiple attribute decision making, Quality and reliability engineering International, 13(1), pp.25–34.20
[15] Zadeh, L.A., (1965), Fuzzy sets, Information and control, 8(3), pp.338–353.
[16] Chen, C.T., (2000), Extensions of the TOPSIS for group decision-making under fuzzy environment, Fuzzy sets and systems, 114(1), pp.1–9.
[17] Jahanshahloo, G.R., Lotfi, F.H. and Izadikhah, M., (2006), Extension of the TOPSIS method for decision-making problems with fuzzy data, Applied Mathematics and computation, 181(2), pp.1544–1551.
[18] Atanassov, K.T, (1989), More on intuitionistic fuzzy sets, Fuzzy sets and systems 33(1), pp.37–45.
[19] Samarandache, F., (1998), A unifying field in logics, Neutrosophy: neutrosophic probability, set and logic. American Research Press,Rehoboth
[20] Yager, R.R., (2013), Pythagorean fuzzy subsets, In 2013 joint IFSA world congress and NAFIPS annual meeting, (IFSA/NAFIPS) pp. 57-61. IEEE.
[21] Boran, F.E, Genc, S., Kurt, M. and Akay, D., (2009), A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method, Expert Systems with Applications, 36(8), pp. 11363–11368.
[22] Zhang, X. and Xu, Z., (2014), Extension of TOPSIS to multiple criteria decision making with Pythagorean fuzzy sets, International Journal of Intelligent Systems,29(12), pp. 1061–1078.
[23] Biswas, P., Pramanik, S. and Giri, B.C, (2016), TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment, Neural computing and Applications, 27(3), pp. 727–737.
[24] Giri, B.C., Molla, M.U. and Biswas, P., (2018), TOPSIS method for MADM based on interval trapezoidal neutrosophic number, Neutrosophic Sets and Systems, 22, pp.151–167.
21
[25] Dikshit-Ratnaparkhi, A., Bormane, D. and Ghongade, R., (2020), A novel entropybased weighted attribute selection in enhanced multicriteria decision-making using fuzzy TOPSIS model for hesitant fuzzy rough environment, Complex and Intelligent Systems, pp.1-12.
[26] Chen, T.Y. and Tsao, C.Y., (2008), The interval-valued fuzzy TOPSIS method and experimental analysis, Fuzzy sets and systems, 159(11), pp.1410–1428.
[27] Wang, Y.M. and Elhag, T.M., (2006) Fuzzy TOPSIS method based on alpha level sets with an application to bridge risk assessment, Expert systems with applications,31(2) pp.309–319.
[28] Chen, T.Y., (2011), Interval-valued fuzzy TOPSIS method with leniency reduction and an experimental analysis, Applied Soft Computing, 11(8), pp.4591–4606.
[29] Prabhu, M., Abdullah, N.N., Ahmed, R.R., Nambirajan, T. and Pandiyan, S., (2020), Segmenting the manufacturing industries and measuring the performance: using interval-valud fuzzy TOPSIS method, Complex and Intelligent Systems, 6, pp.591–606. https://doi.org/10.1007/s40747-020-00157-0.
[30] Chou, C.C, (2003), The canonical representation of multiplication operation on triangular fuzzy numbers, Computers and Mathematics with Applications, 45, pp. 1601–1610.
[31] Zimmermann, H.J., (1991), Fuzzy set theory and its applications, (2nd ed.) Boston, MA: Kluwer-Nijhoff.