International Journal of Soft Computing 11 (4): 227-235, 2016
ISSN: 1816-9503

Evaluation and Selection of Urban Planning Projects Using Integration of Methods Fuzzy AHP and Fuzzy VIKOR

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Abstract: In this research was used to fuzzy multiple criteria decision making for assessing urban planning projects and extract the optimized master plan for cities. For the results of the most reliable were merged two methods, namely Fuzzy AHP and Fuzzy VIKOR. Where researcher used Fuzzy AHP to extract the relative importance of the criteria and used Fuzzy VIKOR to rank alternatives and extract the optimized alternative. Muqdadiyah City has taken as a case study to research and received the land use criteria at the highest importance among the criteria, after completing calculations show that the optimized master plan is the third alternative. And used these methods to ensure the accuracy of the results in uncertainty environment.

Key words: Master plan of city, urban planning, fuzzy AHP, fuzzy VIKOR, optimized master

INTRODUCTION

According to Diamantini and Zanon (2000), urban planning as a conventional tool in inquiry a balance between economic, environmental, social and governance aspects, then promoting interaction among city planners and the local community. Moreover, urban planning procedures are utilized as a part of the assessment of the social, economic and environmental effects of urban policies. They take into consideration a deliberate investigation of the relationship between social, economic and environmental advancements which portrays the shared reliance between urban planning and sustainable development (Rotmansa *et al*., 2000). As such, city planning should be based on the principle of sustainability, in order to achieve sustainable urban development. Urban planning ought to be a reaction to the worldwide changes and patterns influencing urban communities, particularly in the developing countries. Those vital urban planning frameworks created in the previous decades comprised of structures connected with an arrangement of indicators which assessed the supportability of the city's polices (Rotmans *et al*., 2000). However, this study suggests the use of modern methods including fuzzy multi criteria decision making instead of traditional methods to give accuracy results for decisions which relating to selecting the optimized master plan for cities from between alternatives.

Literature review: Urban planning is a complex process made up of comprehensive criteria covering various aspects of economic, social, environmental and technical aspects to evaluate and choose the best alternative to the development of the city. Therefore, the use of new ways, for example, fuzzy set theory would give better and far reaching results which would accommodate with more conceivable outcomes in development planning. Urban quality evaluation is a vital part of planning and management. Conventional theory does not give as good assessment as the fuzzy set theory which gives the basis to urban planning Pleho and Avdagic in 2008. Multi-Criteria Decision Making (MCDM) is the techniques that support the subjective judgement and assessment of a finite number of decision alternatives under a finite number of criteria by a group decision maker or by a single.

For analyze the model of decision making to support the decision making process in the urban planning using Fuzzy Multi-Criteria Decision Making method (FMCDM).

Traditional MADM methods cannot efficiently handle problems with this imprecise information. To solve that difficulty, fuzzy set theory, first introduced by Zadeh (1965). The concept fuzzy set theory has been integrated with MCDM techniques.

In complex systems, the experiences and judgments of decision makers are represented by linguistic variable like

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Table 1: Advantages and disadvantages of the first alternative

Advantage	Disadvantage
Strong economic development through trade progressing which has a positive impact on the situation in the city where they are taking advantage of this economic through providing new income opportunities	Economic development ignores agricultural identity as an alternative consternates on the industry and neglected agricultural base of the city
Including Mehrot river within the municipal boundaries and taking up the riverbank to the tourist side	Taking up the other side of the housing expansion as residential lands have a negative impact on the nature of Mehrot river
State officials departments gathered in one place for the benefit of the citizen	The nature of the city is comprehensively commercial as well as the social amenities and public services are few
Surrounding the industrial zone with a greenbelt	No maintaining offered toward greenbelt which is already existed, because of the new land uses which exploit a lot of farmland
The presence of the industrial zone in the Al-Atha'aa area which is sandy and untapped one, thus it is considered an important task for this exploitation	Pollution increasing in the city, especially industrial waste and factory waste, this large industrial areas may have a negative impact on the environment
Expansion towards northward	Expansion towards the south where the quicksand
There is a proposed train station to promote the link of the city with the outer surrounding in order to establish economic development	There is no expansion towards westward
	Business functions based on the length of the main roads where the traffic functions limits the activation of public places

"poor", "vary poor" and "good". Therefore, these linguistics data can be transformed to quantitative data (Ozdagoglu and Ozdagoglu, 2007) where linguistic variables in the questionnaire is aimed of obtaining experts opinions. Thus, linguistic variables are defined as the triangular fuzzy numbers (Paslari *et al*., 2014). A TFN is denoted simply as (l, m, u) the parameters (l) is denote the smallest possible value (m) is denote the most promising value and (u) is denote the largest possible value that is describe a fuzzy event (Shukla *et al*., 2014). Let A be the classical set of objects whose elements are symbolize by X. The crisp value of a statement can be given by membership function as M_A from X to [0, 1] (Samantra *et al*., 2012):

$$\mu(x) = \begin{cases} 1, & \text{if } x \in A \\ 0, & \end{cases} \quad (1)$$

otherwise

$$\mu(x) = \begin{cases} \dfrac{x-1}{m-1} & x < l; l \le x \le m \\ \dfrac{m-x}{u-m} & m \le x \le u; x > u \end{cases} \quad (2)$$

Fuzzy MCDM is expected to be capable to help the multi-stakeholders to make an appropriate decision in urban land use planning. The model is more suitable for the problems involving stakeholders in the decision making to avoid decisions that have political and manipulative influences (Mosadeghi *et al*., 2015).

CASE STUDY (THE MASTER PLAN FOR AL- MUQDADIYAH CITY)

Al-Muqdadiyah city is the center of Al-Muqdadiyah district where it located in Diyala governorate at the northeast of the Baqubah City with a distance of 41 km.

The proposed alternatives for the design of the city will be put and updated in order to be harmonized with global progress until the target year (2035) due to consultation and exchange of expert's opinions and specialists of Engineering Consultative Office at Diyala University as well as German consultative team representative by Raicher consultative company to reach better future development alternatives. Three development alternatives are put to achieve diversity and integration as follows.

The first alternative (Al-Muqdadiyah commercial center): This alternative is based on the important strategic of Al-Muqdadiyah City within its regional environment where Al-Muqdadiyah city is considered as a commercial center for all villages in the Hamrin basin. The commercial activities survey shown the frailty of business activity in the city compared to the possibilities of the city, where it is supposed to be an important commercial use and a key factor in terms of land use as well as the fact that such use does not serve only the city but also the neighboring villages to Al-Muqdadiyah City and also it extends sometimes to neighboring governorates. As shown Fig. 1 first alternative and Table 1 shown advantages and disadvantages of the first alternative.

The second alternative (integrated regional centre): The current alternative confirms the need of Al-Muqdadiyah City to have a vital role in the field of tourism and recreation, regarded as one of the main resources for the development of city's economy. As shown Fig. 2 second alternative and Table 2 shown advantages and disadvantages of the second alternative.

The third alternative (Al-Muqdadiyah: urban and agricultural center): This alternative is based on the agricultural capabilities of Al-Muqdadiyah City and

Fig. 1: The first alternative (Al-Muqdadiyah of commercial center)

Fig. 2: The second alternative (Al-Muqdadiyah of integrated regional center)

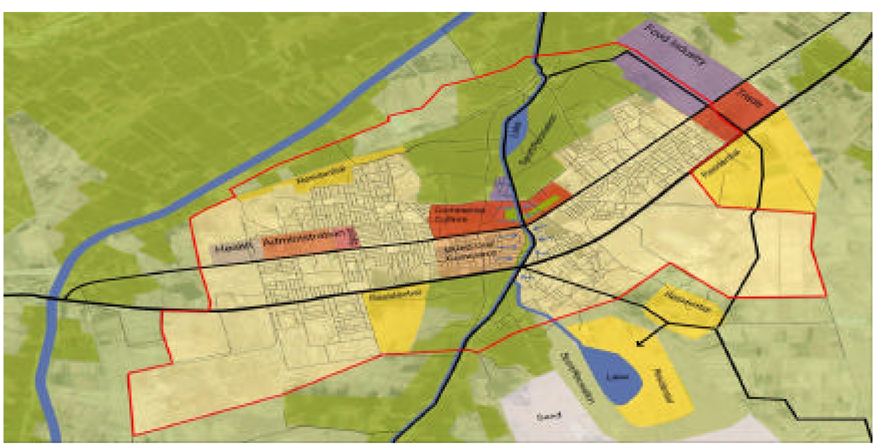

Fig. 3: The third alternative (Al-Muqdadiyah of agricultural and urban center)

importance of environmental factors in the growth of the city and the growth of the concept of green cities. As shown Fig. 3 third alternative and Table 3 shown advantages and disadvantages of the third alternative.

Table 2: Advantages and disadvantages of the second alternative

Advantage	Disadvantage
Identifying the city as a center for the region, therefore to be an integrated regional center, there will be a mix of different economic sectors to diversify its development and the city offers many amenities and social services for the governorate	Losing of large agricultural areas (where the alternative takes a lot of agricultural land) where the alternative neglects the agricultural base and ignoresagricultural and historical identity of the city
It contributes in establishing transport at city center and provides the best condition	The issue of expropriation of land of the airports and the railway owned by individuals, which requires a high effort and budget
Working on constructing an island on Al-Muqdadiyah river and opening additional river in order to attract citizens attentions	The need for large amounts of water, especially that the country is going through a water crisis
Establishing a touristic hotel in Al-Sedour area	Agriculture department and the municipal area must prevent land allocation which are dedicated as a land use
Al-Muqdadiyah city needs to establisha university for various studies that may help in creating jobsof high quality	
The historical depth of Al-Shakhah river, where there are attractive spaces along the riverbanks in the city center	The establishment of another river with Al-Shakhah river because of the lack of water and high cost
Expansion towards northward	The presence of the university towards the east of the city prevents expansion towards the north of the city or diminishes, so the presence of the university in the north of the city increases the opportunities for expansion to the northward

Table 3: Advantages and disadvantages of the third alternative

Advantage	Disadvantage
Emphasizingon the economic development and focusing on agriculture as one of the city's strengths	Overlooking on the economic aspects which are unrelated to agriculture while the alternative focuses on agriculture and neglects the economic value of tourism
Planting areas surrounding the city where the agricultural areas surrounding the city formed as greenbelt of the city	The need of many possibilities and efforts to increase green space and safekeeping it
Encouraging financing fruits industries, so foodstuffs industry is a profit for agricultural and regional products	Increasing the amount ofpollutants especially factories products and the need for waste sorting factories
Creeping of green zone, where the alternative maintains most of the agricultural land and construction of a large green area in Al-Atha'aa	Establishing of the green zone in Al-Atha'aa consume high expenses money
Establishing commercial buildings	The absence of a university
Constructing residential buildings in accordance with the green environment	It did not take into consideration the old city (housing+commercial) and the possibility of using it in any other activity
Water gatherings are excellent, creating new lakes in the North and South of the city and providing attractive public spaces for recreation and housing	Setting up lakes tourist concentrated on the houses which may raise up the price of the land
Constructing recreational areas and green areas along the riverbanks of Al-Shakhah	Mehrot river did not exploit
Opening administrative buildings for business men	
Pay attentionfor the environment where the focus will be on green technology and sustainability and create innovative identity as well as achieve a high quality of life in the city to follow the green sustainable development	
Collecting officials departments in a Central Park	

Table 4: Linguistic terms and the corresponding triangular fuzzy numbers (Ayhan, 2013)

Linguistic terms	Fuzzy number	Explanation
Equally important	(1, 1, 1)	The criterion i is equally important when compared to criterion j
Weakly important	(2, 3, 4)	The criterion i is Weakly important when compared to criterion j
Fairly important	(4, 5, 6)	The criterion i is Fairly important when compared to criterion j
Strongly important	(6, 7, 8)	The criterion i is Strongly important when compared to criterion j
Absolutely important	(9, 9, 9)	The criterion i is Absolutely importantwhen compared to criterion j
Intermediate values between the two adjacent judgments	(1, 2,3) (3, 4,5) (5, 6,7) (7, 8, 9)	When compromise is needed
Reciprocals number	The reciprocals such as 1/3,1/5 1/7, 1/9, etc.,indicate the opposite respectively of the values 3, 5, 7, 9, etc	If criterion (j) to him the importance of higher from criterion (i) it takes this reciprocalnumber allocated to the criterion (i)

FUZZY AHP METHOD

The Analytic Hierarchy Process technique (AHP) which was introduced by Saaty (1990). Fuzzy AHP is an advanced analytical method developed from the classic AHP (Bouyssou *et al*., 2000).

The objective of using Fuzzy AHP is to determine the relative important of the criteria. A pairwise comparison matrix that correspond he linguistic data is formed in the questionnaire and experts are asked to fill it (Shukla *et al*., 2014).

In computing the relative importance for the criteria. The steps are as follows (Aydin and Kahraman, 2012; Shukla *et al*., 2014) linguistic terms shown in Table 4. Comparison matrix expressed by:

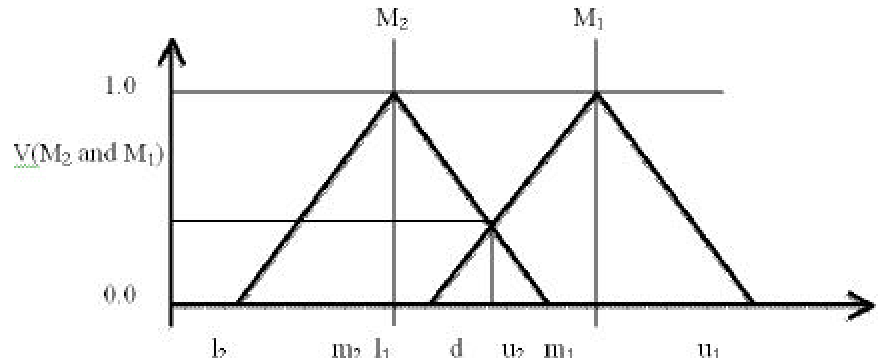

Fig. 4: The intersection between M_1 and M_2

$$\tilde{A}=(a_n)=\begin{bmatrix}(1.1.1) & (l_{12}.m_{12}.n_{12}) & \cdots & (l_{1n}.m_{1n}.n_{1n})\\ (l_{22}.m_{21}.n_{21}) & (1.1.1) & \cdots & (l_{1n}.m_{1n}.n_{1n})\\ \vdots & \vdots & \vdots & \vdots\\ (l_{22}.m_{21}.n_{21}) & (l_{22}.m_{21}.n_{21}) & \cdots & (1.1.1)\end{bmatrix} \quad (3)$$

Each object is taken and extent analysis for each goal, gi is performed, respectively. Therefore, m extent analysis values for each object can be obtained with the following signs:

$$M_{gi}^1 \cdot M_{gi}^2 \cdot M_{gi}^3 \cdot M_{gi}^4 \cdot M_{gi}^5 \ldots\ldots\ldots\ldots M_{gi}^m \quad (4)$$

where, gi is the goal set (i = 1, 2, 3, 4, …, n) and M^m_{gi} (j = 1, 2, 3, 4, …, m), all are TFNs. The value of fuzzy synthetic extent with respect to the ith object is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{m}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} \quad (5)$$

To obtain $\sum_{j=1}^{m} M_{gi}^j$ for a particular matrix such that:

$$\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \quad (6)$$

and to obtain $\left[\sum_{i=1}^{m}\sum_{j=1}^{m} M_{gi}^j\right]^{-1}$, where M^m_{gi} (j = 1, 2, 3, 4, ….., m) such that:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{i=1}^{n} lj, \sum_{i=1}^{n} mj, \sum_{i=1}^{n} uj\right) \quad (7)$$

and then compute the inverse of the vector in Eq. 2 such that:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} ui}, \frac{1}{\sum_{j=1}^{n} mi}, \frac{1}{\sum_{i=1}^{n} li}\right) \quad (8)$$

$M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two TFNS, the degree of possibility of $M_2 = (l_2, m_2, u_2) = M_1 = (l_1, m_1, u)$ and can be equivalently expressed as follows:

$$= \begin{cases} 1, & \\ 0, & \text{if } m_2 \geq m_1; \text{if } l_1 \geq u_1, \text{ otherwise} \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \end{cases} \quad (9)$$

where, d is the ordinate of the highest intersection point D between μM_1 and μM_2 (Fig. 4). To compare M_1 and M_2, we need both the values of $V(M_1 = M_2)$ and $V(M_2 = M_1)$.

The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers Mi (I = 1, 2, 3, 4, ….., K) can be defined by:

$$\begin{aligned} &V(M \geq M_1, M_2, M_3, M_4, \ldots, M_K) = V[(M \geq M_1),\\ &(M \geq M_2), (M \geq M_3), (M = M_4), (M \geq M_K)] = \min\\ &V(M \geq M_i), i = 1, 2, 3, 4, \ldots, k \end{aligned} \quad (10)$$

Assume that $d'(C_i) = \min V(S_i \geq S_k)$ for k = 1, 2, 3, 4, ….., n. k≠1, then the weight vector is given by:

$$W' = [\, d'(C_1), d'(C_2), d'(C_3), d'(C_4), \ldots, d'(C_5)]^T \quad (11)$$

Via normalization, the normalized weight vectors is given:

$$W = [d(C_1), d(C_2), d(C_3), d(C_4), \ldots, d(C_n)] \quad (12)$$

where, W is non-fuzz numbers. The criteria include economic, environmental, social, land uses and technical criteria that need to be assessed by linguistic

Table 5: Aggregate fuzzy numbers decision making matrix

Criteria	Economic	Environmental	Social	Land uses	Technical
C1	(1,1,1)	(2.009, 2.765,3.539)	(1.635, 2.139, 2.671)	(0.339, 0.467, 0.636)	(0.968, 1.371, 1.805)
C2	(0.283, 0.362, 0.498)	(1,1,1)	(4.842, 5.842, 6.842)	(0.25, 0.331, 0.458)	(0.187, 0.234, 0.318)
C3	(0.374, 0.468, 0.612)	(0.146, 0.171, 0.207)	(1, 1, 1)	(0.25, 0.331, 0.458)	(4.316, 5.316, 6.31)
C4	(1.572, 2.141, 2.95)	(2.183, 3.021, 4)	(2.183, 3.021, 4)	(1,1,1)	(2.98, 3.832, 4.694)
C5	(0.554, 0.729, 1.033)	(3.145, 4.274, 5.348)	(0.158, 0.188, 0.232)	(0.213, 0.261, 0.336)	(1, 1, 1)

variables. The criteria set is determined at the beginning and modeling depending upon to these criteria:

$$\sum l = 1+0.283+0.374+1.572+0.554+2.009+1+0.146+2.183+3.145+1.635+4.842+1+2.183+0.158+0.339+0.25+0.25+1+0.213+0.968+0.187+4.316+2.98+1 = 33.587 \quad (13)$$

$$\sum m = 1+0.362+0.468+2.141+0.729+2.765+1+0.171+3.021+4.274+2.139+5.842+1+3.021+0.188+0.467+0.331+0.331+1+0.261+1.371+0.234+5.316+3.832+1 = 42.264 \quad (14)$$

$$\sum u = 1+0.498+0.612+2.95+1.033+3.539+1+0.207+4+5.348+2.671+6.842+1+4+0.232+0.636+0.458+0.458+1+0.336+1.805+0.318+6.31+4.694+1 = 51.952 \quad (15)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{n} M_{gi}^{j}\right]^{-1} = (1/51.952,\ 1/42.264,\ 1/33.587) \quad (16)$$

Through applying the Eq. 2 on the values in the Table 5 to extract the values of as it shown below:

$$S1 = (5.951, 7.742, 9.651)\times(1/51.952, 1/42.264, 1/33.587) = (0.115, 0.183, 0.287) \quad (17)$$

$$S2 = (6.562, 7.769, 9.116)\times(1/51.952, 1/42.264, 1/33.587) = (0.126, 0.184, 0.271) \quad (18)$$

$$S3 = (6.086, 7.286, 8.593)\times(1/51.952, 1/42.264, 1/33.587) = (0.117, 0.172, 0.256) \quad (19)$$

$$S4 = (9.918, 13.015, 16.643)\times(1/51.952, 1/42.264, 1/33.587) = (0.191, 0.308, 0.496) \quad (20)$$

$$S5 = (5.07, 6.452, 7.949)\times(1/51.952, 1/42.264, 1/33.587) = (0.098, 0.153, 0.237) \quad (21)$$

Also, applying the Eq. 6 to extract the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ as it shown in the following accounts:

$$V(S1 \geq S2) = \frac{0.287-0.126}{(0.287-0.183)+(0.184-0.126)} = 0.994;\ V(S1 \geq S3) = 1 \quad (22)$$

$$V(S1 \geq S4) = \frac{0.287-0.191}{(0.287-0.183)+(0.308-0.191)} = 0.434;\ V(S1 \geq S5) = 1 \quad (23)$$

$$V(S2 \geq S1) = 1;\ V(S2 \geq S3) = 1 \quad (24)$$

$$V(S2 \geq S4) = \frac{0.271-0.191}{(0.271-0.183)+(0.308-0.191)} = 0.392;\ V(S2 \geq S5) = 1 \quad (25)$$

$$V(S3 \geq S1) = \frac{0.256-0.115}{(0.256-0.172)+(0.184-0.126)} = 0.928 \quad (26)$$

$$V(S3 \geq S2) = \frac{0.256-0.126}{(0.256-0.172)+(0.184-0.126)} = 0.915 \quad (27)$$

$$V(S3 \geq S4) = \frac{0.256-0.191}{(0.256-0.172)+(0.308-0.191)} = 0.323;\ V(S3 \geq S5) = 1 \quad (28)$$

$$V(S4 \geq S1) = 1;\ V(S4 \geq S2) = 1;\ V(S4 \geq S3) = 1;\ V(S4 \geq S5) = 1 \quad (29)$$

$$V(S5 \geq S1) = \frac{0.237-0.115}{(0.256-0.153)+(0.183-0.115)} = 0.803 \quad (30)$$

$$V(S5 \geq S2) = \frac{0.237-0.126}{(0.256-0.153)+(0.183-0.115)} = 0.782 \quad (31)$$

$$V(S5 \geq S3) = \frac{0.237-0.117}{(0.256-0.153)+(0.172-0.117)} = 0.863 \quad (32)$$

$$V(S5 \geq S4) = \frac{0.237-0.191}{(0.237-0.153)+(0.308-0.191)} = 0.229 \quad (33)$$

Then applying Equations to get the values min $V(M \geq M_i)$ as follows:

Table 6: The relative importance for criteria

Main criteria	Relative importance
Economic criteria (C_1)	0.183
Environmental criteria (C_2)	0.165
Social criteria (C_3)	0.136
Land use criteria (C_4)	0.421
Technical criteria (C_5)	0.096

$$\begin{aligned} d'(C1) &= \min(0.994, 1, 0.434, 1) = 0.434 \\ d'(C2) &= \min(1, 1, 0.392, 1) = 0.409 \\ d'(C3) &= \min(0.928, 0.915, 0.323, 1) = 0.337 \\ d'(C4) &= \min(1, 1, 1, 1) = 1 \\ d'(C5) &= \min(0.803, 0.782, 0.863, 0.229) = 0.197 \end{aligned} \quad (34)$$

To calculate the weights of the criteria (W) Table 6, the equations are applied as follows:

$$\text{Priority weight } (W') = (0.434, 0.392, 0.323, 1, 0.229)$$

$$W1 = \frac{1}{0.434+0.392+0.323+1+0.229} = 0.183 \quad (35)$$

$$W = (0.183, 0.165, 0.136, 0.421, 0.096)$$

FUZZY VIKOR METHOD

The VlseKriterijumska Optimizacija IKompromisno Resenje (VIKOR) means multi-criteria optimization and compromise solution was introducted by Opricovic in 1998.

Fuzzy VIKOR method is a persuasive decision approach for solving MCDM problem. This technique is used to give the weight, the ranking list of alternatives and provide a compromise solution. The compromise solution is an achievable solution which is closest to the ideal (Opricovic and Tzeng, 2007).

In this study, to express decision-makers opinions in the form of linguistic variable to assess the weights and ranking of alternatives to the qualitative data. Linguistic judgment has been converted to fuzzy numbers as shown in Table 7 (Samantra *et al*., 2012). The steps of fuzzy vikor are as follows (Ahmad *et al*., 2015).

Describing the proper linguistic variables. These linguistic variables are expressed by triangular fuzzy numbers. In this step the suitable linguistic variables for fuzzy ratings of alternatives for each criterion are expressed. The decision maker aggregate fuzzy ratings of each alternative are computed as the following equation:

$$\tilde{x}_{ij} = \frac{1}{k}\left[\tilde{x}_{ij}^{(1)} \otimes \tilde{x}_{ij}^{(2)} \otimes \tilde{x}_{ij}^{(3)} \otimes \ldots \tilde{x}_{ij}^{(t)} \oplus\right] \quad (36)$$

The weight of each criterion is calculated from Fuzzy AHP Technique. Defuzzification the fuzzy decision matrix

Table 7: Linguistic variables for alternative ratings (Aydin and Kahraman, 2012)

Linguistic variables	Fuzzy number
Very poor	(0,0, 1)
Poor	(0, 1, 3)
Medium poor	(1, 3, 5)
Fair	(3, 5, 7)
Medium good	(5, 7, 9)
Good	(7, 9, 10)
Very good	(9, 10, 10)

to convert the fuzzy values into crisp numbers be calculated as following (Aydin and Kahraman, 2012):

$$\text{Crisp} = \frac{1+4m+u}{6} \quad (37)$$

Compute the best values f_j^* and the worst values f_j^- for all criteria. Where j is criteria as follows:

$$fj = \max x_{ij},\ \bar{fj} = \min x_{ij} \quad (38)$$

Compute the S_i which refers to measure of ith alternative with the best value and also compute the index R_i which refers to measure of ith alternative to the worst value. W_j is the weight of the jth criteria:

$$S_i = \sum_{j=1}^{n} wj\left[\frac{(f_j^* - x_{ij})}{(f_j^- - f_j^-)}\right] \quad (39)$$

$$R_i = \max\left[Wj\frac{(f_j^* - x_{ij})}{(f_j^- - f_j^-)}\right] \quad (40)$$

where, R_i is with the minimum individual regret while S_i is a maximum group utility. Compute the values Qi from the following equation:

$$Q_i = v\frac{S_i - S_{min}}{S_{max} - S_{min}} + (1-v)\frac{R_i - R_{min}}{R_{max} - R_{min}} \quad (41)$$

Where:

$$\{S_{max} = \max_t S_t, S_{min} = \min_t S_t,\ R_t = \max_t R_t, R_{min} = \min_t R_t\} \quad (42)$$

and v is the strategy weight of maximum group utility while 1-v shows the weight of individual regret where use (v = 0.5)

Rank the alternatives depend on the values S, R and Q in ascending order. The index Qi implies the separation measures of the ith alternative Ai from the best alternative. That is the smaller the value Q is the best alternative.

Table 8: Aggregate fuzzy number decision matrix

CA	C1	C2	C3	C4	C5
A1	(2.25, 4, 5.75)	(2.25, 3, 4.25)	(0.5, 1.75, 3.5)	(1.25, 3, 5)	(3, 5, 7)
A2	(5, 7, 8.50)	(2.75, 4.50, 6.5)	(0.5, 1.75, 3.50)	(3.25, 4.75, 6.25)	(4, 6, 7.75)
A3	(5.75, 7.25, 8.25)	(7.50, 9, 9.75)	(7.50, 9.25, 10)	(2.75, 4.50, 6.50)	(4.75, 6.25,7 .25)

Table 9: Crisp values for decision making matrix and weight of each criterion

CA	C1	C2	C3	C4	C5
A1	4.000	3.167	1.917	3.083	5.000
A2	6.833	4.583	1.917	4.750	5.917
A3	7.083	8.750	8.917	4.583	6.167
Weights of criteria	0.183	0.165	0.136	0.421	0.096

Suggest a compromise solution. The alternative denoted as A(1) is the best ranked by the measure Q (minimum) is considered as a promise solution if the following two conditions are satisfied. Condition 1: acceptable advantage:

$$Adv = Q(A^{((m)))} - Q(A((1))) \geq 1/((m\text{-}1)) \quad (43)$$

where, Adv is the advantage of the alternative A(1) ranked first, A(2) is the alternative with the second position in {A}Q.

Condition 2: acceptable stability in decision making: The alternative A(1) must also be the best ranked by S and R. If one of the two conditions is not satisfied, then a set of compromise solution is suggested which involve of:

- Alternative A (1) and A (2) if only the condition 2 is not satisfied
- Alternative A (1), A (2), ..., A(M) if the condition condition 1 is not satisfied

A (M) is determined by the relation for maximum M. This infers that the positions of these alternatives in closeness" and therefore A(1), A(2), ..., A(M) are the set of alternatives to be re-examined well further considered (Table 8-13).

The condition1 is not satisfied, that means Q(A)-Q (A^1)<1/(m-1) the alternatives A1, A2, A3 all are the same compromise solution there is no comparative advantage of A3 from others. But for the case of maximum, the corresponding alternative is compromise (closeness) solution:

$$Q(A'')\text{-}Q(A') \geq 1/(m\text{-}1) \rightarrow 0.256\text{-}0.000<0.5 \quad (44)$$

The condition 2 is satisfied. Alternative 3 is the best ranked by Q, S and R.

Table 10: The best values and the worst values of all criteria ratings

F*	The best values	F^-	The worst values
F1*	7.083	$F1^-$	4.000
F2*	8.750	$F2^-$	3.167
F3*	8.917	$F3^-$	1.917
F4*	4.750	$F4^-$	3.083
F5*	6.167	$F5^-$	5.000

Table 11: The values of S, R and Q for all alternatives

Alternatives	Si	Ri	Qi
A1	1.001	0.421	1.000
A2	0.295	0.136	0.256
A3	0.042	0.042	0.000

Table 12: The ranking of the alternatives by S , R and Q in ascending order.

Ranking alternatives	1	2	3
By S	A3	A2	A1
By R	A3	A2	A1
By Q	A3	A2	A1

Table 13: The ranking of alternatives

Alternatives	Rank
A1	3
A2	2
A3	1

CONCLUSION

It is shown that the current methods to evaluate and select the optimized master plan are preliminary. It was used simple statistics methods and it was generally based on personal intuition or previous experience and both are influenced by uncertainty, therefore the need of decision-makers to effective and comprehensive ways to assess criteria and alternatives, then choose the alternative and that is what the researcher has done during his research through the utility of use modern methods in the selection of optimized master plan.

The integration of several methods are FVIKOR and FAHP to give the most accurate results in the selection process for the optimized master plan by designing a series of mathematical models as it focused on the weights criteria provided by FAHP method and these weights are the same as entering FVIKOR method whereas the third alternative obtained on the first rank and thus proved that techniques used in the research through the research results be have analysis tools in different situations through the active involvement of decision makers in the evaluation process and therefore they give basic rationality in decision-making.

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