ISSN 2348 – 9928
IJAICT Volume 4, Issue 1, January 2017 Doi:01.0401/ijaict.2014.07.20 Published on 05 (1) 2017

MULTI CRITERIA DECISION MAKING MODEL TO ANALYSE HEALTH HAZARDS OF TRAFFIC POLICE

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Abstract— ***In this paper algorithm for fuzzy TOPSIS method is proposed for multi criteria decision making problem (MCDM). Due to uncertainty and imprecise data fuzzy set theory has been used to establish fuzzy TOPSIS method. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is the best method to find out the ideal solution of the problem. The trapezoidal fuzzy number is used in a linguistic environment and fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) is obtained. The health hazards of traffic police is analysed by this algorithm and the conclusion is given based on our study.***

Keywords— Topsis Method, Traffic Police Health Issues, Ranking Method.

I. INTRODUCTION

Fuzzy set theory was introduced by Lofit Zadeh (1965) is an efficient way to model uncertainty and imprecision in terms of linguistic variable. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is the best method to find out the ideal solution of the problem. In this method two artificial alternatives are considered one is positive ideal alternative, the one which has the best level for all attributes considered and the other one is Negative ideal solution the one which has the worst attribute values. TOPSIS selects the alternative that is the closest to the ideal solution and farthest from negative ideal alternative. Linguistic variable is a "variable whose values are not numbers but words or sentences in a natural or artificial language" [16].

1.1 Trapezoidal fuzzy number

If a fuzzy number A = (a, b, c, d) is said to be trapezoidal if its membership function is given by

$$\mu_A(x) = \begin{cases} 0 & x < a \\ \dfrac{x-a}{b-a} & a < x \le b \\ 1 & b < x < c \\ \dfrac{d-x}{d-c} & c \le x < d \\ 0 & x > d \end{cases}$$

Where $a \le b \le c \le d$.

1.2 Distance between two trapezoidal fuzzy numbers:

Let $A=(a_1,b_1,c_1,d_1)$ and $B = (a_2,b_2,c_2,d_2)$ be two trapezoidal numbers .The Euclidean distance between two trapezoidal fuzzy numbers defined as

$$d(A,B)=\sqrt{\tfrac{1}{6}((a_1-b_1)^2+2(a_2-b_2)^2+2(a_3-b_3)^2+(a_4-b_4)^2)} \rightarrow (1)$$

II. FUZZY TOPSIS ALGORITHM

- Assume that there is n criterion $\{D_1, D_2 \dots D_n\}$ and m alternatives $\{A_1, A_2 \dots A_n\}$
- According to experts opinion ,obtain the linguistic rating for each alternative with respect to the criteria as a trapezoidal fuzzy number defined by Ding(et.al)

Linguistic variable	Linguistic value
Very Low	(0,0,0.2,0.3)
Low	(0.2,0.3,0.4,0.5)
Medium	(0.4,0.5,0.6,0.7)
High	(0.6,0.70.8,0.9)
Very High	(0.8,0.9,1,1)

- According to experts opinion , also obtain the linguistic variables for the weight of the criterion

Linguistic variable	Linguistic value
Very Low	(0,0,0.1,0.2)
Low	(0.1,0.2,0.2,0.3)
Medium Low	(0.2,0.3,0.4,0.5)
Medium	(0.4,0.5,0.5,0.6)
Medium High	(0.5,0.6,0.7,0.8)
High	(0.7,0.8,0.8,0.9)
Very High	(0.8,0.9,1,1)

- Obtain the fuzzy decision matrix

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Doi:01.0401/ijaict.2014.07.20 Published on 05 (1) 2017

$X = (x_{ij})_{n \times m}$ Where i= 1,2...n, j = 1,2...m and $x_{ij} = (l_{ij}, m_{ij}, n_{ij}, o_{ij})$

- Obtain the normalized fuzzy decision matrix $Y = (y_{ij})_{n \times m}$ Where i= 1,2...n, j = 1,2...m and $y_{ij} = \left(\frac{l_{ij}}{O_j^*}, \frac{m_{ij}}{O_j^*}, \frac{n_{ij}}{O_j^*}, \frac{o_{ij}}{O_j^*}\right)$ where $O_j^* = Max\{o_{ij}\}$
- Construct the weighted fuzzy normalized matrix Z= $(z_{ij})_{n \times m}$ Where $z_{ij} = y_{ij} \times w_i$, $w_i = (w_1, w_2 \dots w_n)$, i= 1,2...n, j = 1,2...m and $z_{ij} = (a_{ij}, b_{ij}, c_{ij}, d_{ij})$
- Determine the fuzzy positive ideal solution $I^+ = (z_1^+, z_2^+, \dots z_n^+)$ and the negative ideal solution $I^- = (z_1^-, z_2^-, \dots z_n^-)$.
  Where $z_i^+ = \left(\underset{j=1\,to\,m}{Max}(a_{ij}), \underset{j=1\,to\,m}{Max}(b_{ij}), \underset{j=1\,to\,m}{Max}(c_{ij}), \underset{j=1\,to\,m}{Max}(d_{ij})\right)$, and
  $z_i^- = \left(\underset{j=1\,to\,m}{Min}(a_{ij}), \underset{j=1\,to\,m}{Min}(b_{ij}), \underset{j=1\,to\,m}{Min}(c_{ij}), \underset{j=1\,to\,m}{Min}(d_{ij})\right)$
  for all i =1 to n.
- Determine the distance of each alternative from fuzzy positive ideal solution (d_i^+) and negative ideal solution ((d_i^-)

$$d_i^+ = \sum_{j=1}^{m} d(z_{ij}, z_i^+) \quad \text{for i = 1 to n}$$

$$d_i^- = \sum_{j=1}^{m} d(z_{ij}, z_i^-) \quad \text{for i = 1 to n}$$

- Calculate the closeness coefficient (CC_i) and rank the alternatives

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}$$

III. NUMERICAL EXAMPLE

As India is a fast growing developing country, primarily it needs the expansion of transportation and traffic facilities. No countries can grow without industries and supporting systems like transportation of resources. For this purpose we must use different vehicles, and 99.99% of them are using fossil fuels for energy. In our country the cities carries 85% of vehicle population. And our major metropolitan cities carry 60% of the above. So the risk of environmental pollution is very high in those large cities [5].

"All they know, few actually walk it", but in policing it is not so. Actually few know the way and a large majority are uncertain about it. What is needed is to change this few into significant few who can make lasting impact on quality of policing [1].

Police personnel play a pivotal role in maintaining the law, order and safety of the country. Officers' involvement ranges from general, daily, and proactive patrol activities to specific criminal activities such as narcotic investigations. Because there is such a wide range of activities involved in police work, there are many health and safety issues surrounding policing as an occupation. Police officers may be exposed to different health and safety risks in their occupation. Not addressing the health and safety issues associated with policing may also impact the general public. For example, if an officer is stressed or fatigued he/she may not perform his/her duties to the best of his/her ability reducing the contribution of policing to the community. Fatigue may also increase the potential for road traffic accidents, thus putting the public at risk [2].

The traffic policemen in metropolitan cities posted at busy intersections are exposed to very high levels of pollution. Carbon monoxide is an important component of air pollution caused by traffic exhaust fumes. According to a recent study conducted by All India Institute of Medical Sciences in collaboration with the Central Road Research Institute, the carbon monoxide level among traffic police is 20 times higher than that found in office environment. Carbon monoxide inhalation displaces oxygen on the haemoglobin molecule, causing hypoxia, carboxyhemoglobinemia and ultimately death when the level of carbon monoxide becomes high. As per findings of this study, concentration of oxides of nitrogen at busy intersections was 5-12 times higher than in office environment. Particulate matter concentration was found to be 2-6 times higher [3].

The traffic policemen are screwing their health for the general public and are more exposed to occupational hazards. They work in an extremely bad working condition, standing for eight to twelve hours in sun, rain, pollution and smoke of the vehicles. It is the responsibility of the health personnel to help them in turn to take care of their health, as many of these health problems are preventable [4].

Automobile vehicles are the major sources of noise in the city, which originates from engines, air turbulence and frictional contact of the vehicle's tires to the ground. Noise is one of the causes of preventable sensory-neural loss. The attention has to be given towards the problem as no cure is available for noise induced hearing loss because of irreversible damage to the hair cells. Noise-induced hearing loss (NIHL) is caused by sustained, repeated exposure to excessive sound levels. It accrues progressively and often remains unnoticed until it has reached a certain degree. Any form of sound exposure can lead to NIHL provided there is sufficient intensity and exposure time [6][7][8][9].

Noise has been a bane and seems to have altered the ecological balance. Noise pollution in mega cities is considered to be one of the most important and pressing problems. A major contribution to the noise is vehicular noise [10].Police officers are commonly considered to be a high-risk group for the development of mental health disturbances because of the

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ISSN 2348 – 9928
IJAICT Volume 4, Issue 1, January 2017 Doi:01.0401/ijaict.2014.07.20 Published on 05 (1) 2017

various critical incidents and potential traumatic events they encounter during their career. These so-called operational stressors, such as witnessing the death of children, confrontations with victims of sexual harassment, serious traffic accidents, suicide and experiencing violence, might increase the risk of symptoms of anxiety, hostility and fatigue. A (small) minority may develop mental disorders, such as depression and post-traumatic stress disorder (PTSD) [11][12][13][14].

Our expert has given the following 10 diseases any traffic police can get. Taking these ten diseases as criterion and the causes of the diseases air pollution, noise pollution, psychological disturbances, work pressure, prolonged standing as attributes. The main cause for this group of diseases will be identified by applying TOPSIS method. The set of criterion are D_1: Blood pressure /D_2:cardiovascular diseases / D_3:Sexual impotent /D_4:Nausea / D_5:Insomnia / D_6:Increased aggressiveness / D_7:damage in the nervous system / D_8:Fatigue / D_9: Hysteria / D_{10}:Decreased working. The set of alternatives are A1:Air pollution / A2:Noise pollution / A3:Psycological disturbances/A4: Work pressure/A5:Prolonged standing.

Obtain the opinion of the expert as a linguistic variable for rating of alternative with respect to the criterion also the weight of each criterion [15][16][17][18][19].

Table1: Linguistic Variable

Criterion	Alternative				
	A_1	A_2	A_3	A_4	A_5
D_1(H)	L	H	H	H	H
D_2(VH)	VL	VH	H	H	L
D_3(H)	H	VH	M	L	VL
D_4(M)	H	H	L	VL	L
D_5(MH)	H	H	L	H	M
D_6(M)	VL	VH	M	L	M
D_7(VH)	VH	H	L	H	M
D_8(M)	L	H	M	H	L
D_9(M)	L	VH	M	M	VL
D_{10}(L)	VL	VH	H	VL	L

Construct the fuzzy decision matrix

Table2: Fuzzy decision matrix

Criterion	Alternative				
	A_1	A_2	A_3	A_4	A_5
D_1(0.7,0.8,0.8,0.9)	(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)
D_2(0.8,0.9,1,1)	(0,0,0.2,0.3)	(0.8,0.9,1,1)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.2,0.3,0.4,0.5)
D_3(0.7,0.8,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.8,0.9,1,1)	(0.4,0.5,0.6,0.7)	(0.2,0.3,0.4,0.5)	(0,0,0.2,0.3)
D_4(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.2,0.3,0.4,0.5)	(0,0,0.2,0.3)	(0.2,0.3,0.4,0.5)
D_5(0.4,0.5,0.5,0.6)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.4,0.5,0.6,0.7)
D_6(0.2,0.3,0.4,0.5)	(0,0,0.2,0.3)	(0.8,0.9,1,1)	(0.4,0.5,0.6,0.7)	(0.2,0.3,0.4,0.5)	(0.4,0.5,0.6,0.7)
D_7(0.8,0.9,1,1)	(0.8,0.9,1,1)	(0.6,0.7,0.8,0.9)	(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.4,0.5,0.6,0.7)
D_8(0.4,0.5,0.5,0.6)	(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.4,0.5,0.6,0.7)	(0.6,0.7,0.8,0.9)	(0.2,0.3,0.4,0.5)
D_9(0.4,0.5,0.5,0.6)	(0.2,0.3,0.4,0.5)	(0.8,0.9,1,1)	(0.4,0.5,0.6,0.7)	(0.4,0.5,0.6,0.7)	(0,0,0.2,0.3)
D_{10}(0.1,0.2,0.2,0.3)	(0,0,0.2,0.3)	(0.8,0.9,1,1)	(0.6,0.7,0.8,0.9)	(0,0,0.2,0.3)	(0.2,0.3,0.4,0.5)

Construct the fuzzy normalized matrix

Table3-Fuzzy Normalized Matrix

Criterion	Alternatives				
	A_1	A_2	A_3	A_4	A_5
D_1(0.7,0.8,0.8,0.9)	(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.667,0.778,0.889,1)	(0.667,0.778,0.889,1)	(0.667,0.778,0.889,1)
D_2(0.8,0.9,1,1)	(0,0,0.2,0.3)	(0.8,0.9,1,1)	(0.667,0.778,0.889,1)	(0.667,0.778,0.889,1)	(0.222,0.333,0.444,0.556)
D_3(0.7,0.8,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.8,0.9,1,1)	(0.444,0.556,0.667,0.778)	(0.222,0.333,0.444,0.556)	(0,0,0.222,0.333)
D_4(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.222,0.333,0.444,0.556)	(0.222,0.333,0.444,0.556)	(0.222,0.333,0.444,0.556)
D_5(0.4,0.5,0.5,0.6)	(0.6,0.7,0.8,0.9)	(0.6,0.7,0.8,0.9)	(0.222,0.333,0.444,0.556)	(0.667,0.778,0.889,1)	(0.444,0.556,0.667,0.778)
D_6(0.2,0.3,0.4,0.5)	(0,0,0.2,0.3)	(0.8,0.9,1,1)	(0.444,0.556,0.667,0.778)	(0.222,0.333,0.444,0.556)	(0.444,0.556,0.667,0.778)
D_7(0.8,0.9,1,1)	(0.8,0.9,1,1)	(0.6,0.7,0.8,0.9)	(0.222,0.333,0.444,0.556)	(0.667,0.778,0.889,1)	(0.444,0.556,0.667,0.778)
D_8(0.4,0.5,0.5,0.6)	(0.2,0.3,0.4,0.5)	(0.6,0.7,0.8,0.9)	(0.444,0.556,0.667,0.778)	(0.667,0.778,0.889,1)	(0.222,0.333,0.444,0.556)
D_9(0.4,0.5,0.5,0.6)	(0.2,0.3,0.4,0.5)	(0.8,0.9,1,1)	(0.444,0.556,0.667,0.778)	(0.444,0.556,0.667,0.778)	(0,0,0.222,0.333)
D_{10}(0.1,0.2,0.2,0.3)	(0,0,0.2,0.3)	(0.8,0.9,1,1)	(0.667,0.778,0.889,1)	(0,0,0.222,0.333)	(0.222,0.333,0.444,0.556)

Construct the weighted normalized matrix

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Table4-Fuzzy weighted normalized matrix

Criterion	**Alternatives**				
	A1	**A2**	**A3**	**A4**	**A5**
D_1	(0.14,0.24,0.32,0.45)	(0.42,0.56,0.64,0.81)	(0.467,0.622,0.711,0.9)	(0.467,0.622,0.711,0.9)	(0.467,0.622,0.711,0.9)
D_2	(0,0,0.2,0.3)	(0.64,0.81,1,1)	(0.533,0.7,0.889,1)	(0.533,0.7,0.889,1)	(0.178,0.3,0.444,0.556)
D_3	(0.42,0.56,0.64,0.81)	(0.56,0.72,0.8,0.9)	(0.311,0.444,0.533,0.7)	(0.156,0.267,0.356,0.5)	(0,0,0.178,0.3)
D_4	(0.12,0.21,0.32,0.45)	(0.12,0.21,0.32,0.45)	(0.044,0.1,0.178,0.278)	(0,0,0.089,0.167)	(0.044.0.1,0.178,0.278)
D_5	(0.12,0.35,0.4,0.54)	(0.24,0.35,0.4,0.54)	(0.089,0.167,0.222,0.333)	(0.267,0.389,0.444,0.6)	(0.178,0.278,0.333,0.467)
D_6	(0,0,0.08,0.15)	(0.16,0.27,0.4,0.5)	(0.089,0.167,0.267,0.389)	(0.044,0.1,0.178,0.278)	(0..089,0.167,0.267,0.389)
D_7	(0.64,0.81,1,1)	(0.48,0.63,0.8,0.9)	(0.178,0.3,0.444,0.556)	(0.533,0.7,0.889,1)	(0.356,0.5,0.667,0.778)
D_8	(0.04,0.09,0.16,0.25)	(0.12,0.21,0.32,0.45)	(0.089,0.167,0.267,0.389)	(0.133,0.233,0.356,0.5)	(0.044,0.1,0.178,0.278)
D_9	(0.04,0.09,0.16,0.25)	(0.16,0.27,0.4,0.5)	(0.089,0.167,0.267,0.389)	(0.089,0.167,0.267,0.389)	(0,0,0.089,0.167)
D_{10}	(0,0,0.04,0.09)	(0.08,0.18,0.2,0.3)	(0.067,0.156,0.178,0.3)	(0,0,0.044,0.1)	(0.022,0.067,0.089,0.167)

Determine the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS)

$$z_i^+ = \left\{ \begin{array}{l} (0.420,0.640,0.640,0.450),(0.640,1.000,1.000,0.640),(0.560,0.800,0.800,0.810),(0.120,0.320,0.320,0.450), \\ (0.240,0.400,0.400,0.540),(0.160,0.400,0.400,0.160),(0.640,1.000,1.000,1.000),(0.120,0.320,0.320,0.250) \\ (0.080,0.200,0.200,0.090) \end{array} \right\}$$

$$z_i^- = \left\{ \begin{array}{l} (0.001,0.010,0.027,0.108),(0,0,0,0.090),(0.031,0.117,0.210,0.478),(0,0,0.003,0.018),(0.001,0.005,0.010,0.046), \\ (0,0,0,0.003),(0.045,0.164,0.307,0.480),(0,0,0.001,0.006),(0,0,0.002,0.008),(0,0,0,0) \end{array} \right\}$$

calculate the distance of each alternative from FPIS

Table5- Distance of each alternative from FPIS

	Alternative				
D_1	0.31707	0.154056	0.189483	0.189483	0.189483
D_2	0.796367	0.183394	0.240024	0.240024	0.550464
D_3	0.176068	0.05902	0.279615	0.451595	0.661818
D_4	0.063509	0.063509	0.169619	0.260225	0.169619
D_5	0.028868	0.028868	0.199016	0.037658	0.089457
D_6	0.302903	0.157797	0.183435	0.225828	0.183435
D_7	0.109697	0.254755	0.578571	0.189767	0.376942
D_8	0.165025	0.103441	0.110279	0.115635	0.154776
D_9	0.231589	0.126689	0.167726	0.167726	0.301697
D_{10}	0.151438	0.086506	0.090569	0.149942	0.107597

Calculate the distance of each alternative from FNIS

Table6- Distance of each alternative from FNIS

	Alternative				
Criteri	**A1**	**A2**	**A3**	**A4**	**A5**
D_1	0.262678	0.580975	0.64937	0.64937	0.64937
D_2	0.143817	0.870814	0.782389	0.782389	0.370452
D_3	0.413131	0.56001	0.303166	0.131212	0.10181
D_4	0.285485	0.285485	0.158064	0.078102	0.158064
D_5	0.374803	0.374803	0.196787	0.418154	0.307048
D_6	0.075789	0.350855	0.243151	0.163703	0.243151
D_7	0.634889	0.462831	0.127732	0.541568	0.333936
D_8	0.146129	0.289733	0.242065	0.322123	0.162578
D_9	0.145232	0.349012	0.241194	0.241194	0.082118
D_{10}	0.043322	0.200445	0.185256	0.048144	0.093888

Calculate the distance from each alternative to FPIS and FNIS

	A1	A2	A3	A4	A5
d^+	2.342532	1.218034	2.208337	2.027882	2.785289
d^-	2.525275	4.324964	3.129174	3.375959	2.502415

Determine the closeness coefficient

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Alternative	CC_i	Rank
A_1	0.518770596	4
A_2	0.780257203	1
A_3	0.586260904	3
A_4	0.624733199	2
A_5	0.473251715	5

$$R(A_2) > R(A_4) > R(A_3) > R(A_1) > R(A_5)$$

Based on the closeness coefficients value the second alternative namely noise pollution is the highest value followed by the fourth alternative work pressure and the third alternative psychological disturbances. The two alternatives air pollution and prolonged standing are in the last two places. So, for the given group of diseases, the main cause is noise pollution.

IV. CONCLUSION

In this paper, fuzzy TOPSIS method is used to identify the main cause for the group of diseases given by the experts. According to decision maker's opinion, fuzzy decision matrix is obtained. The trapezoidal fuzzy number is being normalised and normalised decision matrix is determined. The Experts gave the weight of alternative as a linguistic variable. Then the weighted normalised is obtained. Fuzzy positive ideal solution and fuzzy negative ideal solution is obtained. Euclidean distance from FPIS and FNIS with respect to each criterion is calculated. Using the value of closeness coefficient the ranking of alternatives is obtained. The health hazards of traffic police are analysed and identified that the noise pollution is the main cause for the group of diseases.

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