INTERNATIONAL JOURNAL OF CONTEMPORARY ACADEMICS (IJCA) ISSN 2536-7110 © 2022 VOL. 6 (1), Pp.53 - 61, © APRIL, 2022 MULTI CRITERIA FUZZY BASED HUMAN RESOURCE PERFORMANCE EVALUATION

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ABSTRACT

Well planned performance appraisal and ranking of staff to promotion is important in tactical human resource management. The methods available for evaluation of academic staff in colleges of education in Nigeria are based on crisp data in the form of rigid boundaries and for any uncertainty this evaluation has limitations. In evaluating academic staff there are several criterions which can contribute on performance evaluation in the form of linguistic terms. Fuzzy expert system was proposed on the basis of multi inputs as required by the institution in ranking the quality of academic staff performance. The proposed method introduces fuzzification of crisp data which depends on the extreme value that exist in the data. The suitability of the model is for evaluating academic staff on number of input variables, vagueness and imprecise information in the data.

KEYWORDS: MULTI -CRITERIA DECISION MAKING, LINGUISTIC VARIABLE, FUZZY EXPERT SYSTEM, PERFORMANCE EVALUATION.

1.0 Introduction

The performance of the public sector organizations in Nigeria has been a cause of concern over the last few decades. It is the general perception that Nigeria civil service has failed to effectively and efficiently implement development goals and administers government policies formulated to meet the needs and yearnings of its citizenry. The civil service is characterized by poor service delivery, inefficiency and ineffectiveness in programme implementation, poor work attitudes and behavior, poor or the absence of infrastructural facilities, mismanagement of public funds and low morale. (Jekelle-Mohammed and Anthony, 2012). Employee performance evaluation is a multi-criteria decision making subject to rank academic staff effectively for promotion (Derebew, et al, 2021). Nigeria greatest wealth is her people. For a nation to attain sound development according to Azunwena (2012) is meeting the needs of the present generation without compromising the needs of the future generation. The primary responsibilities of the Human Resources Management (HRM) in any organisation and all managers are the utilization of human capital, to achieve organisational goals. The main tasks of HRM is related to job analysis, planning for manpower requirements, staffing, selecting and hiring the best employee for the job, staff training, system design and performance evaluation (Joma *et al.,* 2017). The performance appraisal of employees can be accomplished by fuzzy logic approach and different defuzzification techniques are applied to rank the employees according to their performance, which shows inconsequential deviation in the rankings and hence proves the robustness of the system. The overall performance evaluation of academic staff of higher institution of learning is very necessary for the development of institution, betterment of the students, society and Nation. The selection of promoted staff over the years in colleges of education, is done manually from the process of advertising for promotion exercise (that is invitation for prequalification) to the selection of successful staff. The traditional system of getting promotable staff in the departments, schools and colleges through manual modes suffers from various problems such as complexity, flexibility, accuracy, sensitivity, inordinate delays

(approximately 5 to 6 months) in processing, heavy paper work, human interface at every stage, inadequate transparency and difficulty in the collection of data, among others. For a staff seeking for promotion into a particular position, the traditional method is getting feedback from head of the institution, students, HODs, senior colleagues, moderators and external assessors. From the foregoing this research is motivated to address these limitations highlighted. The overall motivation for this research, is therefore the need for development of a multi-criteria fuzzy based human resource performance evaluation system for promotion screening exercise and ranking of candidates for promotion in colleges of education. The research findings will establish a human resource system capable of ranking academic staff for promotion and judging candidates within limited time and resources.

2.0 Related Work

Literatures were reviewed and below is the list of some authors who have worked in related areas:

S/N	Authors(year)	Title	Method Used	Strengths	Weaknesses
1.	Derebew et al. (2021)	Fuzzy logic decision support system for hospital employee performance evaluation with maple implementation.	Interval Value Fuzzy Weighted Distance Algorithm	The paper presented a multi-criteria decision making algorithm.	The study is not extended to fuzzy multi-sets and bipolar fuzzy sets.
2.	Seyma et al. (2020)	Performance evaluation of municipal services with fuzzy multi-criteria decision making approaches: a case study from Turkey.	Used FAH process and fuzzy technique for order preference by similarity to ideal solution.	Prioritization of five most important services using FAHP and FTOPSIS for comparison.	In this study services have been prioritized by using fuzzy AHP and fuzzy TOPSIS methods. However, different multi-criteria decision-making techniques such as fuzzy promethee and interval type2 can be used.
3.	Nobari et al. (2019)	Development of a complementary fuzzy decision support system for employees' performance evaluation.	Used precision assessment to convert qualitative assessments of human resource panel to linguistic variables.	The method ensures that the results of employee evaluation are accurate, consistent and fair in the short and long term.	The authors just show the first step of the change plan implemented in IKCO by proving that FDSS is a valid and advance tool in comparison with the traditional methods of employee hence lack the required quality.
4.	Utama and Rustamaji (2018)	Fuzzy decision support model for human resources performance appraisal.	The model adopts two methods; they are fuzzy logic to characterize parameters and their behavior with fuzzy rule base for determining the	Constructed a Fuzzy Support Model (DSM) for performance appraisal that is applied to compute	The fuzzy support model developed only measured few parameters living some other important aspect

			result, and HC to optimize the searching process and result. It realizes four parameters (education, teaching capability, research, and community service) to objectively identify the lecturers' performance through bonus coefficient calculation.	the lecturers'performance bonus in educational institution.	of performance evaluation out.
5.	Ojokoh et al. (2018)	Fuzzy driven decision support system for enhanced performance appraisal.	The study proposed a fuzzy logic decision support system based on Henri Fayol's principles of management for the appraisal of employees' performance in an organisation.	Design of a fuzzy decision-support system based on Henri Fayol's 14 principles of management for the appraisal of employees' performance.	The study is questionnaire based therefor lack the required quality.
6.	Thakrel et al. (2017)	A fuzzy logic multi criteria approach for evaluation of teachers' performance.	Used fuzzy logic to evaluate the overall performance of a teacher for the development of the institution.	Development of a fuzzy expert system for ranking the quality of teachers' performance in an institution.	The drawback of this model is that personnel evaluation is based on crisp data in the form of rigid boundaries.
7.	Turskis and Juodagalviene (2016)	A novel hybrid multi criteria decision-making model.	Presented a novel and original hybrid M.C.D.M. model, which was based on ten different M.C.D.M. methods: game theory, A.H.P., simple additive weighting, multiplicative exponential weighting, TOPSIS, evaluation based on distance from average solution (E.D.A.S.), A.R.A.S., full multiplicative form, Laplace rule and Bayes rule; this method is used to solve complicated problems.		

8.	Odun-Ayo (2015)	A fuzzy model for performance appraisal and promotion ranking system.		The study established a robust, multilevel, scalable security HRM for Nigeria Air Force.	Customized for Nigeria Airforce hence, not adaptable to other organisations.
9.	Samuel et al. (2014)	Online fuzzy based decision support system for human resource performance appraisal.	Used Mamdani computational technique for human resource performance appraisal.	The system can predict accurately the appraisal status of an academic staff.	Computational complexity is high with the approach used.
10.	Maheswari and Kumari (2013)	A performance appraisal model using fuzzy multi-criteria group decision making.	Fuzzy trapezoidal numbers are used and presented graphically using MATLAB software.	The system developed help to remove the uncertainty associated with human judgement during performance appraisal process.	The system is short of decision support system which acts as a performance appraisal system to monitor the performance of employees in any organisation.

3.0 MATERIALS AND METHOD

3.1 The Model Formulation

This approach uses a fuzzy set theory for multi-criteria evaluation in the group decision making on academic staff promotion screening exercise. A ranking method that simultaneously considers the metric distance and fuzzy mean value is proposed. Candidates for promotion are scored by linguistic variable.

3.2 Fuzzy Set

A fuzzy set is a set with fuzzy boundaries. Defined fuzzy sets or classes for each variable allows intermediate grades of membership in them, which means each set could have elements that belongs partially to it; the degree of belonging is called membership functions ranging from 0 to1. If X is the Universe of discourse and its elements are denoted as x, in contrast with crisp set, then the fuzzy set A of X has characteristics function associated to it.

The fuzzy set is represented by a characteristic function, defined as follows:

$$\mu_A: X \rightarrow [0,1]$$

$$\mu_A(X) = \begin{cases} 1, if\ X\ is\ totally\ in\ A \\ 0, if\ X\ is\ not\ in\ A \\ (0,1), if\ X\ is\ partially\ in\ A \end{cases}$$

3.3 Membership Function

A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. The input space is sometimes referred to as the universe of discourse, a fancy name for a simple concept. It maps each element of X to a membership grade between 0 and 1. It provides the degree of belongingness for element to a fuzzy set. Membership function has many forms, either we choose arbitrarily or based on user's experience. There are different types of membership functions used for representing fuzzy sets however, in this study, triangular membership function is used. Triangular membership function is commonly used because it constitutes an immediate solution to the optimization problems that emerges from fuzzy modelling. It has been frequently and quite often without any deeper justification used in many applications of fuzzy sets including fuzzy controllers, fuzzy models, classifications schemes. Perhaps the most obvious motivation behind their utilization stems from an interesting simplicity of this type of membership function.

Membership function is represented in the equation below.

$$\mu_A(x) \begin{cases} \frac{x-a}{b-a}\ if a \leq x < b \\ 1 \qquad if\ x = b \\ \frac{c-x}{c-b}\ if\ b \leq x\ < c \\ 0 \qquad otherwise \end{cases}$$

Figure 1 presents the architecture of the proposed Multi Criteria Fuzzy Logic based Human Resource Performance Appraisal System.

The architecture is made up a *User Interface* which provides a means of communicating and receiving feedback from the

system; an *Input* component that enables the entry of the decision variables; *Output* component which displays the overall appraisal result of a given staff; a *Knowledge Base* that houses the knowledge of Domain Experts (HRMs); a *Fuzzy Inference System* (FIS) which utilizes a set of pre-defined procedures based on the fact and rules in Performance Appraisal and input decision variables in order to provide an efficient PA result for a particular staff.

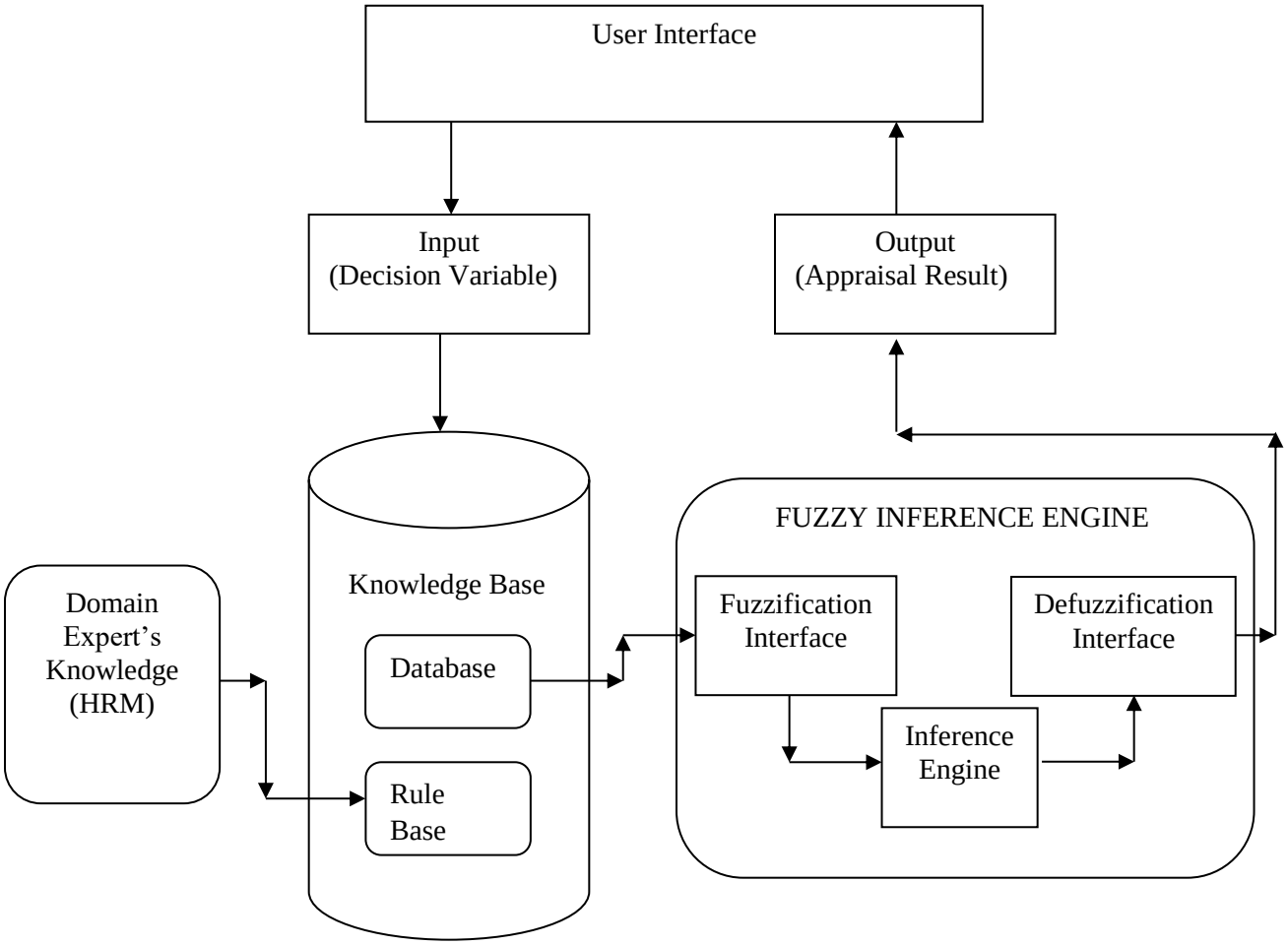

Figure 1: Architecture of Fuzzy Based Performance Appraisal System

User Interface: This module provides all the interactions of the users with the system. This module is used to accept inputs from the users, display the results or outputs of the inference process. It interprets and explains the reasoning outcomes.

Fuzzy Knowledge Based: Knowledge Base is made up of rule base and database where rule base consists of fuzzy If-then rules and the database defines the membership functions of the fuzzy sets used in the fuzzy rules (Rezaei and Dowlatshahi, 2010). A knowledge base combines the knowledge of multiple human experts. Knowledge Base stores all relevant information, data, rules, cases and relationships used by the expert system.

The rules are of the following form:

If X is high AND Y is low then Z is medium.

Where X and Y are fuzzy linguistic input variables and high, low are possible linguistic values of X and Y respectively. Similarly, Z is a fuzzy linguistic output variable and medium is its linguistic value.

3.4 INFERENCE ENGINE: The inference engine seeks information and relationship from the knowledge base and provide answers, predictions, and suggestions in the way a human expert would. The inference engine must find the right facts, interpretations and rules and assemble them correctly.

3.5 Method

The proposed system consists of eight promotion criteria (qualifications, publications, teaching experience, teaching/research load, administrative experience, academic/professional distinction, and quality of teaching), the output is the aggregate score from all the evaluators, and seven rule system applied. The rules are evaluated in parallel using fuzzy reasoning. The research proposes three procedures to rank academic staff by the evaluators. First, equation (1) will be used to assign weights to each criterion. The rule for scoring each candidate for promotion is applied to each value in the weighting criteria ($\bar{\nabla}^c$) in equation (1). Secondly, the evaluators' score will be aggregated for each candidate. The aggregate scores are calculated for each candidate using equation (2). Lastly, ranking of candidates for promotion will be carried out using equation (4).

Let $V^c(1 \leq c \leq r)$ be the weights for each criterion which are predetermined by the institution management. A normalised weight is defined as follow;

$$\bar{\nabla}^c = \frac{v^c}{\sum_{a=1}^{r} v^a} = \left(\frac{v_r^c}{\sum_{a=1}^{r} v_y^a}, \frac{v_{rp}^c}{\sum_{a=1}^{r} v_{yp}^a}, \frac{v_{yp}^c}{\sum_{a=1}^{r} v_{rp}^a}, \frac{v_y^c}{\sum_{a=1}^{r} v_r^a}\right) \quad (1)$$

where, $v^a = (v_r^a, v_{rp}^a, v_{yp}^a, v_y^a)$ represents a trapezoidal fuzzy number with lower, lower modal, upper modal and upper values and v^c = $(v_r^c, v_{rp}^c, v_{yp}^c, v_y^c)$ represents the weights for criteria.

The fuzzy number $g_a(1 \leq a \leq p)$ is defined as the aggregated score for the a[th] candidate and g_a is defined as:

$$g_a = \sum_{c=1}^{r} \left\{ \bar{\nabla}^c \otimes \left(\frac{1}{n} \sum_{b=1}^{q} z_{abc} \right) \right\} \quad (2)$$

$$= \sum_{c=1}^{r} \left\{ \left(\frac{v_r^c}{\sum_{a=1}^{r} v_y^a}, \frac{v_{rp}^c}{\sum_{a=1}^{r} v_{yp}^a}, \frac{v_{yp}^c}{\sum_{a=1}^{r} v_{rp}^a}, \frac{v_y^c}{\sum_{a=1}^{r} v_r^a} \right) \otimes \left(\frac{1}{n} \sum_{b=1}^{q} z_{abc} \right) \right\} \quad (3)$$

where $\otimes$ = tensor operator, z_{abc} represents fuzzy number with lower, lower modal, upper modal and upper values. Also, *y* = upper, *yp* = upper modal, *rp* = lower modal and *r* =lower.

The last stage in the fuzzy inference process is the defuzzification. The input for defuzzification process is the aggregate fuzzy output from equation (3). The candidate that scores "Excellent" or "Very Poor" in all criteria will be chosen as the positive (negative)-ideal solution. The value of this positive (negative)-ideal solution is dependent on the weights for criteria.

The ranking will be carried out using ranking ordering method. Let $y^* = (i^*, j^*, k^*, l^*)$, $g^- = (i^-, j^-, k^-, l^-)$, and $y_a = (i_a j_{a,} k_{a,} l_a)$ be the positive-ideal solution, negative-ideal solution, and a[th] candidate's score respectively. Also, let $\emptyset^*$, $\emptyset^-$, and $\emptyset_a$ be the mean values of the positive–ideal solution, negative-ideal solution, and a[th] candidate respectively, then the ranking measures are obtained in equation (4).

$$S_a^* = \frac{1}{2}\left(\frac{l_a - l^-}{r^* - r^-} + \frac{\emptyset_a - \emptyset^-}{\emptyset^* - \emptyset^-}\right) \leq 1 \quad (4)$$

where $l^- \leq l_a \leq l^* \; and \; \emptyset^- \leq \emptyset_a \leq \emptyset^*$, and the values of S_a^* are between 0 and 1. If the value of S_a^* is larger, the candidate is closer to the positive–ideal solution and farther from the negative solution, the higher the candidate ranks.

4.0 Result and Discussion

Table 1: Crisp Value for different positions

Variable Name	Linguistic Term	Current Position	Crisp Value
Level	Very low	Assistant Lecturer	0
	Fairly Low	Lecturer III	1
	Low	Lecturer II	2
	Medium	Lecturer I	3
	High	Senior Lecturer	4
	Fairly high	Principal Lecturer	5
	Very high	Chief Lecturer	6

Table 2: Domain Ranges of different positions

Variable Name	Linguistic Term	Merit Position	Domain
Score	Very low	Assistant Lecturer	[6 – 9]
	Fairly Low	Lecturer III	[10 – 14]
	Low	Lecturer II	[15 – 24]
	Medium	Lecturer I	[25 – 39]
	High	Senior Lecturer	[40 – 54]
	Fairly high	Principal Lecturer	[55 – 64]
	Very high	Chief Lecturer	[65 – 100]

The dataset used for the study was collected from the human resource unit that is the registry department of Osun State College of Education, Ilesa, Nigeria. This will be used to run the fuzzy application. NB: aq (academic qualification), pq (professional qualification), te (teaching experience), trl (teaching research load), qt (quality of teaching), rp (recognized publication), ae (administrative experience), pd (academic/professional distinction).

In today's competitive environment, decisions making with the application of information technology are the irrefutable principles of organisations and help to managers in making decisions meaningfully. This research provides the opportunity to incorporate uncertainty by introducing the linguistic variable for each of the selected criteria. Fuzzy Inference Systems have proven to be successful applications in automatic control, data classification, decision Analysis. The research presents the integration of fuzzy logic into assessment of employees' performance in Colleges of Education in Nigeria. The expected results will be presented on a graph of manual promotion scores against fuzzy scores. Some of the advantages of this technology is that it can also be applied to other tertiary institutions. Also, in situation where there is limited vacancy for promotion, then this model which determines the degree by which each candidate qualifies, will be suitable for the selection of the most qualified candidate. The limitation of this study is that it is not extended to the non-academic staff.

Conclusion

The Multi-criteria fuzzy-based human resource performance evaluation model follows a systematic step in determining a staff's performance and also rank them for promotion. Therefore, it creates a system of appraisal which is able to consistently produce reliable and valid results for the appraisal process. From this study, it is expected that reasoning based on fuzzy models will provide an alternative way in handling various kinds of imprecise data, which often reflected in the way people think and make judgments,

Recommendations

Reasoning based on fuzzy models will provide an alternative way in handling various kinds of imprecise data, which often reflected in the way people think and make judgments. The method can easily be extended to evaluate performances of academic staff of higher institutions on some critical factors which directly or indirectly influence their performances. This work can be extended further by taking the non-academic staff into consideration.

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