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ASSESSMENT OF URBAN WELFARE TO ACHIEVE SUSTAINABLE URBAN DEVELOPMENT USING AN INTEGRATED FUZZY AHP-VIKOR WITH A CASE STUDY

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Original scientific paper
Capabilities and relative advantages of regional and local-scale urban welfare vary due to the influence of numerous economic, social and environmental factors; this causes excellence of some areas over other areas. Similarly, understanding the local and regional advantages and capabilities is considered as the basic principle of development planning and achieving urban welfare; scientific solutions of development also make sense by an explanation of the status quo. Analysis of welfare facilities available in different parts of Tehran can detect shortcomings and irregular compactions as well as the level of availability of the considered facilities throughout Tehran. Therefore, better understanding of development level of urban welfare facilities leads to recognition of strengths and weaknesses, capabilities and limitations and finally a successful regional planning. The used methods are an integration approach based on fuzzy multi-criteria decision-making methods, including Fuzzy AHP and VIKOR. The fuzzy AHP is used to determine the weights of criteria; moreover, the VIKOR method is used to prioritize the 15 towns of Tehran province. The results showed that Tehran has the highest prioritization of sustainable welfare based on criteria related to R=0,052, S=0,0716 and Q=0,0434 and the lowest prioritization is related to Qarchak with R=0,1194, S=0,9693 and Q=0,990.

Keywords: *Fuzzy AHP, sustainable urban development, Tehran Province, urban welfare, VIKOR*

Procjena urbanog blagostanja u svrhu postizanja održivog urbanog razvoja primjenom integriranih Fuzzy AHP-VIKOR u analizi slučaja

Izvorni znanstveni članak
Mogućnosti i relativne prednosti u postizanju urbanog blagostanja u regiji i lokalno razlikuju se zbog utjecaja brojnih ekonomskih, društvenih i ekoloških čimbenika zbog kojih se neka područja znatno ističu u odnosu na druga. Slično tome, smatra se da je razumijevanje lokalnih i regionalnih prednosti i mogućnosti osnovni princip u planiranju razvoja i postizanja urbanog blagostanja; znanstvena rješenja razvoja imaju također smisla objašnjenjem statusa quo. Analiza uvjeta za postizanje blagostanja u različitim dijelovima Teherana može otkriti nedostatke i nepravilnu kompaktnost kao i stupanj raspoloživosti razmatranih pogodnosti u cijelom Teheranu. Prema tome, bolje poznavanje stupnja razvijenosti urbanih mogućnosti za postizanje blagostanja vodi ka prepoznavanju jakih i slabih strana, mogućnosti i ograničenja, te konačno uspješnom regionalnom planiranju. Primijenjene metode rada predstavljaju integracijski pristup zasnovan na metodama donošenja odluka na osnovu fuzzy multi-kriterija, uključujući Fuzzy AHP i VIKOR. Fuzzy AHP se koristi za određivanje težine kriterija; štoviše, metoda VIKOR je primijenjena da se odrede prioriteti između 15 gradova pokrajine Teheran. Rezultati su pokazali da Teheran ima najveći prioritet u razvoju održivog blagostanja zasnovanog na kriterijima povezanim s R=0,052, S=0,0716 i Q=0,0434, a najniži stupanj prednosti ima Qarchak s R=0,1194, S=0,9693 i Q=0,990.

Ključne riječi: *Fuzzy AHP, održivi urbani razvoj, pokrajina Teheran, urbano blagostanje, VIKOR*

1 Introduction

Development has not occurred similarly at different times and places between countries; instead, regional disparities are considerable in each scale. Moreover, some areas have a privileged position in terms of regional criteria compared to other areas [1]. Regional planning does not result from a regionalized national program; alternatively, it adds to the national role establishing a mutual relationship by identifying needs, capabilities and limitations of a region. Regional planning does not refer to relative advantages in terms of national economy and participation in international division of labour; instead, it prioritizes the advantages considered by regional residents serving the economy [2]. The goal setting is always the first step throughout the planning process; the goal of regional planning may be to identify the degree of development of different regions with together [3].

The general objectives of regional planning are the establishment of social justice and balanced distribution of wealth and welfare among people; moreover, one of the most important features of a dynamic healthy economy is a fair and equitable distribution of facilities and the fruits of development among all the populations of a region or country [4]. Thus, understanding the local and regional advantages and capabilities is considered as the basic principle of development planning; scientific solutions of development also make sense by an explanation of the status quo. More severe unbalanced spatial distribution of development criteria exponentially adds to imbalanced spatial distribution of facilities and the population. Moreover, the imbalanced distribution both intensifies concentration of criteria on areas, which already suffer concentration, and moves population and facilities away from underserved areas; this, in turn, increases imbalance in the level of geographical space.

Ignoring imbalances of a region not only suppresses the space, resources and the population in focal areas, but also it decreases optimal productivity of resources in low-concentrated regions and finally decentralized population and human resources. In this case, the achievement of sustainable human development would be impossible [5].

The main objective of sustainable development is to provide opportunities for urban management at any time and everywhere. Sustainable development provides quality of life, social integration, participation and a healthy environment for all [6]. Therefore, it is important to use proper methods able to combine various criteria in order to prioritize geographical spaces. During recent years, numerous methods often called as decision-making techniques have been used to prioritize the region with respect to sustainability [7]. Accordingly, the present study tries to prioritize the towns located in Tehran province with respect to the urban welfare for achieving a

sustainable city. The purpose of an evaluation and prioritization is that an organization, whether public or private, uses the information gathered by the decision-making process, including error corrections [8].
The remaining parts of the current paper are structured as follows: Section 2 presents theoretical framework. Section 3 describes the proposed methodology, fuzzy AHP, VIKOR and evaluation criteria. Section 4 describes the case study. In Section 5, the results of research are presented. Finally, conclusion part of the present paper is presented in Section 6.

2 Theoretical framework

Development, meaning change, has been always concerned by a human; thus, development is not a new phenomenon. The changes made in the form and content of the human life indicate development, because it has been by development that a human could shift from cave-inhibiting and nomadic life to modern sedentarization and urbanization. Nevertheless, not any change can be called development. Development refers to positive changes, which improve the lives of people. However, development has been defined as a conscious effort based on planning for social and economic progress in a society which is unique to the twentieth century and began by the Soviet Union in 1917 [9].

Sustainable development is a comprehensive approach to improve the quality of human life in order to achieve economic, environmental and social welfare of human settlements [10]. In this sense, the process of sustainable development facilitates the achievement of increasingly continuous production, reliable life, food security, social stability, justice and public participation by organization and adjustment of the relationship between human and environment and management of resources. The sustainable development process integrates socio-economic and environmental objectives of society, wherever possible, through establishment of policies, required actions and supportive operations.

The central core of the concept of sustainability is based on capital preservation; in fact, the sustainable development refers to preservation of capital reservoirs such as human, social, natural and economic capital. Thus, conservation and preservation of resources by sustainable welfare approach, efficiency of change processes and equity of present and future generations for optimized utilization of capital resources can be considered as the core of sustainable development [11].

Development is sustainable when it is economically persistent, socially acceptable and environmentally valid because an activity performed by the human (social) is often motivated by profit and income (economic) and occurs within the nature using natural resources [12].

Sustainable development is a new process which considers the economic development as a failed unfinished process disregarding the environmental sustainability and social justice. Sustainable development is a process which considers the economic growth not as a goal but a means to improve the human condition in all aspects. Sustainable development involves a comprehensive program, including economic, social, cultural, political and environmental aspects to match the current requirements with future priorities [13]. According to Burton et al. [14], sustainable development is a chair with four basic economic, social, ecological and cultural legs, which together lead to sustainable human development. Sustainable development does not only refer to environment protection, but is a new concept of economic growth, which provides all people of the world, not a few of them, with justice and facilities. In the process of sustainable development, economic policies (energy, agriculture, industry, etc.) are to be designed to sustain economic, social and environmental development [15].

Development prioritizes the decreased poverty, productive employment, social integration and environmental restoration; it also balances human population and responsibility of societies to both requirements and capacities of the nature and places. This type of development accelerates the economic growth without destroying the natural capital needed to support opportunities of the future generations. In conclusion, the sustainable development is an endogenous, justice-driven, ecologically based, holistic, prospective and wise-based process which occurs in long term based on three parts: inseparability of economy and environment, justice and equity within a generation and justice and equity between generations; according to Morris Strong: ‘the sustainable development is reassuring to combine traditional and modern practices’ [16].

3 Proposed methodology

One of the main purposes of planning is establishment of a prospective balanced development in different geographical areas. This process requires evaluation and identification of areas and their potential and actual capabilities as well as evaluation and identification of the relationship between influencing factors on the development. Therefore, various methods and techniques are required to reach this stage. One of the most important strategies is mathematical and quantitative techniques which are derived from logical relations between phenomena; thus, they can present a reasonable and accurate evaluation of the characteristics and the relationships between phenomena. Considering the studied components and nature of the subject, the approach used in this study is a descriptive-analytical approach.

Table 1 Criteria driven from Delphi

Criteria	Code
Life expectancy (years)	C_1
Public services (percent)	C_2
Proportion of households receiving the installations and equipment (percent)	C_3
Mental Health (percent)	C_4
Literacy rate (percent)	C_5
Health care (percent)	C_6
Concentration of the industrial and service sectors (coefficient)	C_7
Internet access (percent)	C_8
Quality of Life (percent)	C_9
Economic participation rate of men (percent)	C_{10}
Economic participation rate of women (percent)	C_{11}
Social security system (percent)	C_{12}
Reverse Dependants (percent)	C_{13}

Criteria are considered as the criteria by which quantity and quality of a problem can be measured. This section addresses the criteria used in this study which were obtained by the Delphi groups, as shown in Tab. 1.

3.1 Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

AHP was proposed in 1970 by Saaty [17]. AHP enables decision makers to determine the simultaneous mutual effects of many complex and uncertain situations. This process helps decision-makers to prioritize based on targets, knowledge and experience, so that they can fully consider their feelings and judgments. To solve decision-making problems by AHP, the problem needs to be defined and explained accurately with all the details and the details need to be plotted as a hierarchical structure [18, 19].

Chang [20] proposed the integration of AHP and the fuzzy combination of the extended analysis (fuzzy AHP). Fuzzy AHP is a relatively new methodology developed by Laarhoven and Pedrycz [21] to handle fuzzy and uncertain environments. Fuzzy AHP is able to handle uncertainty and relative human judgments [18, 19, 22, 23]. The linguistic scale and corresponding triangular fuzzy numbers to state pair wise comparisons in Fuzzy AHP method are illustrated in Fig. 1. Definitions and descriptions associated with linguistic variables are shown in Tab. 2.

Table 2 An example of fuzzy numbers defined by fuzzy AHP

Fuzzy number	Definition	Triangular fuzzy scale	Range	Membership function
$\tilde{9}$	Absolutely more important (AMI)	(7,9,9)	$7 \le x \le 9$	$\frac{x-7}{9-7}$
$\tilde{7}$	Very strongly more important (WSMI)	(5,7,9)	$7 \le x \le 9$	$\frac{9-x}{9-7}$
			$5 \le x \le 7$	$\frac{x-5}{7-5}$
$\tilde{5}$	Strongly more important (SMI)	(3,5,7)	$5 \le x \le 7$	$\frac{7-x}{7-5}$
			$3 \le x \le 5$	$\frac{x-3}{5-3}$
$\tilde{3}$	Weakly more important(WMI)	(1,3,5)	$3 \le x \le 5$	$\frac{5-x}{5-3}$
			$1 \le x \le 3$	$\frac{x-1}{3-1}$
$\tilde{1}$	Equally important (EI)	(1,1,3)	$1 \le x \le 3$	$\frac{3-x}{3-1}$
1	Just equal	(1,1,1)	-	-

In the following, the fuzzy AHP is expressed from Chang's point of view. The numbers used in this procedure are fuzzy triangular numbers. The concepts and definitions are described according to the extended analysis [24].

Consider the two triangular numbers, $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$, drawn in Fig. 2.

The mathematical operators are defined as (1), (2) and (3):

$$M_1 + M_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2), \qquad (1)$$

$$M_1 * M_2 = (l_1 * l_2, m_1 * m_2, u_1 * u_2), \qquad (2)$$

$$M_1^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right), M_2^{-1} = \left(\frac{1}{u_2}, \frac{1}{m_2}, \frac{1}{l_2}\right). \qquad (3)$$

It is noteworthy that multiplication of two triangular fuzzy numbers, or a reverse triangular fuzzy number, is no longer a triangular fuzzy number. This relationship expresses only an approximation of the actual multiplication of two triangular fuzzy numbers and a reverse triangular fuzzy number. The extended analysis calculates the value of S_k, which is a triangular number, for each row of the matrix of pairwise comparisons, as shown in (4) (Chou et al, 2012):

$$S_k = \sum_{j=1}^{n} M_{kj} * \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij}\right]^{-1}, \qquad (4)$$

where, k represents the number of rows i and j indicate alternatives and criteria, respectively.

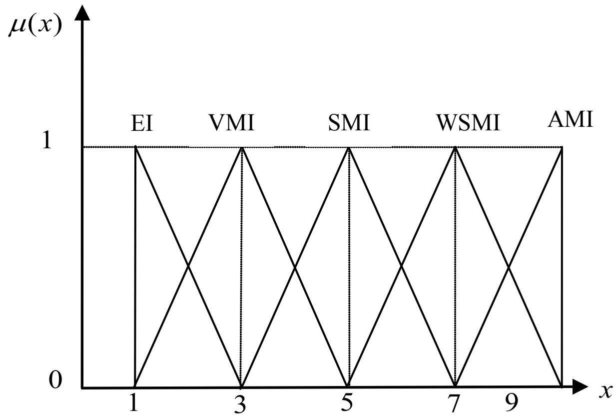

Figure 1 Fuzzy membership functions for linguistic variables

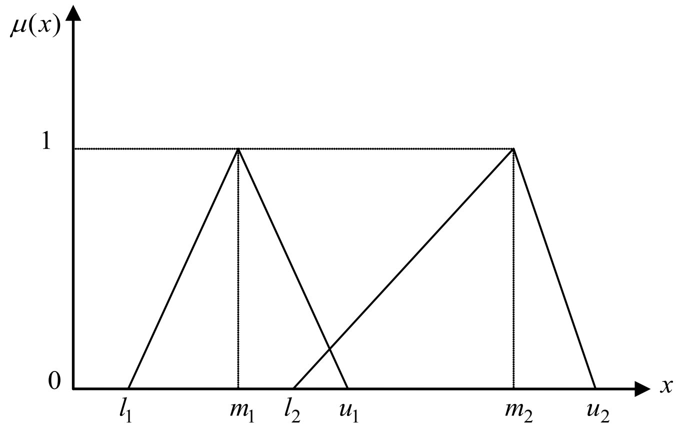

Figure 2 Triangular fuzzy numbers (M_1 *and* M_2)

In next step, the degree of possibility of M_1 and M_2 should be calculated. In general, let $M_1$and M_2 be two triangular fuzzy numbers; the degree of possibility of M_1 and M_2, shown by $V(M_1 \ge M_2)$, could be defined as Eq. (5):

$$V(M_2 \ge M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & \text{if } m_2 \ge m_1 \\ 0 & \text{if } l_1 \ge u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise} \end{cases} \qquad (5)$$

The degree possibility for a convex fuzzy number over other triangular fuzzy numbers could be calculated using Eq (6).

$$V(M_1 \geq M_2, \dots, M_K) = V(M_1 \geq M_2), \dots, V(M_1 \geq M_K). \quad (6)$$

Then the weight vector is given by Eq (7).

$$W'(X_i) = \min\{V(S_i \geq S_k)\}, k = 1,2,\dots,n.\ k \neq i. \quad (7)$$

Finally, the weight vectors could be shown as Eq. (8).

$$W'(X_i) = [W'(C_1), W'(C_2), \dots, W'(C_n)]^{\mathrm{T}}, \quad (8)$$

which is the same vector of the non-normalized fuzzy AHP coefficients. Using Eq. (9), the non-normalized results obtained from Eq. (8) are normalized. The normalized results obtained from (9), are called W [25].

$$W_i = \frac{w_1'}{\sum w_i'}. \quad (9)$$

3.2 VIKOR method

Opricovic [26] developed VIKOR (the Serbian name, ViseKriterijumska Optimizacija i kompromisno Resenje) as one of the multi criteria decision making models. This model is based on the compromise programming approach. TOPSIS and VIKOR are two methods that are easy to use among the ranking methods of MCDM [27]. However, these two models are different in basic definitions. The TOPSIS method does not introduce the relative importance of the distances from two 'reference' points. Based on TOPSIS, the best alternative is not always closest to the ideal solution [28]. To dominate the weakness of TOPSIS, Opricovic introduced VIKOR method. Steps of VIKOR are briefly given below:

a) Normalize the decision matrix

The normalized matrix could be calculated according to the following formula [29]:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}. \quad (10)$$

b) Determination of the best (f_i^*) and the worst (f_i^-) value $f_i^* = \max_j f_{ij}; f_i^- = \min_j f_{ij}$ (if the i^{th} criterion represents a benefit) $f_i^* = \min_j f_{ij}; f_i^- = \max_j f_{ij}$ (if the i^{th} criterion represents a cost).

c) Calculate the values S_j and R_j; $j = 1, 2, \dots, J$, by the following relations, Eqs. (11) and (12)

$$S_j = \sum^{n} w_i (f_i^* - f_{ij}) / (f_i^* - f^-), \quad (11)$$

$$R_j = \max_i \left[w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right], \quad (12)$$

where, w_i is the weight of i th criterion.

d) Calculate the values Q_j, $j = 1, 2, \dots, J$, by the following relations (Eq. 13)

$$Q_j = v \cdot \frac{S_j - S^-}{S^* - S^-} + (1 - v) \cdot \frac{R_j - R^-}{R^* - R^-}, \quad (13)$$

where,

$$S^* = \min_j S_j; S^- = \max_j S_j,$$
$$R^* = \min_j R_j; R^- = \max_j R_j.$$

$0 \leq v \leq 1$ and v could be considered as a weight for the strategy of maximum group utility, whereas $(1 - v)$ is the weight of the individual regret.

e) Rank the alternatives based on values S_j, R_j and Q_j in decreasing order.

f) Propose as a compromise solution the alternative which is ranked first ($A^{(1)}$) with the lowest Q if the following two conditions are satisfied

I) Acceptable advantage

$$Q(A^{(2)}) - Q(A^{(1)}) \geq DQ, \quad (14)$$

II) Acceptable stability in decision making

$A^{(1)}$ must also be the best alternative in terms of S or R.

If one of the conditions I and II is not satisfied, then a set of compromise solutions is proposed, which consists of:

- Alternatives $A^{(1)}$, and $A^{(2)}$ if only condition 2 is not satisfied, or;
- Alternatives $A^{(1)}$, $A^{(2)}$,…, $A^{(M)}$ if condition I is not satisfied; $A^{(M)}$ is determined by the relation $Q(A^{(M)}) - Q(A^{(1)}) < DQ$ for maximum M (the positions of these alternatives are "in closeness"). (Chiu et al, 2012).

4 Empirical case study

The Tehran Province is located in an area of 12,981 km^2; 34÷36,5 °N and 50÷53 °E. The Tehran Province is limited to Mazandaran Province from the north, to Qom Province from the south, to Markazi Province from the southwest, to Alborz Province from the west and to Semnan Province from the east. Population was 13 281 858 in 2006. The capital of this province is Tehran which is also the capital of Iran.

There are fifteen towns in Tehran province: Damavand (C_1), Islam Shahr (C_2), Firoozkooh (C_3), Ray (C_4), Robat Karim (C_5), Shemiranat (C_6), (Tehran C_7), Varamin (C_8), Pakdasht (C_9), Pishva (C_{10}), Shahriar (C_{11}), Mallard (C_{12}), Ghods (C_{13}), Baharestan (C_{14}) and Qarchak (C_{15}).

Overall, 17,5 % of the total population of Iran resides in Tehran, with a population of over 13 million. Of this amount, 12 252 reside in the urban and 1161 live in the rural areas. Accordingly, 63,6 % of the urban population live in Tehran and remaining inhibit in 44 other towns. The growth rate of Tehran's population is 1,4 %, which slightly increased compared to the previous decade. Among the towns of Tehran Province, Shahriar with 16.8% annual growth is in the first place followed by Kamal Shahr with 11/4 %, Mallard with 10 %, Pakdasht with 9/9 % and Safadasht with 8/8 %. During 1996 ÷ 2006, ten towns were added to the Province, the largest of which are Andisheh, Saleh Abad, Baghestan and Nasirabad with 75 000, 54 000 52 0000 and 23 000, respectively, and the smallest is Arjomand with 1700 people. Tehran province now has 15 towns, 45 cities and 78 villages (See Fig. 3).

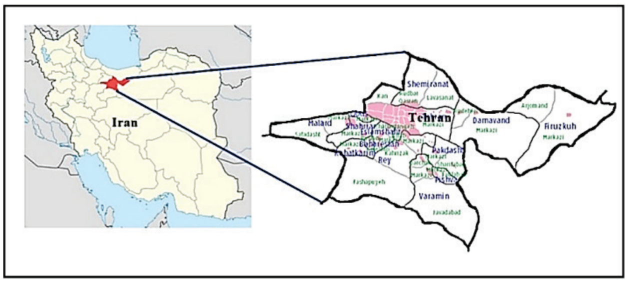

Figure 3 Location of the studied area

5 Results

Processing, analyzing and combining data of this study are given in Tab. 1 considering the thirteen criteria. In case of data preparation, these thirteen criteria were used to prioritize urban welfare in order to implement the sustainable city of Tehran Province.

5.1 Applying Fuzzy AHP

After preparation of the data layers, the fuzzy pairwise comparisons were applied on the data. In the fuzzy pairwise comparison, the weight of each criterion was determined by the Delphi group including experts. The weights were inserted in MATLAB software. Then, the fuzzy pairwise comparison was applied on input weights; the weight of each criterion was extracted from the software, as shown in Tab. 3. The criteria for social security system (X12) and quality of life (X9) had the highest fuzzy weight.

5.2 Applying VIKOR technique

First, suppose that there are m alternatives and n criteria. These alternatives are displayed by AL_j. There is a series of criteria for each alternative and its value is shown as X_{ij}; in other words, X_{ij} is the value of the ith criterion. The thirteen criteria are identified by Delphi group. Tab. 4 shows scores in percentage as the location decision matrix in which the used criteria were listed in the columns from C_1 to C_{13} and the studied towns were listed in rows from AL_1 to AL_{15}.

Second, calculation of the normalized values: The decision matrix is normalized using Eq. (10) and results are shown in Tab. 5.

Third, the weight and significance of the attribute: In this stage, criteria were weighed (w) following the normalized decision matrix. There are several synthetic methods which are used if necessary. Fuzzy AHP was used in this study (Tab. 3). The weights for each criterion are given in Tab. 6.

Table 3 Pairwise comparison of fuzzy AHP

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
C_1	(1,1,1)	(5,7,9)	(3,5,7)	(1/3,1/3,1)	)5,7,9(	(1/7,1/5,1/3)	(1,3,3)	(1,3,3)	(3,5,7)	(1/7,1/5,1/3)	(5,7,9)	(1/3,1/3,1)	(1,3,3)
C_2	-	(1,1,1)	(1,3,5)	(1/3,1/3,1)	(1,3,3)	(7,9,9)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,3,3)	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(1,3,3)
C_3	-	-	(1,1,1)	(5,7,9)	(1,3,3)	(1,3,3)	(1/3,1/3,1)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(5,7,9)	(7,9,9)
C_4	-	-	-	(1,1,1)	(1,3,5)	(1,3,5)	(1,3,5)	(5,7,9)	(1/3,1/3,1)	(1/3,1/3,1)	(5,7,9)	(1/5,1/3,1)	(3,5,7
C_5	-	-	-	-	(1,1,1)	(1/5,1/3,1)	(3,5,7)	(3,5,7)	(1,3,3)	(1,3,3)	(1/3,1/3,1)	(1/5,1/3,1)	(1,3,3)
C_6	-	-	-	-	-	(1,1,1)	(1/3,1/3,1)	(5,7,9)	(5,7,9)	(1,3,5)	(1,3,5)	(1/3,1/3,1)	(5,7,9)
C_7	-	-	-	-	-	-	(1,1,1)	(3,5,7)	(1/5,1/3,1)	(1,3,5)	(1/3,1/3,1)	(3,5,7)	(5,7,9)
C_8	-	-	-	-	-	-	-	(1,1,1)	(1,3,3)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)
C_9	-	-	-	-	-	-	-	-	(1,1,1)	(1,3,5)	(1,3,3)	(1,3,5)	(5,7,9)
C_{10}	-	-	-	-	-	-	-	-	-	(1,1,1)	(1/9,1/9,1/7)	(1/9,1/9,1/7)	(1/7,1/5,1/3)
C_{11}	-	-	-	-	-	-	-	-	-		(1,1,1)	(1/5,1/3,1)	(1,3,5)
C_{12}	-	-	-	-	-	-	-	-	-			(1,1,1)	(1/3,1/3,1)
C_{13}	-	-	-	-	-	-	-	-	-				(1,1,1)

Table 4 Location decision matrix to rate towns of the Tehran Province

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
AL_1	71,2	98,5	87,4	62,7	82,6	50,3	4,2	34,3	43,3	62,8	63,6	51,6	96,9
AL_2	67,1	79,6	76,3	57,8	72,5	42,3	2,8	21,2	30,2	60,3	53,6	43,7	95,7
AL_3	71,2	89,9	89,6	63,6	80,7	51,8	3,7	38,7	47,7	63,3	63,4	51,7	96,9
AL_4	70,4	91,3	91,7	65,1	90,4	67,3	4,1	42,1	51,1	63,4	69,7	51,8	96,2
AL_5	67,3	79,8	83,6	51,6	77,4	40,6	3,8	19,2	28,2	57,0	43,5	32,5	95,3
AL_6	72,3	91,6	95,4	69,4	87,8	68,5	6,0	41,8	50,8	66,1	73,5	50,5	96,1
AL_7	71,3	95,4	96,5	67,5	93,3	77,6	3,0	54,5	63,5	67,6	82,8	54,3	97,3
AL_8	69,5	88,7	80,9	55,7	72,9	42,3	3,2	33,5	42,5	59,2	40,5	47,7	96,4
AL_9	67,6	86,1	77,7	51,7	70,4	41,9	5,9	15,3	24,3	57,1	55,3	32,3	96,4
AL_{10}	68,7	79,3	83,4	67,1	86,9	61,3	2,6	31,4	40,4	65,0	62,3	48,1	96,9
AL_{11}	69,4	91,3	87,1	51,5	88,2	64,5	2,2	37,9	46,9	57,0	56,8	46,5	96,7
AL_{12}	70,8	78,6	81,3	58,6	76,6	53,8	3,4	23,6	32,6	60,8	47,6	39,4	95,8
AL_{13}	67,4	76,8	73,8	59,8	77,1	48,6	2,9	23,3	32,3	61,4	43,9	35,6	95,7
AL_{14}	71,2	85,4	85,7	64,5	90,1	66,6	3,1	19,7	28,7	63,7	57,8	50,2	96,8
AL_{15}	65,5	74,8	70,7	50,1	71,7	39,9	2,8	13,7	22,7	56,2	43,9	32,6	95,8

Table 5 The normalized matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
AL_1	0,265	0,295	0,267	0,269	0,261	0,233	0,290	0,276	0,275	0,264	0,281	0,295	0,260
AL_2	0,250	0,239	0,233	0,248	0,229	0,196	0,193	0,171	0,192	0,253	0,237	0,249	0,257
AL_3	0,265	0,270	0,274	0,273	0,255	0,240	0,256	0,311	0,303	0,266	0,280	0,295	0,260
AL_4	0,262	0,274	0,281	0,280	0,286	0,312	0,283	0,339	0,325	0,266	0,308	0,296	0,258
AL_5	0,250	0,239	0,256	0,222	0,245	0,188	0,263	0,155	0,179	0,239	0,192	0,186	0,255
AL_6	0,269	0,275	0,292	0,298	0,278	0,317	0,415	0,336	0,323	0,278	0,325	0,288	0,258
AL_7	0,265	0,286	0,295	0,290	0,295	0,359	0,207	0,439	0,404	0,284	0,366	0,310	0,261
AL_8	0,258	0,266	0,248	0,239	0,231	0,196	0,221	0,270	0,270	0,249	0,179	0,272	0,258
AL_9	0,251	0,258	0,238	0,222	0,223	0,194	0,408	0,123	0,154	0,240	0,244	0,184	0,258
AL_{10}	0,256	0,238	0,255	0,288	0,275	0,284	0,180	0,253	0,257	0,273	0,275	0,275	0,260
AL_{11}	0,258	0,274	0,266	0,221	0,279	0,299	0,152	0,305	0,298	0,239	0,251	0,265	0,259
AL_{12}	0,263	0,236	0,249	0,252	0,242	0,249	0,235	0,190	0,207	0,255	0,210	0,225	0,257
AL_{13}	0,251	0,230	0,226	0,257	0,244	0,225	0,200	0,188	0,205	0,258	0,194	0,203	0,257
AL_{14}	0,265	0,256	0,262	0,277	0,285	0,308	0,214	0,159	0,182	0,268	0,255	0,287	0,259
AL_{15}	0,244	0,224	0,216	0,215	0,227	0,185	0,193	0,110	0,144	0,236	0,194	0,186	0,257

Table 6 Weights of criteria obtained by fuzzy AHP

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
W	0,062	0,074	0,083	0,095	0,096	0,077	0,055	0,098	0,113	0,023	0,064	0,121	0,039

Table 7 The weighted normalized matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
AL_1	0,0164	0,0219	0,0222	0,0256	0,0251	0,0179	0,0160	0,0271	0,0311	0,0061	0,0180	0,0356	0,0101
AL_2	0,0155	0,0177	0,0194	0,0236	0,0220	0,0151	0,0106	0,0167	0,0217	0,0058	0,0152	0,0302	0,0100
AL_3	0,0164	0,0200	0,0228	0,0260	0,0245	0,0185	0,0141	0,0305	0,0343	0,0061	0,0179	0,0357	0,0101
AL_4	0,0162	0,0203	0,0233	0,0266	0,0275	0,0240	0,0156	0,0332	0,0367	0,0061	0,0197	0,0358	0,0101
AL_5	0,0155	0,0177	0,0212	0,0211	0,0235	0,0145	0,0144	0,0151	0,0203	0,0055	0,0123	0,0225	0,0100
AL_6	0,0167	0,0203	0,0242	0,0283	0,0267	0,0244	0,0228	0,0330	0,0365	0,0064	0,0208	0,0349	0,0100
AL_7	0,0164	0,0212	0,0245	0,0275	0,0283	0,0277	0,0114	0,0430	0,0456	0,0065	0,0234	0,0375	0,0102
AL_8	0,0160	0,0197	0,0205	0,0227	0,0221	0,0151	0,0122	0,0264	0,0305	0,0057	0,0115	0,0330	0,0101
AL_9	0,0156	0,0191	0,0197	0,0211	0,0214	0,0149	0,0224	0,0121	0,0175	0,0055	0,0156	0,0223	0,0101
AL_{10}	0,0158	0,0176	0,0212	0,0274	0,0264	0,0219	0,0099	0,0248	0,0290	0,0063	0,0176	0,0332	0,0101
AL_{11}	0,0160	0,0203	0,0221	0,0210	0,0268	0,0230	0,0084	0,0299	0,0337	0,0055	0,0161	0,0321	0,0101
AL_{12}	0,0163	0,0174	0,0206	0,0239	0,0233	0,0192	0,0129	0,0186	0,0234	0,0059	0,0135	0,0272	0,0100
AL_{13}	0,0155	0,0170	0,0187	0,0244	0,0234	0,0173	0,0110	0,0184	0,0232	0,0059	0,0124	0,0246	0,0100
AL_{14}	0,0164	0,0190	0,0218	0,0263	0,0274	0,0237	0,0118	0,0155	0,0206	0,0062	0,0163	0,0347	0,0101
AL_{15}	0,0151	0,0166	0,0180	0,0204	0,0218	0,0142	0,0106	0,0108	0,0163	0,0054	0,0124	0,0225	0,0100

Table 8 The highest and lowest values of criteria

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
$f^*_{(max)}$	0,0167	0,0219	0,0245	0,0283	0,0283	0,0277	0,0228	0,0430	0,0456	0,0065	0,0234	0,0375	0,0102
$f^-_{(min)}$	0,0151	0,0166	0,0180	0,0204	0,0214	0,0142	0,0084	0,0108	0,0163	0,0054	0,0115	0,0223	0,0100
$f_i^* - f_i^-$	0,0016	0,0053	0,0066	0,0079	0,0070	0,0134	0,0144	0,0322	0,0293	0,0011	0,0120	0,0152	0,0002

Table 9 Multiplication of criteria in decision matrix and calculation of S_i, R_i and Q_i

$(f^*-f_{kj})/(f^*-f^-)$	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
AL_1	0,0100	0,0000	0,0293	0,0330	0,0449	0,0558	0,0261	0,0485	0,0559	0,0096	0,0290	0,0149	0,0078
AL_2	0,0474	0,0590	0,0650	0,0571	0,0872	0,0721	0,0463	0,0800	0,0922	0,0146	0,0442	0,0583	0,0312
AL_3	0,0100	0,0269	0,0222	0,0285	0,0528	0,0527	0,0333	0,0380	0,0438	0,0087	0,0294	0,0143	0,0078
AL_4	0,0173	0,0225	0,0154	0,0212	0,0122	0,0210	0,0275	0,0298	0,0343	0,0085	0,0198	0,0138	0,0214
AL_5	0,0456	0,0584	0,0415	0,0876	0,0667	0,0756	0,0318	0,0848	0,0978	0,0213	0,0595	0,1199	0,0390
AL_6	0,0000	0,0215	0,0035	0,0000	0,0231	0,0186	0,0000	0,0305	0,0352	0,0030	0,0141	0,0209	0,0234
AL_7	0,0091	0,0097	0,0000	0,0094	0,0000	0,0000	0,0434	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
AL_8	0,0255	0,0306	0,0502	0,0674	0,0855	0,0721	0,0405	0,0504	0,0582	0,0168	0,0640	0,0363	0,0175
AL_9	0,0429	0,0387	0,0605	0,0871	0,0960	0,0729	0,0014	0,0942	0,1086	0,0212	0,0416	0,1210	0,0175
AL_{10}	0,0328	0,0599	0,0421	0,0113	0,0268	0,0333	0,0492	0,0555	0,0640	0,0052	0,0310	0,0341	0,0078
AL_{11}	0,0264	0,0225	0,0302	0,0881	0,0214	0,0268	0,0550	0,0399	0,0460	0,0214	0,0393	0,0429	0,0117
AL_{12}	0,0137	0,0621	0,0489	0,0532	0,0700	0,0486	0,0376	0,0742	0,0856	0,0138	0,0533	0,0820	0,0292
AL_{13}	0,0447	0,0678	0,0730	0,0473	0,0679	0,0592	0,0449	0,0749	0,0864	0,0125	0,0589	0,1029	0,0312
AL_{14}	0,0100	0,0409	0,0347	0,0241	0,0134	0,0225	0,0420	0,0836	0,0964	0,0078	0,0378	0,0226	0,0097
AL_{15}	0,0620	0,0740	0,0830	0,0950	0,0906	0,0770	0,0463	0,0980	0,1130	0,0230	0,0589	0,1194	0,0292

Fourth, Calculation of the weighted normalized values: after weighting parameters, the normalized matrix was multiplied by the weight of the criteria influencing the urban welfare to obtain the weighted normalized matrix (Tab. 7).

Fifth, Determination of the highest and lowest values for all functions: At this stage, the highest value f_i^* and the lowest value f_i^- of the benchmark functions are derived from the decision matrix (Tab. 8).

Sixth, Calculation of the values of the distance between alternatives and the ideal solution: the value of S_j (goodness indicator) and R_j (dissatisfaction) was calculated after determination of the highest and lowest values of benchmark functions. Therefore, the weights obtained in Fuzzy AHP were multiplied in the decision matrix; then, S_j and R_j were obtained using Eq. (11) and Eq. (12) (Tab. 9):

Seventh, The VIKOR value for i= 1, 2, ..., m: at this stage, the VIKOR indicator which is the same final score of each option was calculated; the less value indicates high goodness obtained using Eq. (13) (Tab. 10).

Prioritization was done based on the value of Q of which the lowest value accounted for the highest priority.

Now, according to the results, the conditions were tested as follows:

First condition: $Q(A^{(2)}) - Q(A^{(1)}) \geq DQ$,

where, $A^{(1)}$ and $A^{(2)}$ are the first and second options, respectively and $DQ = \frac{1}{(J-1)}$ and i are the number of alternatives.

DQ = 1/(15−1) = 0,071 and $(A^{(2)}) - Q(A^{(1)}) \geq 0{,}071$; given that the value of Q for the second alternative is 0,073 and for the first alternative is 0,052, the difference between these two values is 0,021, which is less than the value of DQ. Thus, the first condition is violated and both Tehran (AL7) and Shemiranat (AL6) have the highest welfare criteria in urban areas of Tehran.

Table 10 Calculation of Q and final rate of urban welfare

Towns	Q_j	S_j	R_j	Towns	Ranking
AL_1	0,288	0,3647	0,0559	Damavand	5
AL_2	0,714	0,7546	0,0922	Islam Shahr	11
AL_3	0,272	0,3683	0,0528	Firoozkooh	4
AL_4	0,108	0,2647	0,0343	Rey	3
AL_5	0,916	0,8294	0,1199	Robat Karim	14
AL_6	0,073	0,1938	0,0352	Shemiranat	2
AL_7	0,052	0,0716	0,0434	Tehran	1
AL_8	0,598	0,6152	0,0855	Varamin	9
AL_9	0,908	0,8036	0,1210	Pakdasht	13
AL_{10}	0,384	0,4532	0,0640	Pishva	6
AL_{11}	0,533	0,4716	0,0881	Shahriyar	7
AL_{12}	0,630	0,6722	0,0856	Malard	10
AL_{13}	0,785	0,7715	0,1029	Ghods	12
AL_{14}	0,566	0,4455	0,0964	Baharestan	8
AL_{15}	0,990	0,9693	0,1194	Qarchak	15

The second condition: The first alternative needs to have the highest rate in terms of S or R. Tehran with the highest welfare criteria in terms of Q does not have the best rate in terms of S and R criteria. Therefore, the second condition is violated.

Let the second condition be violated; the series of optimal solutions will include the first to the m^{th} alternative, so that m meets the following condition.

$$Q(A^{(M)}) - Q(A^{(1)}) < DQ$$

Given that DQ is 0,071, those options will have the highest rate that their difference with the first alternative is less than DQ. Depending on the condition, its value is less than this value for Shemiranat and Ray; therefore, Shemiranat and Ray are selected as the towns with high level of urban welfare.

6 Conclusion

Prioritization is a hierarchical grouping for similar phenomena based on a set of criteria or characteristics and the status and condition of each to the rest. Urban welfare of areas is rated when their hierarchical location is determined in terms of spatial functions in local, regional or national levels.

All aspects are only considered by the sustainable development approach because sustainable development is not consistent with the one-dimensional or one-factor approaches. The integration of different social, economic, environmental and political environment is holistically considered by this approach. Therefore, evaluation of the sustainable development is the best approach to prioritize urban welfare. Because sustainability is a dynamic concept with different characteristics, such as speed and variations, the rate of factors influenced by its change, and variations related to the primary and final conditions.

Conventional decision models are not efficient enough to explain these criteria. Therefore, multi-criteria decision models are used which allow several decision-makers and various criteria and alternatives to be inserted simultaneously. Therefore, the present study used different criteria and indicators for towns of Tehran province. Considering that the criteria of sustainability are not equally significant and considering the lack of a certain threshold to determine the exact value of them, the VIKOR, expert opinions or Delphi group were used to determine the criteria in order to calculate the final weight of criteria by Fuzzy AHP. According to calculations where S, the distance from j th alterative to the ideal solution, and R, the distance from the alternative to the ideal solution, are negative and where v > 0,5, the Q_i has the maximum agreement. If v < 0,5, the maximum agreement is negative. The results of prioritization revealed that Tehran, Ray and Shemiranat had high prioritizations of sustainable welfare with R = 0,052; 0,073 and 0,108; S = 0,0716; 0,1938 and 0,2647; and Q = 0,0434, respectively. Firoozkooh was the fourth town followed by Damavand, Pishva, Shahriyar, Baharestan, Malard, Islam Shahr, Ghods, Pakdasht and Robat Karim. Qarchak (R = 0,1194; S = 0,9693 and Q = 0,990) had the lowest rate in terms of urban welfare.

For future research, other fuzzy multi-criteria decision making models for assessing the urban welfare to achieve sustainable urban development can be used. These models are fuzzy analytical hierarchy process by Azadeh et al. [18, 23], fuzzy Entropy method, weighted least square method, fuzzy TOPSIS, and fuzzy PROMETHEE. To serve as guidance for future research, other criteria can be considered rather than the used criteria. Future studies can also focus on the comparison of the proposed methodology results with these models.

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