A Performance Appraisal Model using Fuzzy Multi Criteria Group Decision Making

A.Uma Maheswari , P.Kumari

Abstract— The aim of this paper is to demonstrate the application of fuzzy numbers in HR management. The performance appraisal process has become the integral part of the Human Resource Management System in the organizations. Performance appraisal defines and measures the performance of the employees and the organization as a whole. It is a tool for assessing the performance of the employees and in turn the Organization. The evaluation of employees is based on multiple criteria evaluations. In this paper an efficient Fuzzy Multi Criteria Group Decision Making FMCGDM model is deviced to rank the employees in an organization based on the performance appraisal. Performance appraisal is influenced by several parameters which are linguistic. Therefore to quantify the linguistic variables fuzzy Trapezoidal numbers are used and are represented graphically using Matlab software. The ranking of the employees is made using Schwartz Beat Path Method. Finally to clarify the proposed procedure, a case study is discussed.

Index Terms. Performance appraisal, fuzzy Trapezoidal numbers, Fuzzy Multi Criteria Group Decision Making, linguistic variables.

1 Introduction

Performance appraisal is a formal management system that provides for the evaluation of the quality of an individual's performance in an organization [1]. Performance appraisal rates the employees in terms of their performance. Performance appraisals of Employees are necessary to understand each employee's abilities, competencies and relative merit and worth for the organization.

360 degree feedback, also known as 'multi-rater feedback', is the most comprehensive appraisal where the feedback about the employees' performance comes from all the sources who are in contact with the employee during the execution of specified job.Performance appraisal is a system for evaluating and recognizing people related to their jobs (Mondy, 1993). Performance appraisal is a formal system to re-learn and evaluate the someone's performance (Mayfield, 1984).

Organizations are increasingly using feedback from various sources such as peer input, customer feedback and input from superiors. Different forms with different formats are being used to obtain the information regarding the employee performance. Some potential aims of performance appraisal includes identifying particular behavior or job[2].

Various techniques or methods have been used by human resource management experts to evaluate the performance of an employee. Regardless of the performance appraisal type, the main purpose of an appraisal is to encourage and develop employees, facilitate goals to be achieved, identify improvement areas and training needs. It continually motivates employees to better their performance since nobody would like to be included in the poor performance band. The purpose of assessment by allocating a score to employee's performance may be used for both development and salary or promotion purposesThe most common performance appraisal types are: Ranking Method, Essay methods, Results oriented (also known as Managing by Objective).

Ranking Methods are the most popular type of performance appraisal. The ranking system refers to the performance appraisal model in which best-to-worst ranking methods are used to identify and separate the poor performers from the good performers. Under this method, the ranking of an employee in a work group is done against that of another employee. The relative position of each employee is tested in terms of his numerical rank.The advantages of ranking method is to rank the Employees according to their performance levels and also it is easier to rank the best and the worst employee.

2 Evaluation Criteria in Performance Appraisal

One of the steps in designing an appraisal programme is to determine the evaluation criteria related to the job.

2.1 Behavior

Rating employees according to job behaviors is based on the assumption that there are effective and ineffective behaviors and that these have been identified for each job or type of job. Behaviors are judged effective or ineffective in terms of the results the behaviors produce (either desirable or undesirable). For example, a customer service representative could be judged on the amount of patience shown to furious customers. Evaluating employees along behavioral dimensions is especially important for employee development purposes.

2.2Job-Result

Result indexes are often used for appraisal purposes if an

- *A.Uma Maheswari, Associate Professor in Mathematics, Quaid-E-Millath Government College for Women (Autonomous)Chennai,India*
- *P.Kumari Assistant Professor in Mathematics ,G.S.S.Jain College for Women,Chennai,India E-mail: kumari_sw15@yahoo.*

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employee's job has measurable results. Examples of job results indexes are money volume of sales, amount of scrap and quantity and quality of work produced. When such quantitative results are not available, evaluators tend to use appraisal forms based on employee behaviors and/or personal characteristics. In some cases, appraisals may of necessity focus on results rather than behaviors. This is especially true where job content is highly variable, as in many managerial positions, thus making it difficult to specify appropriate behaviors for evaluative purposes. Result indexes such as turnover, absenteeism, grievances and profitability and production rates can be used to evaluate the performance of organization units.

The common criteria for assessing performance are Quality, Quantity, Timeliness, Cost Effectiveness , Need for Supervision , Interpersonal impact.[3]

2.3 Standards

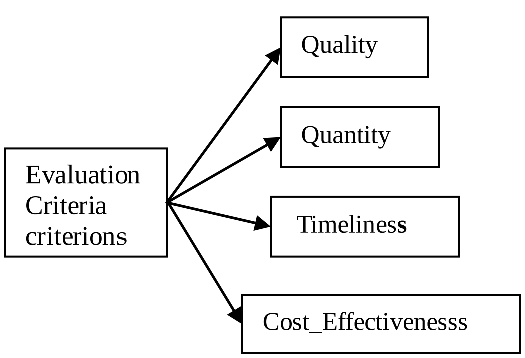
The performance standards are expressions of the performance threshold(s), requirement(s), or expectation(s) that must be met for each element at a particular level of performance. They must be focused on results and include credible measures such as:

• QUALITY, addresses how well the employee or work unit is expected to perform the work and/or the accuracy or effectiveness of the final product. It refers to accuracy, appearance, usefulness and effectiveness. Measures can include error rates (such as the number or percentage of errors allowable per unit of work) and customer satisfaction rates (determined through a customer survey/feedback).

• QUANTITY addresses how much work the employee or work unit is expected to produce. Measures are expressed as a number of products or services expected, or as a general result to achieve.

• TIMELINESS addresses how quickly, when, or by what date the employee or work unit is expected to produce the work.

• COST-EFFECTIVENESS addresses cost savings or cost control. These should address cost-effectiveness on specific resource levels (money, personnel, or time) that can generally be documented and measured. Cost-effectiveness measures may include such aspects of performance as maintaining or reducing unit costs, reducing the time it takes to produce or provide a product or service, or reducing waste.



2.4 Time period

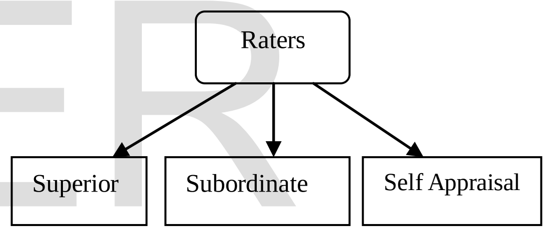
Performance can be appraised

- After each project is completed
- After a milestone is reached
- Quarterly
- Semi-Annually
- Annually

Many employers use rating committees to evaluate employees. These committees rate the employees based on the set criterions.

2.5 Raters

Raters can be immediate supervisors, specialists from the HR department , subordinates, peers, committees, clients, self appraisal. When appraisal is made by superiors, peers, subordinates and clients it is called 360- degree system of appraisal. First developed at General Electric , USA in 1992,the system has become popular in India too.GE India, Reliance Industries, Crompton Creaves, Wipro, Infosys and many others are using this method with greater benefits [4]



3 DECISION MAKING

Decision making problem is the process of finding the best option from a set of the feasible alternatives. In almost all such problems the multiplicity of criteria for judging the alternatives is large. That is, the decision maker DM wants to solve a multiple criteria decision making (MCDM) problem. In classical MCDM methods ,the ratings and the weights of the criteria are known precisely. However, under many conditions, crisp data are inadequate to model real-life situations since human judgments including preferences are often vague and cannot estimate his preference with an exact numerical value.

A more realistic approach may be to use linguistic assessments instead of numerical values, that is, to suppose that the ratings and weights of the criteria in the problem are assessed by means of linguistic variables. Lingual expressions, for example, low, medium, high, etc. are regarded as the natural representation of the judgment. These characteristics indicate the applicability of fuzzy set theory in capturing the decision makers' preference structure. Researchers have demonstrated that fuzzy set theory could be successfully used to solve multiple criteria problems [5].

Fuzzy set theory aids in measuring the ambiguity of concepts that are associated with human being's subjective judgment. Moreover, since in the group decision making, evaluation is resulted from different evaluator's view of linguistic variables, its evaluation must be conducted in an uncertain, fuzzy environment. The goal of the multiple criteria decision-making (MCDM) method is to aid decision-makers in integrating objective measurements with value judgments that are based not on individual opinions but on collective group ideas [6].

4 Fuzzy Group Decision Making

Kacprzyk and Nurmi (1998) present a methodology which takes in opinions of m individuals concerning n crisp alternatives, and then outputs an alternative (or a set of alternatives) that are preferred by most individuals. Each individual is required to make a pairwise comparison between the alternatives; then a fuzzy preference relation matrix is constructed for each expert, results aggregated, and a group decision made. Unlike the above methodology which assign different experts different levels of importance in this paper the model assigns equal weightage for all DM's opinion . Since Zadeh (1965) proposed the fuzzy theory [7], Bellman and Zadeh (1970) explored the decision-making methods under fuzzy environment [8]. They made fuzzy theory to have a considerable theoretical basis in the study of uncertainty. When FMCDM is introduced into the activities of performance appraisal, the decision-making methods more complying with DM's thinking are used and the framework of a decision support system can be constructed. The traditional multiple criteria analysis did not directly use the concept or method of fuzzy to solve the problem of inaccuracy. In this paper the model is designed so as to overcome the ambiguity in performance appraisal using TrFN's.

5 Preliminaries

The theory of fuzzy set is based on Zadeh [6], involves a mathematical description of vague (inexact, fuzzy) elements, with the vagueness of information resulting from the lack of uniqueness or selectivity

5.1 Fuzzy Set

A Fuzzy set is a set whose boundary is not clear, whose elements are characterized by a membership function. Let X be a universal set. A fuzzy set $\tilde{A}$ defined on X is a set of order pair of elements, whose first element x $\in$ X, second element $\mu_{\tilde{A}}$ (x) is the membership value of element x in the set $\tilde{A}$. It is denoted by $\tilde{A}$ or A, and is defined by

$\tilde{A} = \{(x; \mu_{\tilde{A}}(x)) \mid x \in X\}$ where $\mu_{\tilde{A}}(x) \to K$ and $K \in [0; 1]$.

5.2 Fuzzy Number

Fuzzy number is expressed as fuzzy set defined in the interval of real number $\tilde{R}$. Since the boundary of this interval is ambiguous thus interval is also a fuzzy set. Among the various types of fuzzy numbers, triangular and trapezoidal fuzzy numbers are the most important. The trapezoidal fuzzy numbers pose several advantages over triangular fuzzy numbers as they are a more generalized form.

Trapezoidal fuzzy numbers of the form (a , b, c , d) have some of the following advantages over other linear and non linear membership functions[9]. The trapezoidal fuzzy numbers form the most generic class of fuzzy numbers with linear membership function and therefore have more applicability in modeling linear uncertainty in scientific and applied engineering problems including fully fuzzy linear systems, fuzzy transportation problems, ranking etc. In this paper a specific attention is given to trapezoidal fuzzy numbers.

6 Trapezoidal Fuzzy Number

6.1 Definition

A trapezoidal fuzzy number $\tilde{A} \approx (a_1, a_2, a_3, a_4)$ is defined by the membership function as

$$\mu_{\tilde{A}}(x) \approx \begin{cases} (x - a_1)/(a_2 - a_1) & \text{if } a_1 \le x \le a_2 \\ 1 & \text{if } a_2 \le x \le a_3 \\ (x - a_4)/(a_3 - a_4) & \text{if } a_3 \le x \le a_4 \\ 0 & \text{otherwise} \end{cases}$$

satisfying the following conditions:

(1) $\mu_A(x)$ is a continuous mapping from R to the closed interval[0,1]

(2) $\mu_A(x) = 0$ for all $x \in (-\infty, a)$;

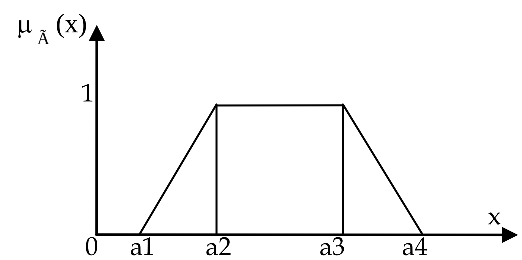
(3) Strictly increasing and continuous on [a,b]

(4) $\mu_A(x) = 1$ for all $x \in [c, d]$;

(5) Strictly decreasing and continuous on [c,d]

(6) $\mu_A(x) = 0$ for all $x \in (d, \infty)$;

The graphic representation of a trapezoidal fuzzy number is shown in Fig.1



Some basic definitions [10] of fuzzy trapezoidal numbers are presented here.

6.2 Ranking Function

If $\tilde{A} \approx$ (a1, a2, a3, a4) is a trapezoidal fuzzy number then the ranking function R ($\tilde{A}$) is given by

$$R(\tilde{A}) \approx \frac{(a1 + a2 + a3 + a4)}{4}$$

6.3 Unit and Zero fuzzy numbers

Unit fuzzy number is one for which R ($\tilde{A}$) is unity and similarly the zero fuzzy number is one for which R ($\tilde{A}$) is zero.

6.4 Equivalent fuzzy numbers

Two fuzzy numbers $\tilde{a}$ and $\tilde{b}$ are said to be equal if their Ranks are equal i.e., R (ã) ≈R(b̃).We say that ã is equal to b̃ and write ã ≈ b̃.

6.5 Order Relation of Fuzzy Numbers

Let ã = (a1, a2, a3, a4) and b̃ = (b1, b2, b3, b4) be any two trapezoidal fuzzy numbers. Then we define the order relation as ã ≤ b̃ iff R (ã) ≤ R(b̃).

6.6 Operations on Fuzzy Numbers

For ã ≈ (a1, a2, a3, a4) and b̃ ≈ (b1, b2, b3, b4) the following operations are defined.

Addition: ã ⊕ b̃ ≈ (a1+b1, a2+b2, a3+b3, a4+b4)

Subtraction: ã Θ b̃ ≈ (a1-b4, a2-b3, a3-b2, a4-b1)

Multiplication: ã ⊗ b̃
≈(a1(b1+b2+b3+b4)/4,a2(b1+b2+b3+b4)/4,a3(b1+b2+b3+b4)/4,a4(b1+b2+b3+b4)/4), if b̃ ⋧ Õ
≈ (a4(b1+b2+b3+b4)/4,a3(b1+b2+b3+b4)/4,a2(b1+b2+b3+b4)/4,a1(b1+b2+b3+b4)/4), if b̃ ⋦ Õ

Scalar Multiplication:

If k≠0 is a scalar, k ã is defined as,

$$k\tilde{a} \approx \begin{cases} (ka1, ka2, ka3, ka4) & \text{if } k > 0 \\ (ka4, ka3, ka2, ka1) & \text{if } k < 0 \end{cases}$$

7 BASIC MODEL

A systematic approach is proposed to extend the FMCDGM to rank the employees on the basis of their performance. The importance weight of various criteria and the ratings of qualitative criteria are considered as linguistic variables. In this paper to approximate the subjective judgment of decision makers, linear trapezoidal membership functions are used. These functions capture the vagueness of the linguistic assessments. Ranking and choosing the best performer is a group multiple criteria decision making problem. The following sets are used here

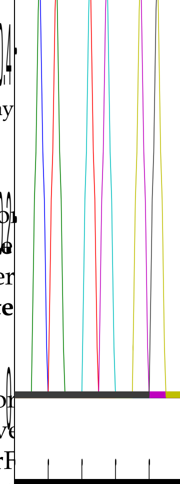
- A set of K decision makers { D1,D2, D3,……, Dk }
- A set of m possible alternatives { A1,A2, A3,……, Am }
- A set of n criterions { C1, C2, C3,……, Cn }, with which performance of employees are measured.
- A set of performance ratings X= {x ij, i= 1,2,…,m , j = 1,2,….,n}of the alternatives Ai with respect to criteria Cj

To rank the employees, seven fuzzy numbers are taken to describe the level of performance based on decision criteria as recommended by Salty(1977).FMGDM model includes the following steps.

Step1: Identifying the objectives of the decision making process.

Decision Making is the process of selecting the best alternative from different available alternatives. Thus defining the decision goal is the most important.

Step 2 : Arranging the Decision making group and describing a finite set of relevant attributes (criterions)



nployees in an organization several people fro ctional areas and also the employee himself are s identifying the criterias for evaluation of per nployees is an important task.

Ste ; the appropriate linguistic variable.

p the appropriate linguistic variable for impo f each criteria and fuzzy rating for alternative with regard to each criterion is expressed as TrF istic weight of criterion and ratings of alternatives with respect to qualitative data drawn using Matlab software is shown in Figure 2 and Figure 3 .

Fig 2.Linguistic variables for important weights for each criteria

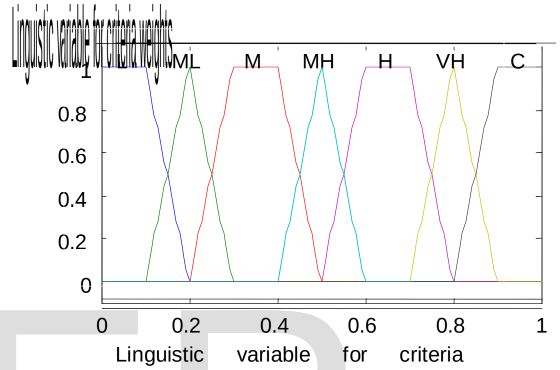
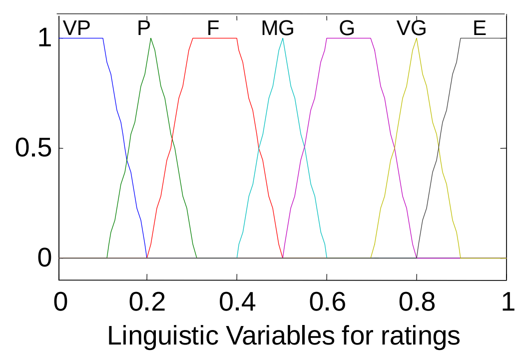


Fig 3. Linguistic variables for ratings



Step 4 : Presenting the DM's opinion to get the aggregated fuzzy weight of criteria and aggregated fuzzy rating of alternatives.

The fuzzy rating and importance weight of the kth DM respectively are

$$x_{ijk} = (x_{ijk1}, x_{ijk2}, x_{ijk3}, x_{ijk4})$$

$$w_{jk} = (w_{jk1}, w_{jk2}, w_{jk3}, w_{jk4})$$

where i = 1,2,….,m ; j = 1,2,….,n

The aggregated fuzzy ratings (xij) of alternatives with respect to each criterion can be calculated as

$x_{ij} = (x_{ij1}, x_{ij2}, x_{ij3}, x_{ij4})$ where $x_{ij1} = \min\{x_{ijk1}\}$, $x_{ij2} = \frac{1}{K}\sum_{1}^{K} x_{ijk2}$, $x_{ij3} = \frac{1}{K}\sum_{1}^{K} x_{ijk3}$, $x_{ij4} = \max\{x$

ijk4 }
The aggregated fuzzy weights (wj) of each criterion can be calculated as wj = (w j1, w j2, w j3, w j4)

where w j1 = min { w jk1} , w jk2 = $\frac{1}{n}\sum_1^K$ w jk2 , w jk3 = $\frac{1}{n}\sum_1^K$ w jk3 and w j4 = max { w jk4}

Step 5 : Constructing the fuzzy decision matrix using TrFN's obtained through linguistic evaluation.
The fuzzy decision matrix is

$$\tilde{D} = \begin{pmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots\cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots\cdots & \tilde{x}_{2n} \\ . & . & & . \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots\cdots & \tilde{x}_{mn} \end{pmatrix}$$

w=[w1,w2,…wn] where xij is the rating of alternative(employee)Ai with respect to Cj,wj is the importance weights of the jth criterion x ij = (x ij1, x ij2, x ij3, x ij4) and wj = (w j1, w j2, w j3, w j4) ; i = 1,2,….,m ; j = 1,2,….,n are linguistic variables approximated by positive trapezoidal numbers.

Step 6: Constructing the defuzzified decision matrix and fuzzy weights of each criterion in to crisp values.

To defuzzify the TrFN's A = (a,b,c,d) into real number centre of area method [11] is used

$$\text{Defuzzify}(x_{ij}) = \frac{\int x\,\mu(x)\,dx}{\int \mu(x)\,dx}$$

$$= \frac{\int_a^b \frac{x-a}{b-a}\,x\,dx + \int_b^c x\,dx + \int_c^d \frac{d-x}{d-c}\,x\,dx}{\int_a^b \frac{x-a}{b-a}\,dx + \int_b^c dx + \int_c^d \frac{d-x}{d-c}\,dx}$$

$$= \frac{-ab+\frac{1}{3}(d-c)^2+\frac{1}{3}(b-a)^2+cd}{-a-b+c+d} \qquad (1)$$

Step7 : Constructing the rank matrices Rj for each criteria

$$\begin{pmatrix} r_{1i}^1 & \ldots r_{1i}^p & \ldots\ldots r_{1i}^k \\ r_{ii}^1 & \ldots r_{ii}^p & \ldots\ldots r_{ii}^k \\ .. & \ldots .. & \ldots .. \; . \\ r_{mi}^1 & r_{mi}^p \ldots\ldots & r_{mi}^k \end{pmatrix}$$

where i=1,2,3,…………m, j=1,2,3,……….n , p= 1,2,3……k
Here the rows of the matrix are employees and the columns are the DM's opinion based on the jth criteria.

Step 8:Computing the linear sum $\sum_{p=1}^k r_{ii}^p$ of each row of rank matrix for all the DM's

Step 9: Constructing the final grade matrix R_G taking employees along rows and criterias along columns

$$R_G = \begin{array}{c} S_1 \\ S_2 \\ . \\ . \\ S_i \\ . \\ S_m \end{array}\begin{pmatrix} r'_{11} & r'_{12} & \ldots r'_{1j} & \ldots\ldots r'_{1n} \\ r'_{21} & r'_{22} & \ldots r'_{2j} & \ldots\ldots r'_{2n} \\ . & .. & .. & . \\ . & .. & & . \\ r'_{i1} & r'_{i2} & \ldots r'_{ij} & \ldots\ldots r'_{in} \\ . & . & \ldots .. & . \\ r'_{m1} & r'_{m2} & \ldots r'_{mj} & \ldots r'_{mn} \end{pmatrix}$$

Step 10: Converting the R_G matrix in to preference matrix using Schwartz Sequential Dropping (SSD) method [12]

Step 11: Ranking of the employees is made by multiplying the strongest path matrix with the corresponding weight vector of criterions. The employees are ranked considering the highest value as the first rank.

8 A Case Study

Inforyas Software India Private Limited ,Chennai is an IT firm.The HR department of this firm ranks employees for promotion and incentive puposes based on appraisal by Superior, Subordinate and the employee himself. The model is applied to rank four employees of the firm based on four criterion namely Quality, Quantity, Timeliness and Attitude to work. Supervisors are considered as the 'heart of the most appraisal system' [13]. The employees appraised by three DM's and the PA are made based on four criterias C1, C2, C3, C4.

Step1: A company wishes to rank its employees based on PA by DM's.In our study only four employees E1,E2,E3,E4 are considered for ranking.This study can be extended to more employees also.

Step2 : The three DM's considered for ranking the employees are Superior(D1), Customer(D2) and the Employee himself(D3). The following criterias C1, C2, C3 are considered for the PA.The linguistic importance scale of employees is shown in Table1 and the performance scale of criteria is shown in Table 2

Table1
Linguistic Variable for importance weight of each criteria

E	0.8	0.9	1	1
VG	0.7	0.8	0.8	0.9
G	0.5	0.6	0.7	0.8
MG	0.4	0.5	0.5	0.6
F	0.2	0.3	0.4	0.5
P	0.1	0.2	0.2	0.3
VP	0.0	0.1	0.1	0.2

Table2
Linguistic Variable for ratings

C	0.8	0.9	1	1
VH	0.7	0.8	0.8	0.9
H	0.5	0.6	0.7	0.8
MH	0.4	0.5	0.5	0.6
M	0.2	0.3	0.4	0.5
ML	0.1	0.2	0.2	0.3
L	0.0	0.1	0.1	0.2

Step 3: The DM's use linguistic weighting variable based on

TrFN's to assess the importance of the criteria. The importance weights of criterions determined by three DM's are shown in Table 3. The ratings of five employees with respect to each criterion by three DM's are shown in Table 4& 4a

Table 3.
Importance weight of criteria from three decision makers

C1	D1	VH	0.7	0.8	0.8	0.9
	D2	VH	0.7	0.8	0.8	0.9
	D3	VH	0.7	0.8	0.8	0.9
C2	D1	C	0.8	0.9	1	1
	D2	C	0.8	0.9	1	1
	D3	C	0.8	0.9	1	1
C3	D1	C	0.8	0.9	1	1
	D2	C	0.8	0.9	1	1
	D3	C	0.8	0.9	1	1
C4	D1	VH	0.7	0.8	0.8	0.9
	D2	VH	0.7	0.8	0.8	0.9
	D3	C	0.8	0.9	1	1

Table 4
Linguistic Ratings of employees by decision makers

	C1				C2			
	E1	E2	E3	E4	E1	E2	E3	E4
D1	G	E	G	VG	G	VG	E	VG
D2	G	E	G	VG	G	VG	E	VG
D3	G	E	VG	VG	G	VG	E	G

Table 4a
Linguistic Ratings of employees by decision makers contd.

	C3				C4			
	E1	E2	E3	E4	E1	E2	E3	E4
D1	VG	VG	G	VG	VG	VG	VG	VG
D2	VG	E	G	VG	VG	E	VG	VG
D3	VG	E	G	VG	VG	VG	VG	E

Step .4: The linguistic evaluations shown in Table 3 and Table 4 are fuzzified using positive TrFN's using procedure shown in Step 4 of Section 7.

Step 5 : The aggregated fuzzy weight of criterias and aggregated fuzzy ratings of Employees are shown in Table 5.

Table 5.
Fuzzy Decision Matrix

		C1	C2
D1	E1	(0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8)
	E2	(0.8,0.9,1,1)	(0.7,0.8,0.8,0.9)
	E3	(0.5,0.6,0.7,0.8)	(0.8,0.9,1,1)
	E4	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
D2	E1	(0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8)
	E2	(0.8,0.9,1,1)	(0.7,0.8,0.8,0.9)
	E3	(0.5,0.6,0.7,0.8)	(0.8,0.9,1,1)
	E4	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
D3	E1	(0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8)
	E2	(0.8,0.9,1,1)	(0.7,0.8,0.8,0.9)
	E3	(0.7,0.8,0.8,0.9)	(0.8,0.9,1,1)
	E4	(0.7,0.8,0.8,0.9)	(0.5,0.6,0.7,0.8)
W		(0.7,0.8,0.8,0.9)	(0.8,0.9,1,1)
D1	E1	C3	C4
	E2	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
	E3	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
	E4	(0.5,0.6,0.7,0.8)	(0.7,0.8,0.8,0.9)
D2	E1	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
	E2	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
	E3	(0.8,0.9,1,1)	(0.8,0.9,1,1)
	E4	(0.5,0.6,0.7,0.8)	(0.7,0.8,0.8,0.9)
D3	E1	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
	E2	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
	E3	(0.8,0.9,1,1)	(0.7,0.8,0.8,0.9)
	E4	(0.5,0.6,0.7,0.8)	(0.7,0.8,0.8,0.9)
W		(0.7,0.8,0.8,0.9)	(0.8,0.9,1,1)

Step 6 :Construct the defuzzified decision matrix as in Table 6 using equation (1)

Table 6
The defuzzified decision matrix with weights

	C1	C2	C3	C4
E1	0.65	0.65	0.8	0.8
E2	0.923	0.8	0.8	0.8
E3	0.65	0.923	0.65	0.8
E4	0.8	0.8	0.8	0.8
E1	0.65	0.65	0.8	0.8
E2	0.923	0.8	0.923	0.923
E3	0.65	0.923	0.65	0.8
E4	0.8	0.8	0.8	0.8
E1	0.65	0.65	0.8	0.8
E2	0.923	0.8	0.923	0.8
E3	0.8	0.923	0.65	0.8
E4	0.8	0.65	0.8	0.923
wts	0.8	0.923	0.923	0.853
Normal wts	0.23	0.26	0.26	0.25

Step 7 :Construct rank matrix Rj taking in to account the proper DM weights as in Table 7

Table 7: The Rank Matrix R_j

C1	D1	D2	D3	∑	RANK
E1	0.15	0.15	0.15	0.45	4
E2	0.212	0.212	0.212	0.636	1
E3	0.15	0.15	0.184	0.484	3
E4	0.184	0.184	0.184	0.552	2

C2	D1	D2	D3	∑	RANK
E1	0.169	0.169	0.169	0.507	4
E2	0.208	0.208	0.208	0.624	2
E3	0.234	0.234	0.234	0.234	1
E4	0.208	0.208	0.208	0.624	2

C3	D1	D2	D3	∑	RANK
E1	0.208	0.208	0.208	0.624	2
E2	0.208	0.234	0.234	0.676	1
E3	0.169	0.169	0.169	0.507	4
E4	0.208	0.208	0.208	0.624	2

C4	D1	D2	D3	∑	RANK
E1	0.2	0.2	0.2	0.6	3
E2	0.2	0.231	0.2	0.631	1
E3	0.2	0.2	0.2	0.6	3
E4	0.2	0.2	0.231	0.631	1

Step 8 : Compute the linear sum for each employee based on various criterions(see table 7)

Step 9 :The final grade matrix RG of all employees is calculated.

$$
RG \quad \begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \end{array}
\begin{array}{c} \begin{array}{cccc} E1 & E2 & E3 & E4 \end{array} \\
\begin{pmatrix} 4 & 1 & 3 & 2 \\ 4 & 2 & 1 & 2 \\ 2 & 1 & 4 & 2 \\ 3 & 1 & 3 & 1 \end{pmatrix} \end{array}
$$

Step 10 :Preference of employees based on four criteria calculated from RG matrix is as follows

1 E2 E4 E3 E1
1 E3 E2 E4 E1
1 E 2 E1 E4 E3
1 E 2 E4 E1 E3

Step 11 : Converting the R_G matrix in to preference matrix using Schwartz Sequential Dropping (SSD) method [12] which is used in electoral Voting.

Matrix of pairwise defeats

$$
\begin{array}{c} \\ E1 \\ E2 \\ E3 \\ E4 \end{array}
\begin{array}{c} \begin{array}{cccc} E1 & E2 & E3 & E4 \end{array} \\
\begin{pmatrix} - & 0 & 2 & 1 \\ 4 & - & 3 & 4 \\ 0 & 1 & - & 1 \\ 3 & 0 & 3 & - \end{pmatrix} \end{array}
$$

Step 12 : Constructing the strongest path matrix[12]

Matrix of strongest path

$$
\begin{array}{c} \\ E1 \\ E2 \\ E3 \\ E4 \end{array}
\begin{array}{c} \begin{array}{cccc} E1 & E2 & E3 & E4 \end{array} \\
\begin{pmatrix} - & 0 & 2 & 0 \\ 4 & - & 3 & 4 \\ 0 & 0 & - & 0 \\ 3 & 0 & 3 & - \end{pmatrix} \end{array}
$$

Step 13 : Ranking of the employees is made by multiplying the strongest path matrix with the corresponding weight vector of criterions. The employees are ranked considering the highest value as the first rank. Rank

$$
\begin{array}{c} E1 \\ E2 \\ E3 \\ E4 \end{array}
\begin{pmatrix} - & 0 & 2 & 0 \\ 4 & - & 3 & 4 \\ 0 & 0 & - & 0 \\ 3 & 0 & 3 & - \end{pmatrix}
\begin{pmatrix} 0.23 \\ 0.26 \\ 0.26 \\ 0.25 \end{pmatrix}
=
\begin{pmatrix} 0.52 \\ 2.7 \\ 0.0 \\ 1.46 \end{pmatrix}
\begin{array}{c} 3 \\ 1 \\ 4 \\ 2 \end{array}
$$

The Ranking of Employees is
E2 > E4 > E1 > E3

9 CONCLUSION

The opinion of decision makers with regard to the employees performance based on various criterion are represented as linguistic variables. These linguistic variables are fuzzified using TrFN's which helps in captuiring the uncertainity associated with human judgement. In this paper an attempt has been made to model a performance appraisal system which is a back bone of every organization. The future direction of research is to develop a Fuzzy Expert System or a Decision Support System which acts as a performance Appraisal System to monitor the performance of employees in any organization.

REFERENCES

[1]Fuzzy decision based soft multi-agent controller for speed controller for three phase induction motor
International Journal for Soft Computing(IJSC) -Vol.2 NO.3 ,AUG 2011
[2] Adnan, S. and Minwir, A. (1998), "Fuzzy Logic Modeling for Performance Appraisal Systems – A
Framework for Empirical Evaluation", Expert Systems with Applications, Vol. 14, No. 3, p. 323-328.

ISSN 2229-5518

[3]John H.Bernardian and Joyce E.A.Russell, Human Resource Management- An Experential Approach,Mc Graw –Hill Newyork 1999

[4]Human Resource M anagement-Text and cases 6/e ,K.Aswathappa, Tata Mc Graw –Hill

[5] Jing, R.C, Cheng, C. H. and Chen, L. S. (2007), “A Fuzzy-Based Military Officer Performance Appraisal System”, Applied Soft Computing, Vol. 7, Issue. 3, p. 936-945.

[6] Pomerol, J.-C.. Barba Romero, S. (2000). Multicriterion Decision in Management: Principles and Practice. Kluwer Academic Publishers.Norwell

[7]Zadeh, 1975 The concept of a linguistic variable and its Applications to approximate reasoning.Information Sciences 8,199-249

[8] Bellman, R.E., Zadeh,L.A., 1970. Decision making in a fuzzy environment, Management science, vol.17, No.4, B-141-B-164.

[9] Abhinav Bansal (2011),Trapezoidal Fuzzy Numbers (a,b,c,d): Arithmetic Behavior ISSN:International Journal of Physical and Mathematical Sciences

[10] ChenS.M.,Hsiao.W.H.and Hong Y.J,A knowledge based method for fuzzy quary processing for document retrieval, Cybernetics and Systems, Vol.28,No.1,PP.99-119,1997.

[11]Amir Sanayei,Seyed Farid Mousavi,A Group Based Fuzzy MCDM for selecting Knowledge Portal System,World Academy of Science, Engineering and Technology,2009

[12]A.Uma Maheswari,P.Kumari, A Fuzzy Mathematical Model for Multi Criteria Group Decision making-An Application in Supply Chain Management, International Journal of computer Applications,vol 54,2012

[13]Dossler, Gary, Personnell Management Reston Publishing Co,Virginia

[14]www.exploreHR.org