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ORIGINAL ARTICLE

Urban Parks Prioritization Concerning the Age-friendly Criteria in Sari, Northern Iran

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ABSTRACT

It is essential to make urban spaces usable for a wide range of citizens, including aged people. This study was carried out in Sari, the center of Mazandaran Province, northern Iran in 2013 to prioritize five urban parks of the city using Fuzzy-AHP method in terms of three pre-defined criteria, including safety, security, and environmental health. Firstly, the criteria and alternatives were defined using Delphi technique and random sampling, and then the questionnaires were designed. The questionnaires were filled by a group of 10 experts and their consistencies were assessed by the Expert Choice software. Finally, criteria and alternatives` total weights were calculated. Among all the cases, Keshavarz, Aftab, and Ghaem parks were ranked first to third, respectively; however, Shahrdari and Koosha both occupied the fourth place. Aged adults as one of the vulnerable groups of the society need an appropriate plan for which not only reduces many unnecessary social and economic costs but it has also co-benefits for the other members of the society.

KEYWORDS: *Age-friendly, Ageing, Urban spaces, AHP, Fuzzy-AHP*

INTRODUCTION

Green spaces and their impacts on the cities are unavoidable/ inevitable. They are not only important for the recreational purposes but also for their role in controlling urban environment and reducing air pollution as well as fostering humankind both physically and mentally [1]. However, to reach their potentials, all citizens must use them. According to WHO`s report [13], about 600 million people of the world population are aged, and this will reach to 2 billion by the year 2050.

One of main concerns, particularly in less developed countries, is that in near future a large number of urban park users will be aged adults.

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To avoid future challenges and to use the power of a large group of aged people as future citizens, there should be some changes in urban open spaces to make them as age-friendly as possible. This issue has attracted more attentions in recent years and the demand for appropriate urban management and planning for the aged people is being felt. To overcome this task, a great amount of interdisciplinary knowledge and acceptable decision-making methods are required to clarify and classify the related issues and challenges. Since 1980 Analytical Hierarchy Process (AHP) has been one of the frequently used multi-criteria decision-making methods used coupled with GIS in different cases of urban planning. Land capacity analysis by AHP can be noted as one of the first studies in this area. Among others, there is an extensive literature

addressing this case, for example, the urban neighborhood park was ranked by using AHP [2]. Site selection for local forest parks using AHP and GIS has been done [3, 4], also applied AHP-TOPSIS to evaluate and classify the provincial landscape construction level of China.

There are still a lot of problems in the real world and some of their decision data cannot be precisely assessed by this method. "Humans are unsuccessful in making quantitative predictions, whereas they are comparatively efficient in qualitative forecasting" [5]. Moreover, "the uncertainty in the preference judgments gives rise to uncertainty in the ranking of alternatives as well as difficulty in determining the consistency of preferences" [6]. Therefore, a method was proposed that coupled AHP (technique) with Fuzzy (theory), the so-called Fuzzy-AHP method.

"The Fuzzy-AHP method can be viewed as an advanced analytical method developed from the traditional one" [7]. Despite both qualitative and quantitative criteria of multi-criteria decision-making problems handled by AHP based on decision makers' judgments, fuzziness in many decision-making problems may cause imprecise judgments in conventional AHP approaches [8]. Since 1992, many researchers have studied the Fuzzy-AHP and showed that the Fuzzy-AHP in comparison with the traditional AHP methods has relatively more sufficient description for such kinds of decision-making processes [7].

In this study, Fuzzy-AHP model was applied to clarify how age-friendly are the urban parks in Sari.

MATERIALS AND METHODS

The study area of this research was the city of Sari located at the longitude of 53°5`E and latitude of 36°34`N of the plain region of Sari county, northern Iran (Fig.1). Sari with a population of about 296,417 people and an area of about 2852 (km2) has only five urban parks which their total area is about 113,385 hectare. Therefore, the urban parks area is about 0.39 hectare per capita [10].

Fig.1. Study area, Northern Iran

The method of this research was based on literature studies and field surveys. To this end, initially, the criteria were identified from the literature and the online resources. Then the pair-wise comparison matrices planned based on Saaty`s scale were filled by ten experts [9]. Then the Expert Choice software tested the consistency factor (CF). At first, it was 1.2, so the questionnaires were explained once more to the experts and they were asked to fill out them again. This time, the CF was acceptable. Finally, the answers were entered into the triangular fuzzification process by the use of the geometric mean method in the Excel sheet and then to Fuzzy-AHP model to clarify the weights of the alternatives. Moreover, Excel software was used for calculations and quantitative description of qualitative data given in the form of diagrams at the end of the study (Fig. 2).

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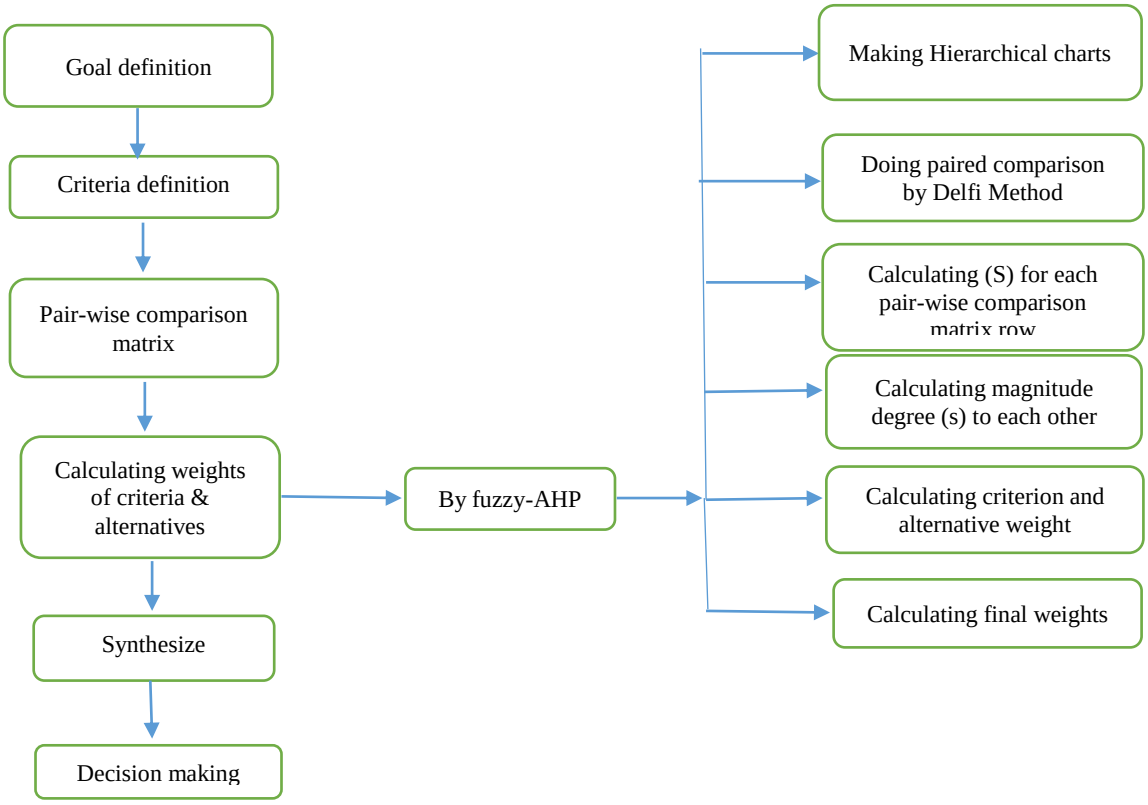

Fig.2. The flowchart of the study process

RESULTS

Aged people mostly experience four groups of changes, including physiological, psychological, social, and economical (Table 1).

Table 1. The frequency of observation of body status in three phases of evaluation in construction

Target organ	Manifestation
Respiratory Sys	Decreased elasticity and chest stiffness, muscular weakness, dyspnea, increased respiratory rate, inability of respiratory discharge, hypersensitivity toward infections
Cardiovascular Sys	Impaired arterial compliance and hypertension, heart failure and cardiac events
Gastrointestinal Sys	Impaired hepatic function, reduced acid output of the stomach, reduction in colon movement resulting in defecation disturbances
Kidneys	Reduction in urine volume and concentration and increased urinary frequency. Other problems like urinary infection and enuresis
Blood and Immune Sys	Bone marrow depletion, increased autoantibodies level resulting in autoimmune disease
Muscular and Skeletal Sys	Increased fatty tissue and reduced muscular mass and the total body bone density, osteomalacia, functional disorders like muscular stiffness, mobile articular osteoarthritis, fractures etc.
Nervous Sys	Sleep disturbances, memorial etc.
Senses	Visual weakness, loss of accommodation in different light stimulation, hyper photosensitivity, hypersensitivity with glare.
Visual	Disorders of vision, depth and distance reception. Inability to face to face cross seeing. Persbioscopia and other common eye disorders.
Auditory	Recognition of disorders of speech and sound producers and increased sensitivity to background voices.
Tastes	Decreased quality and quantity of the tasting sense usually because of the tasting cell changes or death and saliva decrease and its further effects on GI1 Sys.
Smell	Decreased quality and quantity of the smelling sense; however with less progression compared to the other senses.
Touch	Touch disorders due to decreased blood supply in remote limbs worsen with other limitations like hyper-sensation due to thermal simulations arising from hypo metabolism and thermoregulation mechanism insufficiencies.

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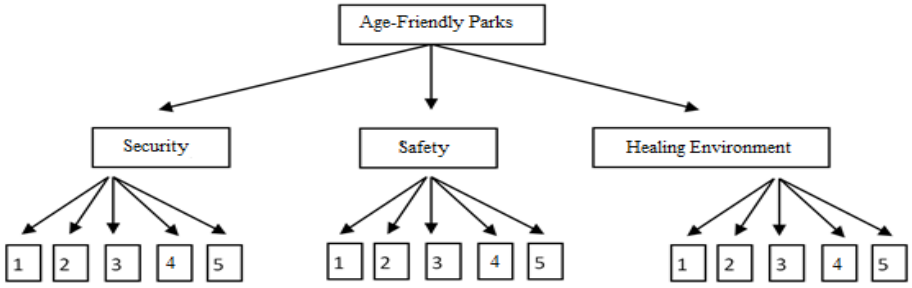
Due to the lack of studies on age-friendly urban parks, in this study safety along with healthy and clean environment - summarized by the proposed framework of WHO - and also security has been chosen as the three criteria by Delphi technique in response to psychological and social changes. The urban parks of Keshvarz, Aftab, Ghaem, Shahrdari, and Kooshawere also chosen by random sampling among eight urban parks of the city. After defining criteria and alternatives, the hierarchy tree was planned (Fig.3).

Then, Saaty`s scale was used to plan the pair-wise matrices (Table 2)



1: Ghaem, 2: Shahrdari, 3: Aftab, 4: Koosha, 5: Keshavarz

Fig.3. The hierarchy tree of the case study

Table2. Saaty scale for pair-wise comparison

Preference	**Relative importance of one criterion to the other in pair-wise comparison**
Equal preference	1
weak preference	3
Strong preference	5
Demonstrated preference	7
Absolute importance	9
Intermediate values	2,4,6,8

At the end of this part, there were ten pair-wise comparisons for criteria and ten pair-wise comparisons for alternatives based on each criterion. Here is an example of criterion pair-wise comparison based on one of the expert's opinion (Table 3). According to the Delphi method, the prepared questionnaire distributed among 10 experts. For the first time, there are no similar opinions, so Koshan Park gets the highest mark as the security criterion. Finally, after three revisions in the questionnaires, they agreed on the same opinion (Table 3).

Table 3. An example of criterion pair-wise comparison (based on Saaty`s scale)

Criteria	**Safety**	**Security**	**Healthy environment**
Safety	1	1.3	1.5
Security	3	1	1
Healthy environment	5	1	1

Then, the answers to the pair-wise comparisons were examined by the Expert-Choice software. For the first time, in some cases, the result was more than 0.1, so the survey was repeated. The next time, the results were acceptable. At this step, each number of each comparison matrix should be changed to fuzzy numbers. Fuzzy numbers are types of numbers that can be explained by three fractions as M_{kj}= (L, m, u). Fuzzy membership function is the same as Equation 1 [11]: (m), (l) and (u) are less, more, and equal to the range of the triangular fuzzy number (TFNs), respectively. In fact, (l) is the minimum; (u) is the maximum, and (m) is the geometric mean of the whole numbers given as the answer to the same pair-wise comparison. Accordingly, the Fuzzy pair-wise comparison matrices for both criteria and the whole alternatives are planned as Equation 2. To make the study method more clear, the study`s criteria for fuzzy pair-wise compared in Table 4. The same has been done between the parks for each criteria, shown in Table 5, 6 and 7.

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Equation 1:

$$\mu_{\tilde{M}}(x) = \begin{cases} \dfrac{(x-1)}{(m-1)}, & 1 \le x \le m \\ \dfrac{(u-x)}{(u-m)}, & m \le x \le u \\ 0 & \text{otherwise} \end{cases}$$

Equation 2:

$$\tilde{A} = (\widetilde{a_{ij}})_{n\times n} = \begin{bmatrix} (1,1,1) & (I_{12}, u_{12}, m_{12}) & (I_{1n}, u_{1n}, m_{1n}) \\ & \cdot & \cdot \\ & \cdot & \\ (I_{n2}, u_{n2}, m_{n2}) & (I_{n2}, u_{n2}, m_{n2}) & (1,1,1) \end{bmatrix}$$

Geometric mean:

$$\left(\prod_{i=1}^{n} a_i\right)^{1/n} = \sqrt[n]{a_1\, a_2\, a_3 \ldots . a_n}$$

Table 4. fuzzy pair-wise comparison in AHP method between study's criteria

Criteria	Safety	Security	Healthy environment
Safety	(1,1,1)	(1,2.45,5)	(1,2.66,5)
Security	(0.20,0.40,1)	(1,1,1)	(0.14,1.15,5)
Healthy environment	(0.20,0.37,1)	(0.20,0.86,7.14)	(1,1,1)

Table 5. fuzzy pair-wise comparison between the selected parks for safety

Safety	Ghaem	Shahrdari	Aftab	Koosha	Keshavarz
Ghaem	(1,1,1)	(0.20,0.75,5)	(0.14,0.34,1)	(0.16,1.07,3)	(3,4.61,7)
Shahrdari	(0.20,1.33,5.00)	(1,1,1)	(0.20,1.14,5)	(0.33,1.52,5)	(0.33,3.67,9)
Aftab	(1,2.94,7.14)	(0.2,0.87,5)	(1,1,1)	(0.33,1.89,7)	(3,5.07,9)
Koosha	(0.33,0.93,6.25)	(0.2,0.65,3.03)	(0.14,0.52,3.03)	(1,1,1)	(1,3.55,9)
Keshavarz	(0.14,0.21,0.33)	(0.11,0.27,3.03)	(0.11,0.19,0.33)	(0.11,0.28,1)	(1,1,1)

Table 6. fuzzy pair-wise comparison between the selected parks for security

Security	Ghaem	Shahrdari	Aftab	Koosha	Keshavarz
Ghaem	(1,1,1)	(0.11,1.92,9)	(1,2.62,5)	(0.33,0.86,3)	(1,2.14,5)
Shahrdari	(0.11,0.52,9.09)	(1,1,1)	(1,2.03,7)	(0.14,0.60,7)	(0.14,1.26,8)
Aftab	(0.20,0.38,1)	(0.14,0.49,1)	(1,1,1)	(0.14,0.35,3)	(0.14,1.26,7)
Koosha	(0.33,1.16,3.03)	(0.14,1.66,7.14)	(0.33,2.85,7.14)	(1,1,1)	(1,2.04,9)
Keshavarz		(0.12,0.79,7.14)	(0.14,0.79,7.14)	(0.11,0.49,1)	(1,1,1)

Table 7. fuzzy pair-wise comparison between the selected parks for healthy environment

Healthy environment	Ghaem	Shahrdari	Aftab	Koosha	Keshavarz
Ghaem	(1,1,1)	(0.14,0.65,3)	(0.14,0.31,1)	(0.14,1.15,5)	(0.20,1.19,4)
Shahrdari	(0.33,1.53,7.14)	(1,1,1)	(0.11,0.37,1)	(0.33,0.64,1)	(0.20,1.12,3)
Aftab	(1,3.22,7.14)	(1,2.70,9.09)	(1,1,1)	(0.33,3.10,7)	(0.20,2.80,7)
Koosha	(0.20,0.86,7.14)	(1,1.56,3.03)	(0.14,0.32,3.03)	(1,1,1)	(1,1.24,3)
Keshavarz	(0.25,0.84,5)	(0.33,0.89,5)	(0.14,0.35,5)	(0.33,0.80,1)	(1,1,1)

Finally, summation of each row was calculated (considering the below mathematical operators) and normalized by fuzzy operators to obtain relative weights of alternatives (Sk).

Equation 3:

$M_1 + M_2 = (I_1 + I_2, m_1 + m_2, u_1 + u_2)$

$M_1 \times M_2 = (I_1 \times I_2, m_1 \times m_2, u_1 \times u_2)$

$M_1^{-1} = (\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{I_1})$, $M_2^{-1} = (\frac{1}{u_2}, \frac{1}{m_2}, \frac{1}{I_2})$

In this study, Sk(s) for each criterion was calculated as below:

S1= (0.1105, 0.5611, 1.9164)

S2= (0.0494, 0.2342, 1.2195)

S3= (0.0516, 0.2048, 1.5923)

The same was done for each of the alternatives based on the first, second and third criteria (safety, security and healthy environment), and results were as below:

S1= (0.0569, 0.2111, 1.0474)

S2= (0.0260, 0.2353, 1.5404)

S3= (0.0699, 0.3198, 1.7954)

S4= (0.0337, 0.1807, 1.3746)

S5= (0.0186, 0.0335, 0.3506)

S1= (0.0305, 0.2878, 1.9459)
S2= (0.0212, 0.1823, 2.7149)
S3= (0.0144, 0.1173, 1.0998)
S4= (0.0248, 0.2936, 2.3105)
S5= (0.0139, 0.2936, 1.4619)

S1=(0.0175, 0.1403, 1.1191)
S2= (0.0213, 0.1521, 1.0504)
S3= (0.0382, 0.4184, 2.4964)
S4= (0.0362, 0.1625, 1.3605)
S5= (0.0222, 0.1625, 1.3589)

n the next step, the preferences of weights to each other or the possibility degree was calculated based on the given function:

Equation 4:

$$\begin{cases} V(M_1 \geq M_2) = 1 & if\ m_1 \geq m_2 \\ V(M_1 \geq M_2) = hgt(M_1 \cap M_2) & otherwise \end{cases}$$

$$hgt(M_1 \cap M_2) = \frac{u_1 - l_2}{(u_1 - l_2) + (m_2 - m_1)}$$

Then to calculate the weights of the criteria and alternatives, the following will be considered:

Equation5:

$$d'(A_i) = \min V[(S_i \geq S_k)] \quad k = 1,2...,n \quad k \neq i$$

The weight vector was calculated as:

Equation 6:

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))$$

The given results of this part are not fuzzy numbers. They are also called the abnormal coefficient of Fuzzy-AHP. However, they can easily be normalized by this formula [12]:

Equation 7:

$$W_i = \frac{w'_i}{\sum w'_i}$$

The normalized weights of criteria and alternatives in this study were:

$W_{criterion}$= (0.3301, 0.3301, 0.3398)

$W_{alternative\ based\ on\ the\ 1st\ criterion}$= (0.1943, 0.1943, 0.1943, 0.1943, 0.2229)

$W_{alternative\ based\ on\ the\ 2nd\ criterion}$= (0.1974, 0.1974, 0.2103, 0.1974, 0.1974)

$W_{alternative\ based\ on\ the\ 3rd\ criterion}$= (0.2019, 0.1995, 0.1995, 0.1995, 0.1995)

Finally, to calculate the overall weight of each alternative, the weight of each of them has been multiplied by the weight of their relevant criteria (Table 8).

Table 8. Weights and the final score of the selected parks

	Safety	**Security**	**Healthy environment**	**Total weight**
	0.3301	0.3301	0.3398	
Ghaem	0.1943	0.1974	0.2019	0.1979
Shahrdari	0.1943	0.1974	0.1995	0.1971
Aftab	0.1943	0.2103	0.1995	0.2013
Koosha	0.1943	0.1974	0.1995	0.1971
Keshavarz	0.2229	0.1974	0.1995	0.2065
				1.0000

In this study, to define the criteria, the age ranges and their changes were considered. According to the World Health Organization (WHO), all the +60 yr old are called aged and are divided into three main groups, namely, the young age (60-69 yr old), the aged (70-79), and the old aged (+80).

Table 1 indicated that conditions such as limited vision may create special needs. For example, an older adult who is not able to drive may use transportation options in urban areas to keep his mobility well beyond the capacity of many others in suburban communities. Therefore, affordable, accessible and suitable options can allow older adults to stay in their community their entire lives and provide opportunities for physical activity and social interactions. Moreover, communities with a safe and secure environment allow older adults to remain independent, active and engaged.

Psychological changes will also appear in the forms of loneliness, sadness, anxiety, depression, feeling of being a burden, and feeling of being absurd, if not being treated may end in severe psychological disease [13].

Moreover, retirement, losing social value, feeling isolated, and being dependent (especially monetary dependency) will also occur as the most important social and economic changes. These problems can be healed by having access to a local meeting place; a place to express their identity and visit and be acquainted with new people, and having to access to cheaper or free services. Considering these limitations, the aged adults are

one of the particular social groups that their requirements should be considered in a sustainable urban design and planning.

In this regard, there are different design theories such as "universal design" which is a type of design in which the requirements of all users must be considered [14]. According to the WHO [15] the following is a checklist of all the necessary features to make a community age-friendly:

- Public areas are clean and pleasant.
- Green spaces and outdoor seating are sufficient in number, well maintained and safe.
- Pavements are well maintained, free of obstructions and reserved for pedestrians.
- Pavements are non-slip, are wide enough for wheelchairs and have dropped curbs to road level.
- Pedestrian crossings are sufficient in number and safe for people with different levels and types of disability, with non-slip markings, visual and audio cues and adequate crossing times.
- Drivers give way to pedestrians at intersections and pedestrian crossings.
- Cycle paths are separate from pavements and other pedestrian walkways.
- Outdoor safety is promoted by good street lighting, police patrols, and community education.
- Services are situated together and are accessible.
- Special customer service arrangements are provided, such as separate queues or service counters for elder people.
- Buildings are well-signed outside and inside, with sufficient seating and toilets, accessible elevators, ramps, railings and stairs, and non-slip floors.
- Public toilets outdoors and indoors are sufficient in number, clean, well maintained and accessible.

Finally, Table 8 indicated that Keshavarz Park having the weight of 0.2065 is the most age-friendly urban park in Sari while Shahrdari and Koosha having the total weight of 0.0.1971 are equally the worst. Aftab and Ghaem also are ranked second and third, respectively.

CONCLUSION

Urban parks of Sari are not adequately meeting the needs of the aged groups and there are little differences among them for being age-friendly. Unfortunately, contrary to its rapid growth of aging rate that is even faster than the whole country, Sari lacks the age-friendly urban parks. The situation would have been different if the age-friendly factors had been considered while designing and building the parks. Having age-friendly urban facilities and open space areas can result in considerable reduced social and medical costs and less economic burden on people and government.

Regarding the few studies investigated this issue in Iran, using the other countries` experiences would be promising. Moreover, only three criteria have been considered in this study while in Fuzzy methods the more the criteria, the more precise the answers would be. Furthermore, although Fuzzy methods will bring an acceptable chance of ranking, using other methods may provide better and more accurate results. Moreover, this would be due to the experts` field experiences of these parks that were a bit different from the study results. Finally, applying this method with some site-selection tools, such as Geographic Information Systems (GIS) is suggested for future studies.

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The authors declare that there is no conflict of interests.

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