Selecting best tractor ranking wise by software using MADM (Multiple – approach decision making approach)

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Abstract – *An extension of TOPSIS (Technique for order performance by similarity to ideal solution), a Multi-attribute decision making (MADM) technique, to a group decision environment investigated. TOPSIS is a useful technique in dealing with MADM problems in the real world. MADM is a practical tool for selection and ranking a number of alternatives its applications are numerous. In classical MADM methods, the ratings and the weights of the criteria are known precisely. Since human judgments including preferences are often vague and cannot be expressed by exact numerical values, the application of fuzzy concepts in decision making is deemed to be relevant. In recent years TOPSIS has been successfully applied to the areas of human resources, management, transportation, product design, manufacturing, water management, quality control and many more areas. We design a model of TOPSIS for the fuzzy environment with the introduction of appropriate negations for ideal solutions. This paper represents an optimization model to determine attribute weights for MADM problems with incomplete weight information. In this method, a series of mathematical programming models are constructed and transformed into a single mathematical programming model to determine the weight of attributes. A concrete problem for selecting best tractor is discussed in the paper, describes the complete process of method.*

Key Words: *Tractor, TOPSIS, MADM, Best Tractor, Software Selection, Best Automobile*

1. INTRODUCTION

"Multi-attribute decision making (MADM) is the most well-known branch of decision making. It is branch of a general class of operations research models that deals with decision problems under the presence of a number of decisions criteria. The MADM approach requires that the selection be made among decision alternatives described by the attributes. MADM problems are assumed to have a predetermined, limited number of decision alternatives. Solving a MADM problem involves sorting and ranking.

MADM approaches can be viewed as alternative methods for combining the information in a problem's decision matrix together with additional information from the decision make to a determine a final ranking or selection from among the alternatives.

A MADM problem with *m* criteria and *n* alternatives can present according to C1…Cm and A1…An as criteria and alternatives, respectively. Moreover, A MADM methodology is shown as 'decision table' (table 1). Each row and column presents the alternatives and criteria, respectively. The score aij describes the value and amount of alternative Aj against criterion Ci. In addition, weights W1…Wm should be assigned to every criterion. Weight presents the importance of criterion Ci to the decision, and is assumed to be positive. After filling the decision table by decision-maker experience, a MADM technique must be selected in order to rank and select alternatives.

Table -1: Decision Table

	W_1			W_m
	C_1	.	.	C_m
A_1	a_{11}	.	.	a_{n1}
.	.	.	.	.
.	.	.	.	.
A_n	a_{n1}	.	.	a_{mn}

Zhang Yao & Fan Zhiping [1] developed a method attribute decision making based on incomplete linguistic judgment matrix. This matrix is transformed into incomplete fuzzy judgment matrix and an optimization model is developed on the basis of incomplete fuzzy judgment matrix provided by the decision maker and the decision matrix to determine attribute weights by lagrange multiplier method. Then the overall values of all alternatives are calculated to rank them.

Jian Ma [2] gives an approach to multiple attribute decision making based on preference information on alternatives, where multiple decision makers gives theory preference information on alternatives in different formats. To reflect decision makers preference information, an optimization model is constructed to assess attribute weights and then to rank the alternatives or select the most desirable one.

Patricia A. Berger [3] describes the development of a multi-attribute decision model that generates depictions of the agricultural landscape for use in alternative future studies. The model first evaluates any changes in the land base due to conversion of farmland to non-agricultural uses, and then uses field descriptions, crop characteristics, and the decision paradigm of an agricultural producer to determine the preferred crop for each field under a particular policy scenario.

Celik Parkan & Ming-Lu Wul [4] presents a decision-making and performance measurement models with applications to robot selection. This model demonstrates the use of and compares some of the current multi-attribute decision making (MADM) and performance measurement methods through a robots selection problem. The final selection is made on the basis of the rankings obtained by averaging the results of OCRA, TOPSIS, and a utility model.

1.1 TOPSIS

Technique for order preference by similarity to ideal solutions (TOPSIS) is one of the technique for solving decision-making problems. This technique is suggested by Yoon & Hwang in 1981. Any problems of the type of the multi-attribute decision with M alternative and N criteria can be evaluated in a geometric system with 'm' points in 'n' dimensional space. Based on the idea the best alternative should have the shortest distance from a positive ideal solution (the best possible) and the longest distance from negative ideal solution (the worst possible).

The TOPSIS technique consists of following steps.

Step 1: Normalize the decision matrix: The normalization of the decision matrix is done using the below transformation for each nij :

$$n_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}}$$

Then, weights should be multiplied to normalized matrix.

Step 2: Determine the positive and negative ideal alternatives:

Error! Reference source not found. = {**Error! Reference source not found.** , **Error! Reference source not found.** , … , **Error! Reference source not found.**} = {(**Error! Reference source not found.** | $j \in J$) , (**Error! Reference source not found.** | $j \in J'$ / i = 1 , 2 , … , m)}

J = { j = 1 ,2 , … , n | $j f$ or positive attributes }

Positive attribute: The one which has the best attribute values (more is better).

J' = { j = 1 , 2 , … , n | $j f$ or negative attributes }

Negative attribute: The one which has the worst attribute values (less is better).

In addition, the weighted normalized decision matrix should be calculated with multiplying the normalized decision matrix by its associated weights. The weighted normalized value **Error! Reference source not found.** is calculated as: **Error! Reference source not found.** = **Error! Reference source not found.**

Where **Error! Reference source not found.** represents the weight of the *jth* attributes or criterion.

Error! Reference source not found. = {**Error! Reference source not found.** , **Error! Reference source not found.** , … , **Error! Reference source not found.** } = {(**Error! Reference source not found.** | $j \in$ J) , (**Error! Reference source not found.** | $j \in$ J' | i = 1,2, … , m)}

J = { j = 1,2, … , n | $j f$ or positive attributes}

J' = { j = 1,2, … , n | $j f$ or negative attributes}

Step 3: Obtain the separation measure (based on Euclidean distance) of the existing alternatives from ideal and negative one (the separation between alternatives will be found according to distance measure called normalized Euclidean distance (Szmidt & Kacprzyk, 2000)):

*d***Error! Reference source not found.**= {**Error! Reference source not found.** - **Error! Reference source not found.** ; *i* = 1,2, … , *m*

*d***Error! Reference source not found.**= {**Error! Reference source not found.** - **Error! Reference source not found.** ; *i* = 1,2, … , *m*

Step 4: Calculate the relative closeness to the ideal alternatives:

*cl***Error! Reference source not found.** = *d***Error! Reference source not found.** / (*d***Error! Reference source not found.** + *d***Error! Reference source not found.**) ; 0 ≤ *cl***Error! Reference source not found.**≤ 1 : *i* = 1,2, … , *m*

Step 5: Rank the alternatives: based on he relative closeness to the ideal alternative, the most is the *cl*Error! Reference source not found., the better is the alternative **Error! Reference source not found.**.

A.S Milani [5] evaluates the effect of different normalization norms within multiple attribute decision making (MADM) models. The application of the work is dedicated to gear material selection for power transmission. Technique for order preference by similarity to ideal solution (TOPSIS) is employed to weigh the selected failure criteria and to rank the selected material IDs, respectively. A simple multi-axial strategy is also recommended from which safer engineering decisions may be attained.

2. PROBLEM FORMULATION

India is a republic and democratic country celebrating its 66th republic day in year 2015. Therefore becoming an advanced country from day to day, year to year there are lots of many up gradations in every field of technology. Today demand for all kind of products is increasing day by day with many options available hence increasing the competition day by day.

Basically, people in India have a single kind of mentality i.e. A person should have as much as he/she can have in lest amount of rupees. But in technical aspects, the product should be good in terms of technical aspects according to the requirement of applications. Therefore this paper will help to find out the best product according to the need of required applications.

To carry out the research work in this paper total 6 numbers models have been selected and all the models selected are of same power. The tractor models which have been compared in the paper have been shown in table 2.

Table -2: Models with make

S.No	Model Name	Tractor Make
1	DI 740 III S3	International Tractors Limited (ITL)
2	744 FE	Punjab Tractors Limited (PTL)
3	5045 D	John Deere India Private Limited (John Deere)
4	EICHER 5150	Tractors and Farm Equipment Limited (TAFE)
5	2042 DI	Indo Farm Equipment Limited (Indo Farm)
6	PREET 4549	Preet Group of Companies (Preet)

The technical attributes of the above listed models have been discussed below in the paper.

2.1 Technical attributes

The research has been carried out in this paper to find the best tractor among the six selected tractors. Configurations of all the six tractors have been collected and same have been shown in table 3 in the comparison form. Total six configurations have been compared in the table 3.

Table -3: Comparison of tractor configurations

Make Specs	ITL	PTL	John Deere	TAFE	Indo Farm	Preet
Model	DI 740 III S3	744FE	5045 D	EICHER 5150	2042DI	PREET 4549
Power (In HP)	45 HP	45 HP	45 HP	45 HP	45 HP	45 HP
Engine (In CC)	2780	3136	2615	2500	2476	2892
Lift (In KG)	1200	1500	1400	1500	1400	1800
PTO (In RPM)	1000	1000	540	625	1000	540
Gears (In NOS.)	10	10	12	10	10	10
Ground Clearance (In MM)	425	400	420	355	380	415
Tractor Price (In Lacs)	3.16	3.26	3.26	3.14	2.90	3.09

3. METHODOLOGY

To carry out the research work MADM approach has been used, the work has been carried out in total four number of different phases. All the phases has been described in the paper research work has been done in the different phases.

3.1 Survey

The first initiatory step to carry out the research work is to collect the attributes i.e. data on which the research could be done. The data has been collected on tractors for

which six numbers of companies has been surveyed. Survey has been done in the companies like – International tractors limited, Punjab tractors limited, John deere, Tafe, Indofram and Preet tractors.

3.2 Data segregation and preparation

After the data (attributes) has been collected, it is necessary to segregate the data in a tabular form so as to compare the attributes. This has already been shown in table 3.

3.3 Manual comparison of technical attributes

The manual comparison has been done by using TOPSIS of MADM approach. However, to perform the manual comparison there are some steps for manual comparison , equations are used for manual comparison and there are also some rules for manual comparison.

There are total six steps for manual comparison that are given below:

Step 1: Prepare decision matrix

Step 2: Normalize the matrix

Step 3: Assign the weightage to the attributes

Step 4: Multiply the weightage to the normalized matrix.

Step 5: Apply TOPSIS i.e. calculate Ideal positive & Negative alternatives

Step 6: Calculate the relative closeness i.e. 1.

There are total five numbers of different equations used for the manual comparison and those are given below in table 4.

Table -4: Equations used in manual comparison

Sr. No.	Area of applying equation	Equation
1.	To prepare normalize matrix	$n_{ij} = \dfrac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}}$
2.	Multiplying weightage and normalize matrix	**Error! Reference source not found. = Error! Reference source not found. Error! Reference source not found.**
3.	Calculating ideal positive attribute	**Error! Reference source not found. = { Error! Reference source not found. - Error! Reference**
4.	Calculating ideal negative attribute	**source not found. Error! Reference source not found.** **Error! Reference source not found. = { Error! Reference source not found. - Error! Reference source not found. Error! Reference source not found.**
5.	Relative closeness	C = **Error! Reference source not found.** / (**Error! Reference source not found. + Error! Reference source not found.**)

There are also some rules for comparison while using TOPSIS technique. These rules should be always kept in mind while making comparison. Total three rules have been given below in this paper.

Rule 1: The rows and column of decision matrix should be of same quantity i.e. the number of companies (alternative) should be same to the number of specifications (attributes). Therefore in the work content total 6 (six) different attributes have been considered of total 6 (six) different companies.

Rule 2: The specifications (attributes) should be considered of common platform. Therefore, in the work content the specification of 45 HP tractor model has been considered of six different companies.

Rule 3: Weightage should be assigned to every type of specification such that the sum of all the specifications should come out to b one (1) only. Weightage can be assigned according to the need of consumer. It is not necessary to assign a fix weightage to any kind of specification.

The weightages to the specifications will be assigned by the consumer. The higher weightage can be assigned to the specifications which is on most priority and similarly the weightage will continue to decrease to the least priority specification (attribute).

The weightages assigned should be such that the sum of these weightages should comes out to be one (1) only. Table 5 shows the weightage assigned to the specifications (attributes).

Table -5: Weightage assigned to specifications (attributes)

Sr. No.	Specification (Attribute)	Weightage assigned
1.	Engine displacement	0.25
2.	Hydraulic lift capacity	0.18
3.	Power take off	0.15
4.	Gear speeds	0.12
5.	Ground Clearance	0.10
6.	Tractor Price	0.20

Manual comparison of the problem has been done below in the paper by using TOPSIS technique of MADM approach. The calculation will be done as per the six discussed steps.

Step 1: Prepare the decision matrix

$$\begin{bmatrix} 2780 & 3136 & 2615 & 2500 & 2476 & 2892 \\ 1200 & 1500 & 1400 & 1500 & 1400 & 1800 \\ 1000 & 1000 & 540 & 625 & 1000 & 540 \\ 10 & 10 & 12 & 10 & 10 & 10 \\ 425 & 400 & 420 & 355 & 380 & 415 \\ 316000 & 326000 & 326000 & 314000 & 290000 & 309000 \end{bmatrix}$$

Step 2: Normalize the decision matrix: The above discussed equation will be used to normalize the prepared decision matrix ,and the normalized matrix (**Error! Reference source not found.**) is given below.

$$\begin{bmatrix} 0.000879701 & 0.00961908 & 0.000802112 & 0.00796141 & 0.008853746 & 0.00935863 \\ 0.00379727 & 0.00460094 & 0.000429429 & 0.000477685 & 0.004482732 & 0.00582487 \\ 0.00316439 & 0.00306729 & 0.00165636 & 0.00199085 & 0.00344808 & 0.00174746 \\ 3.16439e{-}005 & 3.06729e{-}005 & 3.68082e{-}005 & 3.18457e{-}005 & 3.44809e{-}005 & 3.23604e{-}005 \\ 0.00134486 & 0.00122691 & 0.00128828 & 0.00113052 & 0.00131027 & 0.00134295 \\ 0.99994819 & 0.99993770 & 0.99995641 & 0.99995430 & 0.99994510 & 0.99993683 \end{bmatrix}$$

Step 3: Assign weightage (**Error! Reference source not found.**) to the attributes

Error! Reference source not found. = 0.25

Error! Reference source not found. = 0.18

Error! Reference source not found. = 0.15

Error! Reference source not found. = 0.12

Error! Reference source not found. = 0.10

Error! Reference source not found. = 0.20

The weightage matrix (**Error! Reference source not found.**) is mentioned below

$$\begin{bmatrix} 0.25 \\ 0.18 \\ 0.15 \\ 0.12 \\ 0.10 \\ 0.20 \end{bmatrix}$$

Step 4: Multiplying the weightage matrix (**Error! Reference source not found.**) and normalized matrix (**Error! Reference source not found.**) to form weight normalized matrix (**Error! Reference source not found.**). The weight normalized matrix (**Error! Reference source not found.**).

$$\begin{bmatrix} 0.00219925 & 0.00173142 & 0.00120316 & 0.00095536 & 0.00085374 & 0.00187172 \\ 0.00094931 & 0.00082816 & 0.00064414 & 0.00057322 & 0.00048273 & 0.00116497 \\ 0.00079109 & 0.00055211 & 0.00024845 & 0.00023884 & 0.00034480 & 0.00034949 \\ 0.00000791 & 0.00000552 & 0.00000460 & 0.00000382 & 0.00000344 & 0.00000647 \\ 0.00033621 & 0.00022084 & 0.00019324 & 0.00013566 & 0.00013102 & 0.00026859 \\ 0.24998704 & 0.17998878 & 0.14999346 & 0.11999451 & 0.09999451 & 0.19998736 \end{bmatrix}$$

Step 5: Apply TOPSIS, calculate ideal positive and negative attributes

Take out **Error! Reference source not found.** array [Highest (+ve) value in column] from weight normalized matrix **Error! Reference source not found.**).

Take out **Error! Reference source not found.** array [Highest (-ve) value in column] from weight normalized matrix **Error! Reference source not found.**).

Now, calculate ideal positive (**Error! Reference source not found.**) & ideal negative (**Error! Reference source not found.**) alternative.

Ideal positive alternative, **Error! Reference source not found.** = [**Error! Reference source not found.** - Error! Reference source not found. Error! Reference source not found.**

Ideal negative alternative, **Error! Reference source not found.** = [**Error! Reference source not found.** - Error! Reference source not found. Error! Reference source not found.**

Prepare, separation measurement matrix by using ideal positive (**Error! Reference source not found.**).

Put all the values in the matrix (**Error! Reference source not found.**)

$$\begin{bmatrix} 0.06139878 & 0.03177568 & 0.02213855 & 0.1417031 & 0.00982889 & 0.03924980 \\ 0.06201979 & 0.03209852 & 0.02230521 & 0.1426144 & 0.00990259 & 0.03953034 \\ 0.06209862 & 0.03219751 & 0.02242356 & 0.1434142 & 0.00993006 & 0.03985527 \\ 0.06248956 & 0.03239397 & 0.02249665 & 0.14397765 & 0.00998214 & 0.03999235 \\ 0.06232553 & 0.03231651 & 0.02244010 & 0.1436614 & 0.00997271 & 0.03988758 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Now, add all the rows

Error! Reference source not found. =**Error! Reference source not found.** **Error! Reference source not found.**

Error! Reference source not found. = 0.422565, **Error! Reference source not found.** = 0.424401, **Error! Reference source not found.** = 0.42525,   **Error! Reference source not found.** = 0.426342, **Error!**

Reference source not found. = 0.425802, **Error! Reference source not found.** = 0

Prepare, separation measurement matrix by using ideal positive (**Error! Reference source not found.**).

Put all the values in the matrix (**Error! Reference source not found.**)

$$\begin{bmatrix} 0.00000480 & 0.00000297 & 0.00000143 & 0.00000090 & 0.0000007Z & 0.00000347 \\ 0.00000088 & 0.00000067 & 0.00000040 & 0.00000324 & 0.0000002Z & 0.00000134 \\ 0.00000061 & 0.00000029 & 0.00000005 & 0.00000005 & 0.00000011 & 0.00000011 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0.00000010 & 0.00000004 & 0.00000003 & 0.00000001 & 0.00000001 & 0.00000006 \\ 0.06248956 & 0.03239397 & 0.02249665 & 0.01439776 & 0.00999821 & 0.03999235 \end{bmatrix}$$

Now, add all the rows

Error! Reference source not found. =**Error! Reference source not found.** **Error! Reference source not found.**

Error! Reference source not found. = 0.003741, **Error! Reference source not found.** = 0.001965, **Error! Reference source not found.** = 0.001122, **Error! Reference source not found.** = 0, **Error! Reference source not found.** = 0.000540, **Error! Reference source not found.** = 0.426342

Step 6: Calculate the relative closeness (**Error! Reference source not found.**) by using the below mentioned formula

Error! Reference source not found. = **Error! Reference source not found.** ; 0 < **Error! Reference source not found.** < 1

Error! Reference source not found. = 0.0087753, **Error! Reference source not found.** = 0.0046087, **Error! Reference source not found.** = 0.0026315, **Error! Reference source not found.** = 0, **Error! Reference source not found.** = 0.0012665, **Error! Reference source not found.** = 1

Hence, based upon the relative closeness calculated, ranking is shown in table 6.

Table -6: Calculated tractor ranking after manual comparison.

Ranking	Model	Make
1st	PREET 4549	PREET Tractors
2nd	DI 740 III S3	International Tractors Limited
3rd	744 FE	Punjab Tractors Limited
4th	5045 D	JOHN DEERE
5th	2042 DI	INDOFARM
6th	EICHER 5150	TAFE

3.4 Software comparison of technical attributes

After doing the manual comparison of the attributes, to prove out the work the comparison can also be done with the software. Author, has prepared a software on the platform of C language. Snapshots of the comparison is shown figure 1 and figure 2.
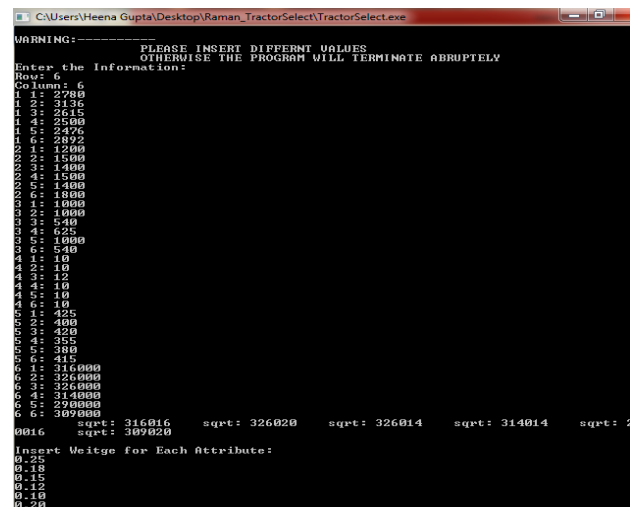

Fig -1: 1st snapshot 1 of software comparison

Fig -2: 2nd snapshot of software comparison

4. CONCLUSION

After the manual comparison of attributes by using MADM approach and TOPSIS, it has been truly diversified the range for selecting any best option in any area of application. Here in this paper, the comparison has been done to select a best tractor and to prepare the ranking, similarly this technique can be used to select any best automobile or any other items which have their own particular specifications. Thus the conclusion here comes that MADM approach using TOPSIS can be used in any term or in any area of field to select any of the best option.

ACKNOWLEDGEMENT

REFERENCES

[1] Zhang Yao and Fan Zhiping, "Method for multiple attribute decision making based on incomplete linguistic judgment matrix", Science Direct, Year 2008, Vol-19, Issue 2, 298-303.

[2] Jian Ma, "An Approach to Multiple Attribute Decision Making Based on Preference Information on Alternatives", Elsevier North-Holland, Year 2002, Vol.-131, Issue 1, 101-106.

[3] Particia A. Berger, "Generating Agricultural Landscape for Alternative Futures Analysis: A Multiple Attribute Decision-Making Model", Pergamon Press, Year 1998.

[4] Celik Parkan and Ming-Llu Wul, "Decision-making and performance measurement models with applications to robot selection", Year 1999, Vol-36, Issue 3,503-523.

[5] A.S. Milani, A. Shanian, R.Madoliat and J.A. Nemes, "The effect of normalization norms in multiple attribute decision making models: a case study in gear material selection", Springer link journal article, Year 2004, vol.-29, 312-318.