# Chapter 172
# A Fuzzy Multi-Criteria Group Decision Making Approach for Hotel Location Evaluation and Selection

**Santoso Wibowo and Hepu Deng**

**Abstract** This paper presents a fuzzy multi-criteria group decision making approach for effectively solving the hotel location evaluation and selection problem. Pairwise comparison is used to help individual decision makers make their subjective assessments in evaluating the performance of alternative hotel locations and the relative importance of the selection criteria in a cognitively less demanding manner. A consensus building process is proposed for ensuring the achievement of consensus at an acceptable level in the evaluation process. An algorithm is developed for determining the overall performance of each alternative location across all the criteria on which the selection decision is made. An example is presented for demonstrating the applicability of the approach for solving the location selection problem in real world situations.

**Keywords** Uncertainty and imprecision · Multi-criteria analysis · Group decision making · Hotel location evaluation and selection

## 172.1 Introduction

The tourism industry is growing rapidly nowadays [1, 2]. A forecast from the Asian Pacific Travel Association indicates that this industry will be the fastest growing industry over the next decade [1]. Within such an important industry, the development of new hotels is a critical part of the tourism business [3].

S. Wibowo (✉) · H. Deng (✉)
School of Business IT and Logistics, RMIT University, Melbourne, Australia
e-mail: santoso.wibowo@rmit.edu.au

H. Deng
e-mail: hepu.deng@rmit.edu.au

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To develop and maintain the competitive advantage in the tourism industry, selecting the most appropriate location for hotel development is critical [2]. This is because the selection of the most suitable hotel location has strategic implications to the development of the tourism business including the increase of market share and the improvement of profitability [3]. As a result, evaluating and selecting the most suitable location from available locations to develop becomes a critical decision to be made.

Evaluating and selecting the most suitable location for development is challenging. This is due to (a) the involvement of multiple decision makers (DMs) and the presence of multiple, often conflicting criteria, (b) the need for adequately modelling the uncertainty and imprecision present, and (c) the cognitive demanding on the DMs. Furthermore, it is critical to reach a certain level of agreement among the DMs for facilitating the acceptance of the decision made. As a result, structured approaches are desirable for effectively solving the location evaluation and selection problem.

This paper presents a fuzzy multi-criteria group decision making approach for effectively solving the hotel location evaluation and selection problem. A pairwise comparison process is used to help individual DMs make their subjective assessments in evaluating the performance of alternative hotel locations and the relative importance of the selection criteria in a cognitively less demanding manner. A consensus building process is proposed for ensuring the achievement of consensus at an acceptable level. A fuzzy multi-criteria algorithm is developed for evaluating the overall performance of alternative hotel locations across all the criteria on which the selection decision is made. An example is presented for demonstrating the applicability of the proposed approach for solving the hotel location evaluation and selection problem.

## 172.2 Some Preliminary Concepts

A fuzzy number is a convex fuzzy set [4], characterized by a given interval of real numbers, each with a grade of membership between 0 and 1. Triangular fuzzy numbers are a special class of fuzzy number, defined by three real numbers expressed as (a1, a2, a3) whose membership function is described as

$$\mu_A(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2, \\ \frac{a_3-x}{a_3-a_2}, & a_2 \le x \le a_3, \\ 0, & \text{otherwise.} \end{cases} \tag{172.1}$$

where $a_2$ is the most possible value of fuzzy number $A$, and $a_1$ and $a_3$ are the lower and upper bounds respectively used to illustrate the fuzziness of the data evaluated.

**Table 172.1** Linguistic variables and their fuzzy number approximations

| Linguistic variables | Fuzzy numbers | Membership function |
|---|---|---|
| Very poor (VP) | $\tilde{1}$ | (1, 1, 3) |
| Poor (P) | $\tilde{3}$ | (1, 3, 5) |
| Fair (F) | $\tilde{5}$ | (3, 5, 7) |
| Good (G) | $\tilde{7}$ | (5, 7, 9) |
| Very good (VG) | $\tilde{9}$ | (7, 9, 9) |

Fuzzy numbers are widely used to approximate the linguistic variables used for expressing the DM's subjective assessments in decision making. To facilitate the making of pairwise comparison, linguistic variables [5] are used. These linguistic variables are approximated by triangular fuzzy numbers defined as in Table 172.1.

Fuzzy extent analysis is widely used for deriving the criteria weights and the alternative performance ratings from the reciprocal matrices resulting from the pairwise comparison process [6, 7] due to its simplicity in concept and computational efficiency. Assume that $X = \{x_1, x_2, \ldots, x_n\}$ is an object set, and $U = \{u_1, u_2, \ldots, u_m\}$ is a goal set. Fuzzy assessments are performed on each object for each goal respectively, resulting in $m$ extent analysis values for each object, given as $\mu_i^1, \mu_i^2, \ldots, \mu_i^m$, $i = 1, 2, \ldots, n$, where all $\mu_i^j$ $(j = 1, 2, \ldots, m)$ are fuzzy numbers representing the performance of the object $x_i$ on goal $u_j$. Using fuzzy synthetic extent analysis, the overall performance of the object $x_i$ across all goals can be determined by

$$S_i = \frac{\sum_{j=1}^{m} \mu_i^j}{\sum_{i=1}^{n} \sum_{j=1}^{m} \mu_i^j}, \quad i = 1, 2, \ldots, n. \tag{172.2}$$

## 172.3 A Fuzzy Multi-Criteria Approach

Evaluating and selecting alternative hotel locations usually involves in (a) discovering all alternative locations $A_i$ ($i = 1, 2, \ldots, n$), (b) identifying the selection criteria $C_j$ ($j = 1, 2, \ldots, m$), (c) assessing the performance of alternative locations and the weight of criteria by DMs $D_k$ ($k = 1, 2, \ldots, s$), (d) aggregating the assessments for producing an overall performance index for each alternative location across all the criteria, and (e) selecting the best alternative location [8].

The selection process starts with determining the performance of alternative locations with respect to each criterion and the importance of the criteria. To reduce the cognitive demanding on the DMs, pairwise comparison [5] using the linguistic variables described in Table 172.1 is used, leading to a pairwise judgment matrix as

$$A = \begin{bmatrix} 1 & a_{12} & \ldots & a_{1k} \\ a_{21} & 1 & \ldots & a_{2k} \\ \ldots & \ldots & \ldots & \ldots \\ a_{k1} & a_{k2} & \ldots & 1 \end{bmatrix} \quad (172.3)$$

Using the fuzzy synthetic extent analysis in (172.2), the criteria weightings and performance rating for DMs $D_k$ with respect to criterion $C_j$ can be obtained, resulting in the determination of the fuzzy decision matrix for the alternatives and the fuzzy weighting vector for the selection criteria respectively as

$$Y^k = \begin{bmatrix} y_{11}^k & y_{12}^k & \ldots & y_{1m}^k \\ y_{21}^k & y_{22}^k & \ldots & y_{2m}^k \\ \ldots & \ldots & \ldots & \ldots \\ y_{n1}^k & y_{n2}^k & \ldots & y_{nm}^k \end{bmatrix} \quad (172.4)$$

$$w^k = (w_1^k,\ w_2^k, \ldots, w_m^k) \quad (172.5)$$

By averaging the fuzzy assessments of individual DMs as given in (172.4) and (172.5), the overall fuzzy decision matrix and the fuzzy weight vector can be obtained as

$$X = \begin{bmatrix} x_{11} & x_{12} & \ldots & x_{1m} \\ x_{21} & x_{22} & \ldots & x_{2m} \\ \ldots & \ldots & \ldots & \ldots \\ x_{n1} & x_{n2} & \ldots & x_{nm} \end{bmatrix} \quad (172.6)$$

$$W = (w_1,\ w_2,\ \ldots,\ w_m) \quad (172.7)$$

where $x_{ij} = \frac{\sum_{k=1}^{s} y_{ij}^k}{s}$ and $w_j = \frac{\sum_{k=1}^{s} w_j^k}{s}$.

To explore the degree of consensus among DMs, the proximity measure is introduced. It measures the distance between the assessments of individual DMs and the group assessments. The proximity measure helps DMs determine the direction of changes in their assessments for improving their consensus level.

Several proximity measures are developed [9–11] for solving group decision making problems with sounding applications. They, however, suffer from various shortcomings including (a) the need for tedious mathematical computation and (b) cognitively very demanding on the DMs. To overcome these shortcomings, the graded mean integration representation distance based measure [12] is introduced due to the accuracy [12], simplicity in concept, and efficiency in computation. The degree of proximity between DMs on the performance ratings of alternatives is determined as

$$S_{ij}^k = \frac{1}{1 + \left[\left(\frac{y_{ij(L)}^k + 4y_{ij(M)}^k + y_{ij(R)}^k}{6}\right) - \left(\frac{x_{ij(L)} + 4x_{ij(M)} + x_{ij(R)}}{6}\right)\right]} \quad (172.8)$$

where $y^k_{ij_{(L)}}$, $y^k_{ij_{(M)}}$, and $y^k_{ij_{(R)}}$ represent the lower bound, middle bound, and upper bound of individual DM's assessments, and $x_{ij_{(L)}}$, $x_{ij_{(M)}}$, and $x_{ij_{(R)}}$ are the lower bound, middle bound, and upper bound of the group assessments about the performance rating of location alternative $A_i$ with respect to criterion $C_j$ respectively.

Similarly, the degree of similarity between DMs on criteria weighting is

$$T^k_j = \frac{1}{1 + \left[\left(\frac{w^k_{j_{(L)}} + 4\,w^k_{j_{(M)}} + w^k_{j_{(R)}}}{6}\right) - \left(\frac{w_{j_{(L)}} + 4\,w_{j_{(M)}} + w_{j_{(R)}}}{6}\right)\right]} \tag{172.9}$$

where $w^k_{j_{(L)}}$, $w^k_{j_{(M)}}$, and $w^k_{j_{(R)}}$ represent the lower bound, middle bound, and upper bound of individual DM's assessments, and $w_{j_{(L)}}$, $w_{j_{(M)}}$, and $w_{j_{(R)}}$ represent the lower bound, middle bound, and upper bound of the group assessments respectively.

A consistency measure (CM) is proposed for identifying whether individual DMs' opinions are within the acceptable level of the consensus threshold. It is calculated by comparing the CM of individual DMs with the consensus threshold. A CM larger than the consensus threshold indicates that the DM's opinion is consistent to the group opinion. Otherwise, the DM is requested to change the assessments. The CM for the group on the performance rating and the criteria weight can be defined as

$$\mathrm{CM} = \max d(S^k_{ij}, T^k_j) \tag{172.10}$$

The consensus building process can be summarized as follows:

Step 1. Obtain the criteria weighting and performance rating with respect to criterion $C_j$ for each DM using fuzzy synthetic extent analysis in (172.2).

Step 2. Determine the decision matrix by each DM as in (172.4).

Step 3. Determine the fuzzy weighting for the selection criteria by each DM as in (172.5).

Step 4. Calculate the overall fuzzy decision matrix for the DMs by averaging the fuzzy assessments made by individual DMs as given in (172.6).

Step 5. Calculate the fuzzy weight for all the DMs by averaging the fuzzy assessments made by individual DMs as given in (172.7).

Step 6. Calculate the proximity measure between individual DMs' assessments and the group assessments for the ratings on each criterion by (172.8).

Step 7. Calculate the proximity measure between individual DMs' assessments and the group assessments for the criteria weights on each criterion by (172.9).

Step 8. Determine whether individual DMs opinions are within the accepTable level of consensus by (172.10). If the CM of a DM is less than the consensus threshold, the DM goes back to Step 1 for adjusting the assessments. Otherwise, the consensus building process is finalized.

The weighted fuzzy performance matrix representing the overall performance of each alternative on each criterion can then be determined by (172.11) as follows

$$Z = \begin{bmatrix} w_1x_{11} & w_2x_{12} & . & w_mx_{1m} \\ w_1x_{21} & w_2x_{22} & . & w_mx_{2m} \\ . & . & . & . \\ w_1x_{n1} & w_1x_{n2} & . & w_mx_{nm} \end{bmatrix} \tag{172.11}$$

Given the fuzzy vector $(w_jx_{1j}, w_jx_{2j}, \ldots, w_jx_{mj})$ for criterion $C_j$, the fuzzy maximum $(M^j_{\max})$ and the fuzzy minimum $(M^j_{\min})$ [13] which represent respectively the best and the worst fuzzy performance ratings among all the alternatives with respect to criterion $C_j$ can be determined as

$$\mu_{M^j_{\max}}(x) = \begin{cases} \frac{x - x^j_{\min}}{x^j_{\max} - x^j_{\min}}, \\ 0, \end{cases} \qquad \mu_{M^j_{\min}}(x) = \begin{cases} \frac{x^j_{\max} - x}{x^j_{\max} - x^j_{\min}}, \\ 0, \end{cases} \tag{172.12}$$

where $x^j_{\max} = \sup\left(\text{supp} \bigcup_{i=1}^{n} (w_jx_{ij})\right)$, and $x^j_{\min} = \inf\left(\text{supp} \bigcup_{i=1}^{n} (w_jx_{ij})\right)$.

The degree to which alternative $A_i$ is the best alternative with respect to criterion $C_j$ can then be determined by calculating the Hamming distance between its weighted fuzzy performance $(w_jx_{ij})$ with the fuzzy maximum and the fuzzy minimum [13] respectively, given as in (13).

$$h_i^+ = \sum_{j=1}^{m} H(w_jx_{ij}, M^j_{\max}), \quad h_i^- = \sum_{j=1}^{m} H(w_jx_{ij}, M^j_{\min}), \tag{172.13}$$

With the use of triangular fuzzy numbers, the Hamming distance between two fuzzy numbers $A = (a_1, a_2, a_3)$ and $B = (b_1, b_2, b_3)$ can be calculated as [14].

$$H(A, B) = |a_1 - b_1| + |a_2 - b_2| + |a_3 - b_3| \tag{172.14}$$

An overall performance index for alternative $A_i$ across all the criteria can be determined by (172.15). The larger the index, the more preferred the alternative.

$$P_i = \frac{(h_i^-)^2}{(h_i^+)^2 + (h_i^-)^2} \tag{172.15}$$

## 172.4 An Example

To demonstrate the applicability of the proposed approach, an example of evaluating and selecting a suitable hotel location involving three hotel managers is presented. Based on a thorough investigation, four hotel location alternatives are identified with respect to four criteria including Geographical Location ($C_1$), Traffic Condition ($C_2$), Hotel Facilities ($C_3$), and Operational Convenience ($C_4$) [2, 3].

Geographical location ($C_1$) refers to the subjective assessment of the DM on the location of the hotel for achieving the competitive advantage. It is measured by the proximity of the location to public facilities, the distance to existing competitors, the security around the location, the natural resources available, and the nearby rest facilities. Using the pairwise comparison, a fuzzy reciprocal judgment matrix for the performance of hotel locations on criterion $C_1$ by each DM can be determined as

$$C_1, D_1 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{bmatrix} \tilde{1} & \tilde{5} & \tilde{5} & \tilde{3} \\ \tilde{5}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{5}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{array}, \quad C_1, D_2 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{bmatrix} \tilde{1} & \tilde{3}^{-1} & \tilde{7}^{-1} & \tilde{5}^{-1} \\ \tilde{3} & \tilde{1} & \tilde{9}^{-1} & \tilde{3} \\ \tilde{7} & \tilde{9} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{5} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{array},$$

$$C_1, D_3 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{bmatrix} \tilde{1} & \tilde{3} & \tilde{5} & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{1} & \tilde{9} & \tilde{5} \\ \tilde{5}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{3} & \tilde{5}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{array}$$

Traffic condition ($C_2$) focuses on the subjective assessment of the DM on the level of convenience of the situated hotel to various locations of interest. This is measured by the distance to airport or freeway, the distance to downtown area, the distance to scenic spots, the parking area, the convenience, and the convenience to scenic spots. Using pairwise comparison, a fuzzy reciprocal judgment matrix for the performance of alternative hotel locations on criterion $C_2$ for each DM can be determined as

$$C_2, D_1 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{bmatrix} \tilde{1} & \tilde{7} & \tilde{5} & \tilde{7}^{-1} \\ \tilde{7}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{5}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{7} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{array}, \quad C_2, D_2 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{bmatrix} \tilde{1} & \tilde{3}^{-1} & \tilde{5} & \tilde{5}^{-1} \\ \tilde{3} & \tilde{1} & \tilde{5}^{-1} & \tilde{3} \\ \tilde{5}^{-1} & \tilde{5} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{5} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{array},$$

$$C_2, D_3 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{bmatrix} \tilde{1} & \tilde{5} & \tilde{5} & \tilde{3} \\ \tilde{5}^{-1} & \tilde{1} & \tilde{9} & \tilde{7}^{-1} \\ \tilde{5}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{7} & \tilde{3} & \tilde{1} \end{bmatrix} \end{array}$$

Hotel facilities ($C_3$) concern about the ability of the hotel to provide both facilities and services for fulfilling the requirements of the customer. This includes the indoor leisure facilities, the diversity of restaurants, the amalgamation with local culture, and the convenience of obtaining nearby land. A fuzzy judgment matrix for the performance of alternative hotel locations on $C_3$ for each DM can be determined as

$$C_3, D_1 = \begin{matrix} & \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{7}^{-1} & \tilde{7} & \tilde{5} \\ \tilde{7} & \tilde{1} & \tilde{9} & \tilde{9}^{-1} \\ \tilde{7}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{5}^{-1} \\ \tilde{5}^{-1} & \tilde{9} & \tilde{5} & \tilde{1} \end{bmatrix} \end{matrix}, \quad C_3, D_2 = \begin{matrix} & \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{3}^{-1} & \tilde{7}^{-1} & \tilde{7} \\ \tilde{3} & \tilde{1} & \tilde{9}^{-1} & \tilde{3}^{-1} \\ \tilde{7} & \tilde{9} & \tilde{1} & \tilde{7}^{-1} \\ \tilde{7}^{-1} & \tilde{3} & \tilde{7} & \tilde{1} \end{bmatrix} \end{matrix},$$

$$C_3, D_3 = \begin{matrix} & \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{9} & \tilde{7} & \tilde{3}^{-1} \\ \tilde{9}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{7}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{matrix}$$

Operational convenience (*$C_4$*) involves with the subjective assessment of the DM on the key resources for supporting the business operations of the hotel. This is assessed from the sufficiency of human resources, the quality of manpower, and the regulation restrictions. A fuzzy reciprocal judgment matrix for the performance of alternative hotel locations in regard to criterion *$C_4$* for each DM can be determined as

$$C_4, D_1 = \begin{matrix} & \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{5} & \tilde{9}^{-1} & \tilde{3}^{-1} \\ \tilde{5}^{-1} & \tilde{1} & \tilde{9} & \tilde{3}^{-1} \\ \tilde{9} & \tilde{9}^{-1} & \tilde{1} & \tilde{9}^{-1} \\ \tilde{3}^{-1} & \tilde{3} & \tilde{9} & \tilde{1} \end{bmatrix} \end{matrix}, \quad C_4, D_2 = \begin{matrix} & \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{3}^{-1} & \tilde{7}^{-1} & \tilde{7}^{-1} \\ \tilde{3} & \tilde{1} & \tilde{9}^{-1} & \tilde{7} \\ \tilde{7} & \tilde{9} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{7} & \tilde{7}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{matrix},$$

$$C_4, D_3 = \begin{matrix} & \begin{matrix} A_1 & A_2 & A_3 & A_4 \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{9} & \tilde{5} & \tilde{9} \\ \tilde{9}^{-1} & \tilde{1} & \tilde{9} & \tilde{5} \\ \tilde{5}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{9} \\ \tilde{9}^{-1} & \tilde{5}^{-1} & \tilde{9}^{-1} & \tilde{1} \end{bmatrix} \end{matrix}$$

To determine the weights of the selection criteria, pairwise comparison is used based on the linguistic variables defined as in Table 172.1, resulting in the determination of a fuzzy judgment matrix for each DM as

$$W, D_1 = \begin{matrix} & \begin{matrix} C_1 & C_2 & C_3 & C_4 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{7} & \tilde{9} & \tilde{5} \\ \tilde{7}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{9}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{5}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{matrix}, \quad W, D_2 = \begin{matrix} & \begin{matrix} C_1 & C_2 & C_3 & C_4 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{7} & \tilde{7} & \tilde{5} \\ \tilde{7}^{-1} & \tilde{1} & \tilde{3} & \tilde{3} \\ \tilde{7}^{-1} & \tilde{3}^{-1} & \tilde{1} & \tilde{5}^{-1} \\ \tilde{5}^{-1} & \tilde{3}^{-1} & \tilde{5} & \tilde{1} \end{bmatrix} \end{matrix},$$

$$W, D_3 = \begin{matrix} & \begin{matrix} C_1 & C_2 & C_3 & C_4 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \end{matrix} & \begin{bmatrix} \tilde{1} & \tilde{3}^{-1} & \tilde{9}^{-1} & \tilde{3} \\ \tilde{3} & \tilde{1} & \tilde{9}^{-1} & \tilde{3} \\ \tilde{9} & \tilde{9} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix} \end{matrix}$$

**Table 172.2** The consistency measure of decision makers

| Decision maker | Consistency measure | | | |
|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ |
| $D_1$ | 0.73 | 0.65 | 0.72 | 0.77 |
| $D_2$ | 0.81 | 0.69 | 0.64 | 0.71 |
| $D_3$ | 0.74 | 0.73 | 0.67 | 0.70 |

**Table 172.3** The overall performance index and ranking of hotel location alternatives

| Hotel location | Index | Ranking |
|---|---|---|
| $A_1$ | 0.73 | 3 |
| $A_2$ | 0.86 | 1 |
| $A_3$ | 0.64 | 4 |
| $A_4$ | 0.78 | 2 |

The proximity measure between individual DMs' assessments and the group assessments for the performance rating and the criteria weight is calculated by (172.8) and (172.9). In this situation, the consensus threshold value is set at 0.60. By using (10), the CM for the group on the performance ratings and the criteria weights is obtained in Table 172.2. It is observed that the CM value of individual DMs on all alternatives is more than the consensus threshold. Therefore, the consensus building process is finalized.

An overall performance index for each location across all criteria is calculated by (172.11) to (172.15). Based on Table 172.3, $A_2$ is the most suitable location.

## 172.5 Conclusion

The hotel location evaluation and selection process is challenging as it involves several DMs, multiple selection criteria, numerous hotel location alternatives, the presence of subjective and imprecise assessments, and the pressure to reach a certain level of agreement among the DMs. To effectively solve this problem, this paper has presented a fuzzy multi-criteria group decision making approach for solving the hotel location evaluation and selection problem. An example is presented that shows the approach is capable of effectively addressing the hotel location selection problem.

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