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Using USFQFD (urban space fuzzy quality function deployment: a modified two phase fuzzy QFD with AHP and TOPSIS) to reflect public demands in urban spaces : Case study : Jamshidie Park

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Abstract: Urban spaces have always been one of the most important city parts with different functions. Public participation in urban space planning and designing, implementation and maintenance has an important role to improve urban space performances. It requires a systematic technique to discover public demands and their reflections in urban spaces. The noted technique should consider different items such as public demands and the importance of each demand, urban space upstream projects, urban space special features like topography, population, culture, history and etc, Planning restrictions like time, capacity and etc. Uncertainty situation about accountability of proposed reflections of public demands in urban spaces should be regarded too. This paper proposes USFQFD which is a modified two phase fuzzy QFD which originally is a method to translate customer demands into industrial productions, with TOPSIS and AHP to discover public demands and to reflect them in urban spaces. The proposed method is implemented in Jamshidie park which is located in Tehran and 8 reflection methods of public demands are proposed.

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1. Introduction

Public spaces such as plazas, streets, urban parks and etc are an important facet of cities and urban culture as they are considered as center of civic life for dwellers (Hou, 2010). Due to the importance and role of urban public spaces in people's social lives (Jalaladdini, Oktay, 2001), there is great emphasis to create or improve the quality of urban spaces. However, sometimes public spaces suffers by neglect (Orvell, Meikle, 2009) and do not adequately reflect users needs which will lead to failure in their design and management (Carr, Francis, Stone, 1995).

Generally, an ideal public space must have 3 primary features including being responsive, democratic and meaningful. Responsive spaces are the spaces with proper designing, planning and maintaining system which can serve the needs of their users (Carr, 1995). In order to create responsive spaces, it seems necessary to use an appropriate method to explore public demands and their suitable reflections in urban spaces. One of the techniques which is used for this purpose is called QFD.

Originally, QFD is an important tool that can enable companies to achieve high quality (Chen, 2010: 678). It uses a set of matrices for deploying the customer desired attributes of a product or service throughout all the appropriate functional components of an organization (Revelle, Moran, Aaron Cox, 1998). In other words, QFD provides specific methods for ensuring quality throughout each stage of product development (Akao, 1990). This technique is used primitively in architecture (Lo, Tseng, Chu, 2010) and landscape design (Mahdavinejad, Abedi: 2011).

The reminder of the paper is organized as follow: Section 2 presents a literature review of urban spaces and public participations and their various types; QFD and Fuzzy QFD and their principles and applications are presented respectively in section 3 and 4; Section 5 is devoted to the modified two phase fuzzy QFD with AHP and TOPSIS techniques; The introduction of Jamshidie park and application of proposed method in that public space are presented in section 6 and 7; Finally, section 8 provides the conclusion remarks.

2. Urban Space and public participation

Traditionally, urban spaces have been one of the main mental concern of architects (Jalaladdini, Oktay). Greek agoras, Roman forums and Persian fields are formed in response to their functional social, economical, cultural and political needs.

Public space is an accessible to people space within the city under the public responsibility of the community (Sherbiny, 2011) which is a ground for public activities (Jalaladdini, Oktay). The public space activities can be divided into 3, necessary, optional and social activities (Turel, Yigit, Altug, 2007). Social activities are so important that urban spaces can be called 'social spaces' (Sherbiny, 2011). These spaces allow urban designers to interact with 'community' (Sherbiny, 2011) to establish a direct link between space and its users needs (Ward Thompson, 2002).

Considering the key role factor of inhabitants in urban space planning and the mutual interaction of spaces and their users (Newman, Dale, Ling, 2011), the importance of public participation, as a key element of local effort for sustainability (Holden, 2011), in comparison with greatly criticized traditional top-down or bureaucratic approach (Momeni, Shamskooshki, Javadian, 2011) in urban space planning can be clarified. Public participation is a process which enables people to influence over policy formations, design alternatives, investment choices and monitoring the developmental interventions (Yung, Chan, 2011). In other words, "it's a formal mechanism to engage citizens to facilitate coordination and collaboration among service providers, community development practitioners, businesses and local government" (Price, 2010). Public participation has many benefits such as improved quality of decisions, minimizing costs and delays, consensus building, increased ease of implementations and anticipating public attitudes (Creighton, 2005).

Public participation has two meanings in urban management: the first meaning of this concept refers to cooperation between private sector and municipality; and the second meaning emerges in cooperation between municipality and community sector (Momeni, Shamskooshki, Javadian, 2011).Totally, public participation can be formed in various degrees. Arnstein distinguishes 8 degrees of public participation as "ladder of citizen participation" which begins with the manipulation and ends to citizen control (Arnstein, 1969). The ladder of citizen participation in shown in table 1.

As the attractiveness and inhabitant numbers of an urban space which are the signs of its success (Houstoun, 2011), depend on interests of citizens (Gediminas, Weimar, 2001), citizen participation in designing, planning and maintaining of public spaces seems necessary which needs a systematic approaches.

Table 1. The ladder of citizen participation and related degree

Public participation	Degree
Citizen control	Degree of citizen power
Delegated power	
Partnership	Degree of Tokenism
Placation	
Consultation	
Informing	
Therapy	Non participation
Manipulation	

3. Quality Function Deployment

QFD concept was initiated by Akaoo in 1966 in Japan (Celik, Cebi, Kahraman, Er, 2009). Basically, QFD as an quality management method (Bevilacqua, Ciarapica, Marchetti, 2012), is an interdisciplinary forward thinking (Chen, 2010) process that aids designers and planners in order to focus on the important characteristics of product or service from the viewpoint of market segment (Celik, Cebi, Kahraman, Er, 2009) for planning new or improved designs and processes (Mahdavinejad, Abedi, 2011). This customer-oriented approach (Park, Ham, Lee, 2012) is a wildly used quality structured tool (Bevilacqua, Ciarapica, Marchetti, 2012) which translates customer 'qualitative requirements' into appropriate 'quantitative technical requirements' (Yang, Khan, Sadiq, Amyotte, 2011) for each production stage (Garibay, Gutiérrez, Figueroa, 2010) from research to engineering, marketing, sales and distribution (Jia, Bai, 2011). Expressed by abstractive words , QFD uses matrices-shaped charts to transform 'WHATS' (what customer wants) to 'HOWS' (how to meet customer needs) (Jia, Bai, 2011).

QFD provides several benefits which can be divided into two groups: 1. Increasing desirable factors such as customer satisfaction (Carnevalli, Miguel, Calarge, 2010), reliability (Carnevalli, Miguel, 2008), chance of success (Bevilacqua, Ciarapica, Marchetti, 2012) and etc; 2. Decreasing undesirable factors such as development cycles (Carnevalli, Miguel, Calarge, 2010), project changes (Carnevalli, Miguel, 2008), designing and manufacturing costs (Vatthanakul, Jangchud, Jangchud, therdthai, Wilkinson, 2010) and etc. Due to great advantages of QFD, It is broadly applied in different industries (Chen, Ko, 2010). Totally, QFD has been used in various fields and cases (Yang, Khan, Sadiq, Amyotte, 2011) which can be categorized in two main fields including Industrial fields (Automotive, Food, Electronic, Marketing, Software (Celik, Cebi, Kahraman, Er, 2009) and etc) and Services (Construction, Healthcare, Education and etc). QFD is proposed as a new method in architecture and urban planning. Dikmen, Birgonul and Kiziltas applied QFD to architecture design to specify colors, lighting and lay-out (Lo, Tseng, Chu, 2010). Mahdavinejad and Abedi also used QFD as a technique toward community-oriented landscape design for sustainability (Mahdavinejad, Abedi, 2011).

An important fact about QFD is its flexibility which has led to various modification over the initial structure of it (Celik, Cebi, Kahraman, Er, 2009). Generally, considering QFD implementation cases and based on the number of QFD constituent sequential matrices, this process can be divided into four general categories as follow :

1. QFD with 30 matrices (Park, Ham, Lee, 2012).
2. QFD with 18 matrices (Rezai, Hosseini Ashtiani, Hooshyar, Vaziri, 2005).
3. QFD with 4 matrices (Park, Ham, Lee, 2012; Vatthanakul, Jangchud, Jangchud, therdthai, Wilkinson, 2010; Liu, 2011).
4. QFD with 1 matrix (Lo, Tseng, Chu, 2010).

The four-phase QFD model consists of four steps: phase 1- house of quality (product planning), phase 2- design deployment (part deployment), phase 3- manufacturing planning (process planning), phase 4- production planning (production operations planning) (Park, Ham, Lee, 2012). Four phases of a conventional QFD are demonstrated in Figure 1. Each step output is the input of the next step.

The HOQ can be considered as the hub of QFD process (Bevilacqua, Ciarapica, Marchetti, 2012) as most of present literature has focused on it (Chen, Ko, 2010). HOQ is consist if six elements including customer requirements, planning matrix, technical characteristics, relationship matrix, correlation matrix and technical characteristic importance (Yang, Khan, Sadiq, Amyotte, 2011) which assist QFD practitioners in identifying the principle customer requirements (CRs) and determine which product or service's technical characteristics influence customer requirements (ECs) (Park, Ham, Lee, 2012). Figure2 shows HOQ. Based on acquired CRs and ECs, the team can specify the relationships between CRs and ECs and the correlations between CEs . The obtained information leads to calculate the CEs importance (Liu, 2011) which can determine the input of design deployment matrices. The next matrices calculations are almost like HOQ.

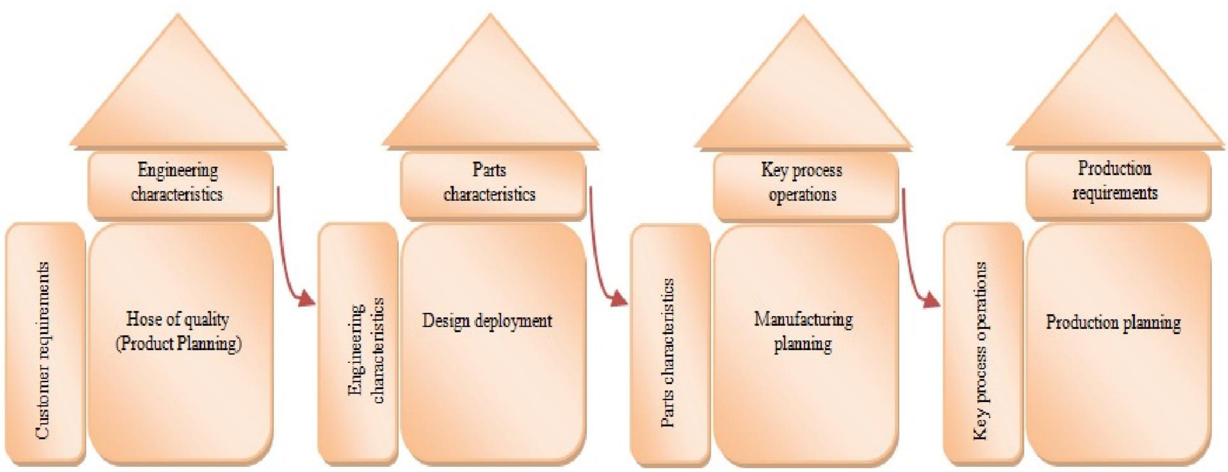


Figure 1. Four phase of a conventional QFD

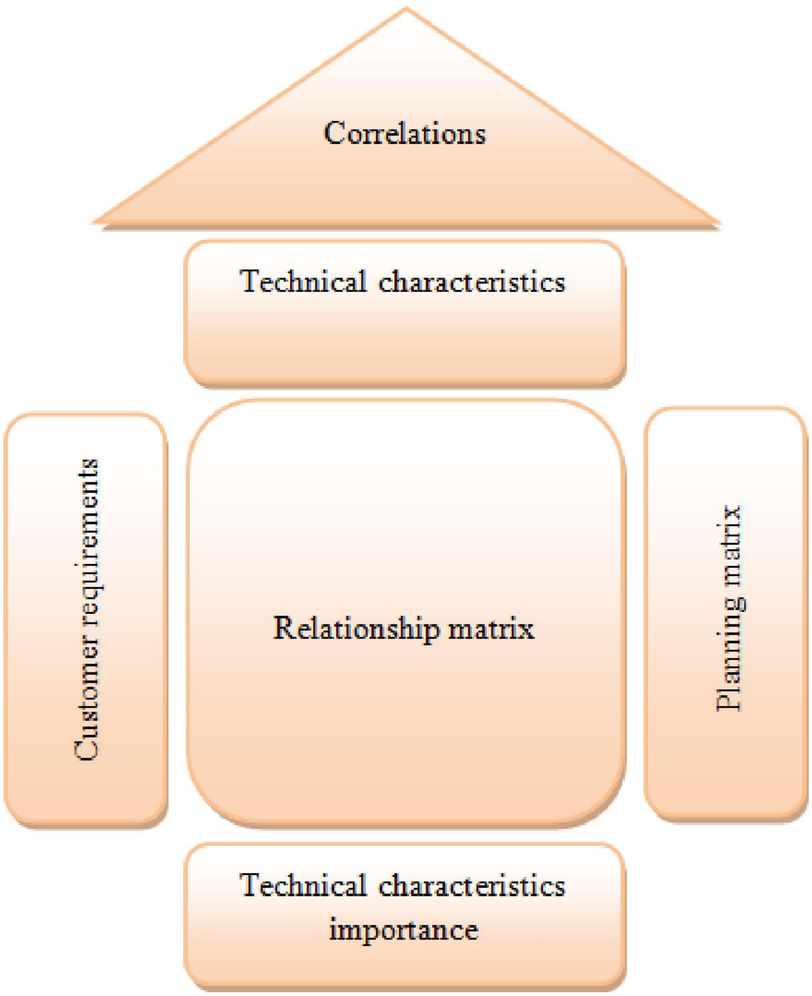


Figure 2. HOQ (house of quality)

4. Fuzzy Quality Function Deployment

Traditionally, most of the inputs and functional variables of QFD are assumed and treated as numerical data (Bevilacqua, Ciarapica, Marchetti, 2012). Because of the lack of knowledge about exact influence of technical characteristics over customer requirements (Chen, Ko, 2010) and vagueness of human linguistic majors to express customer requirements (Kazancoglu, Aksoy, 2011), research on fuzzy QFD has received great attention (Chen, Fung, Tang, 2006; Bevilacqua, Ciarapica, Marchetti, 2012). Khoo and Ho (1996) proposed the concept of fuzzy QFD. They fuzzifield linguistic variables (Liu, 2011). Sohn and Choi (2001) used fuzzy MCDM with fuzzy QFD method and Chan and Wue (2005) suggested to use symmetrical triangle fuzzy numbers in QFD (Zarei, Fakhrzad, Paghaleh, 2001).

Fuzzy set theory is proposed by Zadeh (1965) which is oriented to rationality of uncertainty, Vagueness and imprecision (Kahraman, Ertay, Buyukozkan, 2006). A fuzzy set is a class of objects with continuum grade of membership. A triangular fuzzy number (α, β ,Ɣ) is consist of 3 parameters

which respectively denote smallest , most and largest possible values of a fuzzy event (Kazancoglu, Aksoy, 2011). Figure 3 shows the left and right presentation of a TFN. The membership of a TFN can be defined as follow (Zarei, Fakhrzad, Paghaleh, 2001):

$$\mu_N(x) : \begin{cases} (x-\alpha) / (x-\beta) & x\epsilon\ [\alpha,\beta] \\ (\gamma-x) / (\gamma-\beta) & x\epsilon\ [\beta,\gamma] \\ 0 & \text{Otherwhise} \end{cases} \quad (1)$$

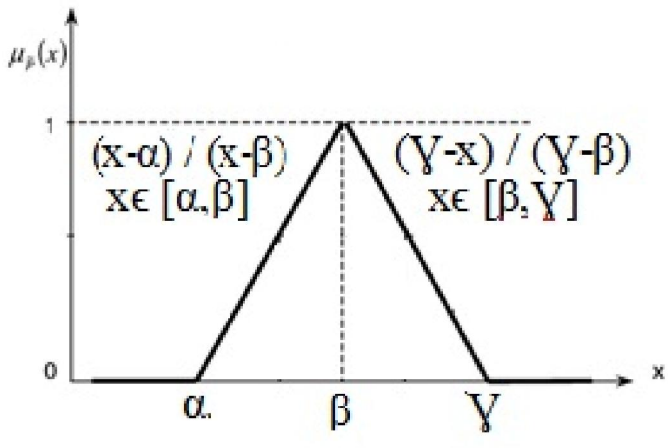


Figure 3. Left and right presentation of a TFN

The linguistic relationships between CRs and CEs and also the degrees of correlations between CEs can be translated into fuzzy number by defining appropriate membership functions as they are shown in table 2 and 3.

Table 2. The degrees of relationship and related fuzzy numbers (Zarei, Fakhrzad, Paghaleh, 2001)

Degree of relationship	Fuzzy number
Strong (S)	(0.7 , 1 ,1)
Medium (M)	(0.3 , 0.5 , 0.7)
Weak (W)	(0 , 0 , 0.3)

Table 3. The degrees of correlation between CEs and their related fuzzy numbers (Zarei, Fakhrzad, Paghaleh, 2001)

Degree of correlation	Fuzzy number
Strong positive (SP)	(0.7 , 1 ,1)
Positive (P)	(0.5 , 0.7 , 1)
Negative (N)	(0 , 0.3 , 0.5)
Strong negative (SN)	(0 , 0 , 0.3)

If i indicates the ith customer requirement and j shows the jth technical characteristic, w_i indicates the priority weight of ith customer requirement. The relative importance of jth technical characteristic (RI_j) and its priority weight (RI_j^*) can be calculated as follow (Bottani, 2009):

$$RI_j = \sum_{i=1}^{n} w_i \otimes R_{ij} \quad j=1,\ldots,m \quad (2)$$

$$RI_j^* = RI_j \oplus \sum_{k \neq j} T_{kj} \otimes RI_k \quad j=1,\ldots,m \quad (3)$$

T_{kj} is the degree of correlation between kth and jth technical characteristics which is indicated on the roof of HOQ . NRI_j^* shows normalized TFN which is calculated by dividing each RI_j^* by the highest one. NRI_j^* can be calculated as follow:

$$NRI_j^* = (\alpha_j/\gamma^{max} , \beta_j/\beta^{max} , \gamma_j/\alpha^{max}) \quad (4)$$

The final crisp value of each technical characteristic is computed by using the following de-fuzzifying formula (Zarei, Fakhrzad, Paghaleh, 2001):

$$\text{Crisp value} = (\alpha+4\beta+\gamma) / 6 \quad (5)$$

5. Using QFD to reflect public desires in urban spaces

Urban space and it's accountability, are some of the most important interest issues of architecture, urban planners and designers in urban management. Since, people are the users of urban spaces, there is a great emphasis on their participation in public space planning, designing and development. Therefore, a systematic quantitative approach is needed which not only considers the technical requirements of urban space planning and designing, but also discovers public demands and their optimal reflections in urban spaces. The approach must be enough flexible to take advantage of appropriate methods and strategies based on cultural differences to discover public demands and tendencies.

As there are usually some various ways to reflect public demands in urban spaces, it seems necessary to use a mechanism associated with public demands, technical requirements and different reflection methods in order to obtain optimal reflections of public tendencies in urban spaces. The mechanism must be compatible with uncertain condition of discovered demands, technical characteristics and different reflections in urban spaces. Moreover, according to the multiplicity options of each type of communication between public demands, technical characteristics and urban space reflections, considering an approach for decision making seems necessary.

This article proposes USFQFD which is consist of a modified two phase Fuzzy QFD with AHP and TOPSIS techniques as the discussed mechanism. Two phase fuzzy QFD to reflect public demands in urban spaces is consist of House of Quality (HOQ) and Reflections in Urban Space (Which we can call RUS) matrices. The HOQ inputs include the discovered public demands and their importance weights which are obtainable in different ways that must be compatible with structural and cultural characteristics of urban space users society. As an instance, considering the urban planning structure of Republic Islamic of Iran, The proposed methods can be such as follow:

1. Interviewing with public space users;
2. Using Questionnaire;
3. Interviewing with the related district council members;
4. Direct observation of users' behavior;
5. Considering predicted issues in upstream urban plans;
6. Establishing a SMS system and considering prizes to motivate the participators;
7. Using PPGIS;
8. Using advisory group and task forces;
9. Using appreciative inquiry summit;
10. Using beneficiary assessment;
11. Using charrette;
12. Using consensus building;
13. Using facilitation;
14. Using focus groups;
15. Using open space method;
16. Using public hearing.

Each public demand priority weight is calculated by AHP with some suitable criteria which are specified by QFD members. One of the criteria is the importance weight of each demand which is acquired by discovered public tendencies (pair-wise values can be rounded). After determining the degrees of relationships between public demands and urban planning and designing technical characteristics which are specified by QFD team brainstorming (using table 2 content) and the degrees of correlations between urban planning and designing technical characteristics (using table 3), RI_j, RI_j^* , NRI_j^* and crisp values are computed (using respectively formula 2 , 3 and 4).

Since, an urban space designing and planning technical characteristics must be compatible with the overall vision and general cultural, economic, social and political structures of that space, using a multi-criteria decision making approach to determine the weight of each urban planning and designing technical characteristic seems suitable. As weight of each criteria is definable in TOPSIS technique, TOPSIS is used to compute the relative similarity of each technical characteristic to ideal solution which is defined as weight of each technical characteristic in this article. One of the used criteria in TOPSIS technique is the achieved crisp value of house of quality which its weight indicates tend degree of public demands related technical characteristics and QFD team specified extra criteria. The final weights of HOQ technical characteristics are the relative weight of TOPSIS outputs which are calculated by dividing each characteristic weight by sum of the characteristics weights. Some of the urban planning and designing characteristics are transferred to RUS based of their final relative weights. The RUS calculations are almost like HOQ calculations with quite differences. As an instance, the weights of the transferred urban planning and designing characteristics are not computed by AHP. The weight of each reflection in urban space is calculated by TOPSIS with QFD team specified criteria which can include items such as resource allocation, time requirements and coordination of reflections in urban space with other coordinated projects or plans.

6. Case study : Jamshidie Park

This paper case study is Jamshidie park which is a well-known park in capital of Republic Islamic of Iran, Tehran. This park is located in north of forth district of first region of Tehran. This park is founded in 1978 and its total area is six hectares.

Based on observations, some shortcomings are evident in Jamshidieh Park. Generally, these shortcomings can be divided into three following categories:

1. Lack of existing facilities and potentials usage in the park: lack of water flow in the park streams and fountains and designed cages with no bird presence, as demonstrated in figure 4 and 5, can be mentioned as instances;
2. Lack of maintenance system in the park: lack of a maintenance system has serve damages to some parts of the park, as some of the park parts such as thinking place (Fazaye khalvate andishe) and children's pond have lost their activities. Thinking place and children's pond are shown in figure 6 and 7;
3. Lack of park facilities diversity to meet various public demands: lack of diversity is observed in different items such as lack of alcoves with different capacities and sizes, lack of various transportation systems to arrive passengers at the park.

Figure 4. lack of water flow in the Jamshidie park streams and fountains

Figure 5. Designed cages with no bird presence in Jamshidie park

Figure 6. Jamshidie park thinking space which has lost its activity

Figure 7. Jamshidie park children's pond which has lost its activity

7. Using Quality function deployment to reflect Jamshidie park user's demands in that space

As there is a mutual interaction between the human use of a park and its structure, public demands have an important role in the planning and designing of the parks. This article uses USFQFD to reflect Jamshidie park user's demands in this park.

As mentioned before, USFQFD implementation first step is discovering user's demands and expectations. To achieve this purpose, observation, interview and survey methods are used. First, observation and interview were used to explore park user's demands. The QFD team examined the results and used brainstorming to adjust a pilot questionnaire. In order to assess the validity of questionnaire, three expert members of regional municipality revised the pilot questionnaire. The pilot questionnaires were filled by 50 park users. Based on the results, the questionnaire Cronbach alpha coefficient was 0.89 which indicates its suitable reliability. Finally, a survey was conducted and based on Cochran sampling method, 277 members of jamshidie park users filled the questionnaires. Based on the results of final questionnaire survey and observations 14 public demands were discovered which can be categorized in 5 groups. Table 4 indicates public discovered demands.

Table 4. Jamishidie park user's demands and their weights

factor		weight	Name
Structure	Providing appropriate flooring in some of the park paths	5	CR1
Function	Providing a dynamic space for children play and rest	4	CR2
	Providing a dynamic exercise place in the park	2	CR3
	Providing an adequate relief place	4	CR4
Nutritional	Providing adequate number of canteens in the park	3	CR5
	Increasing food quality in the park restaurant	3	CR6
vitality	Providing the possibility of animals presence and their sounds freshness presence in park space	4	CR7
	Providing water flow in the park streams and fountains	5	CR8
Furniture and facilities	Providing adequate clean WCs	5	CR9
	Providing appropriate furniture and facilities for children	4	CR10
	Providing facilities for elderly use	2	CR11
	providing adequate appropriate seats in the park	5	CR12
	Providing appropriate lighting at night in the park	3	CR13
	Providing adequate number of public telephone in the park space	2	CR14

Then, AHP was deployed to rank Jamshidie park user's demands. The AHP criteria were consist of weight of each demand based on user's ideas and two other criteria based on Tehran first region vision. The criteria were as follow:

1. Weight of each user's demand based on user's ideas (C1);
2. Maintaining this region villa residential characteristics (C2);
3. Considering the tourism characteristics of the region (C3).

Table 5,6 and 7 respectively show the pair-wise assessments for alternatives with respect to C1,C2 and C3.

Table 5. The pair-wise assessment for alternatives with respect to C1

C1	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10	CR11	CR12	CR13	CR14
CR1	1	1	2	1	2	2	1	1	1	1	2	1	2	2
CR2	1	1	2	1	1	1	1	1	1	1	2	1	1	2
CR3	1/2	1/2	1	1/2	1	1	1/2	1/2	1/2	1/2	1	1/2	1	1
CR4	1	1	2	1	1	1	1	1	1	1	2	1	1	2
CR5	1/2	1	1	1	1	1	1	2	2	1	1	1/2	1	1
CR6	1/2	1	1	1	1	1	1	1/2	1/2	1	1	2	1	1
CR7	1	1	2	1	1	1	1	1	1	1	2	1	1	2
CR8	1	1	2	1	2	2	1	1	1	1	2	1	2	2
CR9	1	1	2	1	2	2	1	1	1	1	2	1	2	2
CR10	1	1	2	1	1	1	1	1	1	1	2	1	1	2
CR11	2	1/2	1	1/2	1	1	1/2	2	1/2	1/2	1	1/2	1	1
CR12	1	1	2	1	2	2	1	1	1	1	2	1	2	2
CR13	1/2	1	1	1	1	1	1	1/2	1/2	1	1	1/2	1	1
CR14	1/2	1/2	1	1/2	1	1	1/2	1/2	1/2	1/2	1	1/2	1	1

Table 6. The pair-wise assessment for alternatives with respect to C2

C2	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10	CR11	CR12	CR13	CR14
CR1	1	3	3	1/6	3	2	1/5	1/5	3	2	2	6	6	3
CR2	1/3	1	1	1/8	9	7	1/7	1/7	9	7	7	4	4	9
CR3	1/3	1	1	1/8	9	7	1/7	1/7	9	7	7	4	4	9
CR4	6	8	8	1	9	3	3	3	9	3	3	9	9	9
CR5	1/3	1/9	1/9	1/9	1	1/6	1/4	1/4	1	1/7	1/7	1/2	1/2	1
CR6	1/2	1/7	1/7	1/3	6	1	1/9	1/9	6	1	1	1/5	1/5	7
CR7	5	7	7	1/3	4	9	1	1	4	9	9	2	2	4
CR8	5	7	7	1/3	4	9	1	1	4	9	9	2	2	4
CR9	1/3	1/9	1/9	1/9	1	1/6	1/4	1/4	1	1/6	1/6	1/2	1/2	1
CR10	1/2	1/7	1/7	1/3	7	1	1/9	1/9	6	1	1	1/5	1/5	6
CR11	1/2	1/7	1/7	1/3	7	1	1/9	1/9	6	1	1	1/5	1/5	6
CR12	1/6	1/4	1/4	1/9	2	5	1/2	1/2	2	5	5	1	1	2
CR13	1/6	1/4	1/4	1/9	2	5	1/2	1/2	2	5	5	1	1	2
CR14	1/3	1/9	1/9	1/9	1	1/7	1/4	1/4	1	1/6	1/6	1/2	1/2	1

Table 7. The pair-wise assessment for alternatives with respect to C3

C3	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10	CR11	CR12	CR13	CR14
CR1	1	1	3	1/6	1	1/5	1/6	1/6	3	1	6	1/3	3	3
CR2	1	1	3	1/6	1	1/5	1/6	1/6	3	1	6	1/3	3	3
CR3	1/3	1/3	1	1/8	1/3	1/7	1/8	1/8	1	1/3	1/3	1/5	1/5	1
CR4	6	6	8	1	6	2	1	1	8	6	9	4	4	8
CR5	1	1	3	1/6	1	1/5	1/6	1/6	1/3	1	6	1/3	1/3	3
CR6	5	5	7	1/2	5	1	1/2	1/2	7	5	2	2	2	7
CR7	6	6	8	1	6	2	1	1	8	6	9	4	4	8
CR8	6	6	8	1	6	2	1	1	8	6	9	4	4	8
CR9	1/3	1/3	1	1/8	3	1/7	1/8	1/8	1	1/3	4	5	5	1
CR10	1	1	3	1/6	1	1/5	1/6	1/6	3	1	6	1/3	1/3	1/3
CR11	1/6	1/6	3	1/9	1/6	1/2	1/9	1/9	1/4	1/6	1	1/8	1/8	¼
CR12	3	3	5	1/4	3	1/2	1/4	1/4	1/5	3	8	1	1	5
CR13	1/3	1/3	5	1/4	3	1/2	1/4	1/4	1/5	3	8	1	1	5
CR14	1/3	1/3	1	1/8	1/3	1/7	1/8	1/8	1	3	4	1/5	1/5	1

After calculating the priority weights of Jamshidie park user's demands, QFD team used brainstorming to propose 10 technical characteristics to supply identified demands. The degrees of correlations between technical characteristics were determined on the roof of HOQ based on table 3. The degrees of relationships between the Jamshidie park user's demands and proposed technical characteristics were specified based on table 2 in the next step. Relative importance technical characteristics (RI_j), priority weights (RI_j^*), normalized priority weights (NRI_j^*) and de-fuzzifield crisp values were calculated by using formula 2,3,4 and 5. Crisp value was used as one three criteria of TOPSIS technique to specify the importance weight of each technical characteristic. Two other criteria were determined based on Jamshidie park upstream projects which were master plan of Tehran and detail plan of Tehran's first region. Totally, TOPSIS technique criteria and their importance weights are demonstrated in table 8.

Table 8. List of the criteria for TOPSIS technique in HOQ

Criteria	weight
Crisp value of relative importance of technical characteristics	0.9
Compatibility with regional features as mentioned in upstream plans	0.05
Compatibility with required features to achieve the regional vision as mentioned in upstream plans	0.05

Technical characteristics final relative weights determined the characteristics which transferred to RUS matrix, was computed by dividing each characteristic relative similarity to ideal solution based on TOPSIS outputs by sum of characteristics similarity to ideal solution. Table 9 shows Jamshidie park HOQ. 7 technical characteristics and their final relative weights were transferred to URS. QFD team used brainstorming technique to review and analyze RUS technical characteristics and proposed 8 reflection methods to meet parks user's demands.

Table 9. Jamshidie park

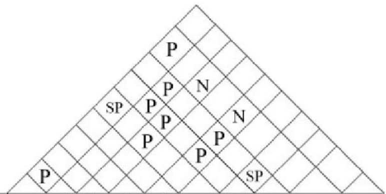
Criteria	weight
Crisp value of relative importance of reflection methods	0.9
Needed capital	0.06
Needed infrastructure facilities	0.02
Implementation required time	0.02

In order to determine the degrees of relationships between technical characteristics and reflection methods in Jamshidie park, the degrees of correlations between reflection methods, relative importance of reflections (RI_j), priority weights of reflections (RI_j^*), normalized priority weights of reflections (NRI_j^*) and de-fuzzifield crisp values in RUS, the same computational and functional procedures as HOQ are performed.

At this stage, TOPSIS was used to rank reflection methods which considered 4 criteria including achieved crisp values of RUS, the needed capital, infrastructure facilities and implementation required time for each reflection method. List of TOPSIS technique criteria and Jamshidie park RUS are respectively shown in table 10 and 11. The final relative weights of TOPSIS outputs are used to rank the public demand reflections in Jamshidie park.

Table 10 . list of TOPSIS technique criteria which were used in RUS

Criteria	weight
Crisp value of relative importance of reflection methods	0.9
Needed capital	0.06
Needed infrastructure facilities	0.02
Implementation required time	0.02

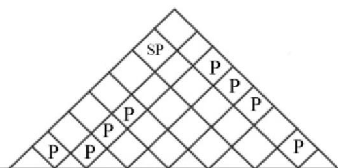


				Technical urban designing and planning requirements									
				EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9	EC10
Technical requirements / Urban space public demands			w_j(Based on AHP calculation)	Attending to the maintenance of park space	Attending to a proper lighting system	Attending to the infrastructures for children play and presence	Attending to the proper infrastructure for elderly presence and use	Attending to the proper infrastructure for animal presence	Attending to the proper infrastructure for increasing water presence in park	Attending to ongoing activities of a R & D team in the park space	Attending to methods for making more dynamic spaces	Attending to providing more relief in park space without noise and visual pollution	Attending to food provision system quality improvement
Jamshidie park user's demands	CR1	Providing appropriate flooring in some of the park paths	0.093	S		W	W			M	M		
	CR2	Providing a dynamic space for children play and rest	0.083	M	W	S			M	S			
	CR3	Providing a dynamic exercise place in the park	0.046	S							M	W	
	CR4	Providing an adequate relief place	0.079		S				S	M		S	
	CR5	Providing adequate number of canteens in the park	0.075			W							S
	CR6	Increasing food quality in the park restaurant	0.066			W							S
	CR7	Providing the possibility of animals presence and their sounds freshness presence in park space	0.079			W		S					
	CR8	Providing water flow in the park streams and fountains	0.085	W		W	W		S		S	W	
	CR9	Providing adequate clean WCs	0.085	S									
	CR10	Providing appropriate furniture and facilities for children	0.079	M		S		W		M	W		
	CR11	Providing facilities for elderly use	0.046	W	W		S		W				
	CR12	providing adequate appropriate seats in the park	0.078	S						M		W	
	CR13	Providing appropriate lighting at night in the park	0.057	M	S	W	W			S	M		M
	CR14	Providing adequate number of public telephone in the park space	0.049	S			W			W			
RI_j				(0.31,0.46,0.54)	(0.09,0.14,0.17)	(0.11,0.16,0.27)	(0.03,0.05,0.13)	(0.05,0.08,0.10)	(0.14,0.20,0.23)	(0.19,0.30,0.38)	(0.12,0.18,0.24)	(0.05,0.08,0.14)	(0.11,0.17,0.18)
RI_j^*				(0.48,0.81,1.08)	(0.4,0.80,1.33)	(0.27,0.53,0.95)	(0.03,0.05,0.13)	(0.20,0.44,0.79)	(0.41,0.77,1.04)	(0.62,0.75,1.16)	(0.31,0.61,0.92)	(0.20,0.47,0.86)	(0.11,0.17,0.18)
Normalized RI_j^* (NRI_j^*)				(0.36,1.1.74)	(0.30,0.99,2.14)	(0.20,0.65,1.53)	(0.02,0.06,0.21)	(0.15,0.54,1.27)	(0.31,0.95,1.68)	(0.47,0.92,1.87)	(0.23,0.75,1.48)	(0.15,0.58,1.39)	(0.8,0.21,0.29)

			EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9	EC10	Criteria / Alternatives	
Crisp value	0.9	+	1.02	1.07	0.72	0.08	0.60	0.96	1	0.79	0.64	0.20	Crisp value	Using TOPSIS to calculate each technical requirement final weight
	0.05	+	5	3	3	1	1	5	3	3	3	1	Compatibility with regional features as mentioned in upstream plans	
	0.5	+	5	1	3	3	3	5	1	5	5	3	Compatibility with required features to achieve the regional vision as mentioned in upstream plans	
similarity of each technical characteristics to ideal solution			0.950	0.955	0.646	0.019	0.523	0.890	0.916	0.717	0.566	0.122		
Final weights of HOQ technical characteristics			0.150	0.151	0.102	0.003	0.083	0.141	0.145	0.113	0.090	0.019		

Table 10 . list of TOPSIS technique criteria which were used in RUS

Table 11. Jamshidie park URS



Technical requirements		Reflection in urban space / Technical requirements	w_i	UR1 Founding repairing and maintenance team	UR2 Installing solar lamps in the park space	UR3 Locating a setting up street theater in park space	UR4 Locating a setting up animal show in park space	UR5 Locating a setting up painting station in park space	UR6 Locating a setting up traditional music concert in park space	UR7 Controlling water flow in park streams, basins and fountains	UR8 Founding an R & D team (research and design team) supervised by municipal
Technical requirements	EC*1	Attending to the maintenance of park space	0.150	S							
	EC*2	Attending to a proper lighting system	0.151	M	S						
	EC*3	Attending to the infrastructures for children play and presence	0.102		W	W	M	S	W		S
	EC*4	Attending to the proper infrastructure for animal presence	0.083	W			S				
	EC*5	Attending to the proper infrastructure for increasing water presence in park	0.141	W						S	
	EC*6	Attending to ongoing activities of a R & D team in the park space	0.145								S
	EC*7	Attending to methods for making more dynamic spaces	0.113	W	W	S	S	S	S		
RI_j				(0.15,0.22,0.36)	(0.10,0.15,0.21)	(0.08,0.11,0.14)	(0.17,0.25,0.27)	(0.15,0.21,0.21)	(0.08,0.11,0.14)	(0.10,0.14,0.14)	(0.17,0.25,0.25)
RI_j^*				(0.27,0.46,0.71)	(0.37,0.70,1.19)	(0.21,0.39,0.6)	(0.30,0.53,0.73)	**(0.28,0.49,0.67)**	(0.08,0.11,0.14)	(0.2,0.36,0.5)	(0.42,0.75,1.01)

Alternatives / Criteria	Weight	+/-	UR1	UR2	UR3	UR4	UR5	UR6	UR7	UR8
Normalized RI_j^* (NRI_j^*)			(0.23,0.61,1.69)	(0.31,0.93,2.83)	(0.18,0.52,1.43)	(0.25,0.71,1.74	(0.23,0.65,1.59)	(0.07,.15,0.33)	(0.17,0.48,1.19)	(0.35,1,2.40)
Crisp value	0.9	+	0.73	1.15	0.61	0.80	0.74	0.16	0.55	1.13
Needed capital (\$)	0.06	-	5000	18000	2000	35000	57000	3000	4000	5000
Needed infrastructure facilities	0.02	-	3	2	4	5	4	2	2	3
Implementation required time (month)	0.02	-	5	3.8	6	8	5	5.5	4	5
similarity of each technical characteristics reflection in urban space to ideal solution			0.676	0.843	0.609	0.559	0.414	.413	0.568	0.964
Final weights of RUS technical characteristics reflection in urban space			0.13	0.17	0.12	0.11	0.08	0.08	0.11	0.19

Using TOPSIS to calculate each technical requirement final weight

Reflection of technical requirements in Urban space

8. Conclusion

QFD is one the total quality management techniques which discovers and translates customer demands into products or services. As this technique is a customer oriented method, it can help organizations to understand their customer's demands to improve their products or services quality continuously.

This paper proposed USFQFD which is a modified two phase fuzzy QDF with AHP and TOPSIS to discover urban space's users demands, their responsive urban planning and designing characteristics and to propose some suggestions to optimally satisfy these space's users.

In order to prioritize public discovered demands AHP technique is used. TOPSIS is used to specify response rate of technical planning and designing characteristics and their reflections in urban space. Triangular fuzzy number is used to cope with vagueness of linguistic variables and uncertainty about the degrees of relationships and correlations of QFD.

Then, Jamshidie Park which is located in Tehran, Republic Islamic Of Iran, is studied as case study and suggestions of public demands reflections in this park are proposed respectively based on their final weights in RUS matrix.

It should be noted that Quality Function Deployment (QFD) is a technique to propose optimal suggestions in order to meet discovered public demands. Optimal suggestions are not necessarily the suggestions which meet the demands with great weight values, because sometimes a suggestion which meets several medium weight value demands, satisfies urban space users more than a single great weight value suggestion.

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