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EVALUATING THE SATISFACTION LEVEL OF CITIZENS IN MUNICIPALITY SERVICES BY USING PICTURE FUZZY VIKOR METHOD: 2014-2019 PERIOD ANALYSIS

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Abstract: *In this study, it is aimed to rank the satisfaction levels of citizens in municipality services. For this purpose, 20 municipal services included in the Life Satisfaction Survey (LSS) that the Turkish Statistical Institution regularly applies every year are considered as alternatives. In addition, the satisfaction of citizens was evaluated not only for the last year, but also for the period of 2014-2019, and these years were considered as a set of criteria. LSS statistics contains the citizens' responses which involve such opinion as abstain and refusal in addition to yes or no answers. For analyze the effect of all opinion types on decision process, the participant responses constituting the dataset were converted into Picture Fuzzy Numbers (PFNs) consisting of 4 parameters (positive, neutral, negative, and refusal). Finally, we apply utilize VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje) method by using PFNs arithmetic operators and evaluate the citizens' satisfaction levels of the municipality services. As a result, it was determined that the municipal services with the highest satisfaction were graveyard (A18) and fire-fighting (A17) activities, while the services with the lowest satisfaction were zoning and city planning (A10) and control of food producing facilities (A20).*

Key words: *Picture Fuzzy Sets; VIKOR; Municipal Services; Satisfaction.*

1. Introduction

The most important duty of local administrations is to provide services that meet the expectations of the citizens. Local administrations in Turkey is organized in three autonomous types of local government which are Special Provincial Administrations, municipalities and villages (Akyıldız, 2012). Among them, municipalities are the most suitable local government units to measure the satisfaction of citizens with the execution of public services. It is important for municipal administrations to be

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sensitive to the needs and wishes of the citizens and to ensure the continuous support, commendation and trust of the citizens. In order for the municipal administrators to be re-elected, it is important that the citizens are satisfied with their duties and the services provided (Bostancı & Erdem, 2020). In addition, the increasing urban needs with the developing technology reveal the necessity of providing more effective and efficient services for the local governments responsible for meeting these needs in the cities (Yıldırım, 2004). The services, duties and authorities offered by the municipalities are spread over a wide area. These duties and authorities are detailed in municipal laws. (Laws of Municipalities, Article 14). TUIK evaluates the satisfaction with the municipalities within the scope of the articles in this law with the life satisfaction survey that it conducts regularly every year.

In this type of research where criteria and alternatives are numerous, managers prefer numerical decision making techniques rather than emotional decision making. Especially in municipal services, multi criteria decision making methods are a very appropriate approach for the level of satisfaction measured by a large number of criteria. Consequently, 20 municipal services included in the Life Satisfaction Survey (LSS) that the Turkish Statistical Institution regularly applies every year are considered as alternatives and, the period of 2014-2019 years was considered as a set of criteria, we design a decision-making problem.

To handle the uncertainty which occurs in many real-life problems, has always been a problem for the researchers and decision makers (Mahmood, 2020). However, it is often difficult to exactly assess the level of satisfaction with each service provided in the decision process, because of human judgments which are vague and ambiguous in many circumstances. When there may exist hesitation in the either assessment process or in the preferences of the attributes, picture fuzzy sets are suitable and flexible tool in dealing with fuzziness and uncertainty due to imprecise knowledge or information involving hesitancy.

The motivation of this paper is ranking the municipal service alternatives according to citizens' judgements over 2004-2019 time period. In the decision process, it is aimed to make more effective decisions by expressing human judgments with fuzzy numbers. In part of LSS, there are 20 questions based on municipal services that measure citizens' satisfaction levels. Items were scored using 5 points Likert scale, with additional options for "no idea" or "no service". For analyzing the effect of all opinion types on decision process, we construct the decision matrix from PFNs which are calculated from citizens' responses. 5 point Likert options use for calculating PFN's positive, neutral and negative membership degrees and additional options use for calculating refusal membership degree. As far as we know, in the literature, picture fuzzy VIKOR method has not been perform to evaluate satisfaction level from municipal service. The originality of this study originating from this point, so we investigate the satisfaction levels of citizens from municipal services using Picture Fuzzy VIKOR. Since the dataset used in this study contains expressions that represent the neutral view, PFS contains grade of neutral and more suitable for analyzing the satisfaction level. The aim of extending the VIKOR by using PFS is analyzing the effect of all opinion types obtained from citizens.

The rest of the study is organized as follows; In Section 2 briefly gives a literature review about evaluating public and municipality satisfaction, paying particular attention to the use of MCDM methods. Following Section 3. some basic concepts of picture fuzzy sets are given. In the fourth section, the analysis steps of VIKOR method using picture fuzzy numbers are presented respectively. The application to evaluate satisfaction levels of the municipality services with picture fuzzy VIKOR method is proposed in Section 5. In the last section, the study is concluded with discuss numerical implementations and future studies are suggested.

2. Literature Review

Studies to determine the quality of municipal service in Turkey have mostly focused on the evaluation of the surveys with statistical methods. In these studies, satisfaction with municipal services was associated with demographic factors (Ince & Sahin, 2011; Gokus & Alpturker, 2011; Yucel et al., 2012; Sabuncu 2016; Bayram & Polat, 2021). Kelly and Swindell (2002) investigated the relationship among them citizen satisfaction level and performance indication in an analysis of municipality services with correlation analysis. Folz (2004) carried out a research on comparison of capacity in municipality services. They applicate clustering analysis to category cities into three homogenous classes based on service standards. Studies on MCDM techniques and the grade of satisfaction with municipal and public services are given in the table below.

Table 1. Evaluation of public and municipality satisfaction with MCDM

Author	Methodology	Results
Bostancı (2016)	Fuzzy AHP	According to the neighborhoods, it was determined that the most satisfied neighborhood in Kayseri Municipality was Yenidoğan.
Ozdogan et al. (2020)	Fuzzy AHP, Fuzzy TOPSIS	The most important factor in the ranking of municipal services is green space. Social and cultural services take the second.
Bostancı& Erdem (2020)	Fuzzy DEMATEL, Fuzzy TOPSIS	When the thematic map determining citizen satisfaction is examined, it is seen that the satisfaction levels are quite high in Mimar Sinan and Adnan Menderes regions, and low in Fakıuşağı District.
Ansari et al. (2016)	Fuzzy AHP, Fuzzy TOPSIS	It was determined that municipality of District 2 has won the first place in Qazvin municipalities.
Celik et al. (2013)	Interval type-2 fuzzy sets, GRA, TOPSIS	According to the results, the public transportation service metrobus with the best customer satisfaction level in Istanbul was determined.
Awasthi (2011)	SERVQUAL, Fuzzy TOPSIS	In Montreal's subway transportation service, the metro line that provides the highest quality service has been determined as the Orange Line.
Bilişik et al. (2013)	SERVQUAL, Fuzzy AHP, Fuzzy TOPSIS	It has been determined that the public transportation service with the highest satisfaction in Istanbul is the metrobus.

Author	Methodology	Results
Rahimi &Najafi (2017)	Fuzzy ANP, Fuzzy TOPSIS, Fuzzy ELECTRE	In the research conducted for Zanjan, “Municipal Area 2” was chosen as the most suitable region with the highest score according to the expectations of the citizens.
Pehlivan & Gürsoy (2019)	Fuzzy TOPSIS, Fuzzy MULTIMOORA Fuzzy ARAS	In Turkey, it was found that Zonguldak had the highest satisfaction with public services, while Van had the lowest satisfaction with public services.
Nassereddine & Eskandari (2017)	Delphi, GAHP, PROMETHEE	The public transport systems in Tehran, in order of increasing importance: Van, Bus, BRT, Taxi and Metro.
Li et al. (2020)	Picture Fuzzy MULTIMOORA	Railway lines in Shanghai are used to show the effectiveness of the recommended passenger satisfaction assessment technique.
Gündoğdu et al. (2021)	Picture Fuzzy AHP	It has been determined that the most influential factor in the satisfaction of public transport services in Budapest is the timetables of the vehicles.

It has not been found in the literature that satisfaction with municipal or public services is examined by the VIKOR method. For this reason, in the last part, studies with VIKOR and its extended versions are given. Kank and Park (2014) measured bank customers' satisfaction with mobile services using the VIKOR method, Dincer and Hacıoğlu (2013) measured their satisfaction with banking services using the Fuzzy VIKOR method. In the beef industry, Meksavang et al. (2019) evaluated and selected a sustainable supplier management with extended Picture Fuzzy VIKOR aproach. In Parkouhi and Ghadikolaei (2017), grey VIKOR techniques were used for supplier selection. Tiwari et al. (2016) applied the product style concept evaluation by using integrated rough VIKOR method. Krishankumar et al. (2020) suggested the intuitionistic fuzzy VIKOR method to the personnel selection problem. Abdel-Bassets' et al. (2018) extended VIKOR method with neutrosophic sets and provided a multi-criteria group decision making method, for evaluating e-government websites. Gundogdu et al. (2019) investigate the waste management problem using Spherical Fuzzy VIKOR method. Similarly, Gundogdu and Kahraman (2019) applied the Spherical Fuzzy VIKOR method to the warehouse location selection. Zhang et al. (2016) carried out an inpatient admission assessment using the hesitant fuzzy VIKOR method with linguistic terms at the West China Hospital. Gül et al. (2019) used the Pythagorean fuzzy VIKOR based decision-making approach in the mining industry for security risk assessment. Akram et al. (2019) contributed a novel multiple-attribute group decision-making method which called the trapezoidal bipolar fuzzy VIKOR method. Apart from these studies, Qin et al. (2015) and Wang et al. (2019) purpose a new approach which VIKOR method extended with interval type-2 fuzzy for multi-attribute decision making. Ashraf et al. (2019) evaluated cleaner production in gold mines using novel distance measure method with cubic picture fuzzy numbers. Mahmood et al. (2019) used the concept of spherical fuzzy sets for the solution of decision making and medical diagnosis problems.

Biswas et al. (2021) applied to extend the basic framework of LBWA in the picture fuzzy environment using actual score evaluate of the picture fuzzy numbers. Pramanik et al. (2021) presented a comparative analysis of various MCDM methods under asymmetric conditions with varying selection alternative sets and criteria.

Ashraf et al. (2019) suggested generalized form of weighted geometric aggregation operator for picture fuzzy information. Ali and Mahmood (2020) investigated the generalization dice similarity measures based patterns recognition models with picture hesitant fuzzy information. Pamučar et al. (2021) applied a new logarithm methodology of additive weights (LMAW) for MCDM. Biswas (2020), carry out a comparative analysis of supply chain performances of leading healthcare organizations in India. Biswas et al. (2019) have suggested an ensemble approach based on a two-stage framework for portfolio selection. For this purpose, using DEA for primary selection of the funds. And then they used MABAC approach in the second stage wherein criteria weights have been calculated using the Entropy method.

3. Picture Fuzzy Sets (PFS)

In this section, we give the definition of PFS and summarize picture fuzzy distance measurement, arithmetic operations, score and accuracy functions.

On the basis of Intuitionistic Fuzzy Sets developed by Atanassov (1986), the concept of Picture Fuzzy Sets (PFS) was proposed by Cuong and Kreinovich (2014) to model the complex and uncertain assessments of experts in real decision making problems. Because of the grade of a neutral cannot be discussed in intuitionistic fuzzy set, picture fuzzy sets investigated by Cuong and Kreinovich (2014) which contains positive, abstinence and negative grades (Mahmood & Ali, 2020).

A picture fuzzy set *P*, on a non-empty set *X* is defined as,

$$P=\left\{\langle x,\mu_P\left(x\right),\eta_P\left(x\right),\nu_P\left(x\right)\rangle \mid x\in X\right\} \tag{1}$$

where $\mu_P\left(x\right)$ represents the *positive membership degree* of *P*, the $\eta_P\left(x\right)$ parameter is the *neutral membership degree* of *P* and finally the $\nu_P\left(x\right)$ parameter indicates the *negative membership degree* of *P*. $\mu_P\left(x\right),\eta_P\left(x\right),\nu_P\left(x\right)$ parameters,

$$\begin{aligned}&0\le\mu_P\left(x\right),\eta_P\left(x\right),\nu_P\left(x\right)\le 1,\\&0\le\mu_P\left(x\right)+\eta_P\left(x\right)+\nu_P\left(x\right)\le 1\end{aligned} \tag{2}$$

provides the conditions. All PFS defined in the *X* universe have a fourth parameter called the *degree of refusal membership*, which makes the sum of $\mu_P\left(x\right),\eta_P\left(x\right),\nu_P\left(x\right)$ parameters equal to 1.

$$\pi_P\left(x\right)=1-\mu_P\left(x\right)-\eta_P\left(x\right)-\nu_P\left(x\right) \tag{3}$$

Since PFSs are developed on the basis of classical fuzzy set and intuitionistic fuzzy set theory, the word "Picture" in the title is used to mean "generality" (Jovčić *et al.*, 2020). For $\pi_P\left(x\right)=0$ the picture fuzzy set turns into an intuitionistic fuzzy set; it turns into a classical fuzzy set for $\pi_P\left(x\right),\nu_P\left(x\right)=0$ (Jovčić *et al.*, 2020). For convenience, Picture fuzzy numbers will be represented by $\left(\mu,\eta,\upsilon\right)$ triplet consisting of symbols representing parameters and arithmetic operators will be introduced.

Let $p_1=\left(\mu_1,\eta_1,v_1\right)$ and $p_2=\left(\mu_2,\eta_2,v_2\right)$ be two picture fuzzy numbers. The basic arithmetic operations that can be performed on these two numbers (addition, multiplication, multiplication by constant and exponentiation, respectively) are as follows (Si *et.al*, 2019).

$$p_1\oplus p_2=\left(\mu_1+\mu_2-\mu_1\mu_2,\eta_1\eta_2,v_1v_2\right) \tag{4}$$

$$p_1 \otimes p_2 = \left(\mu_1\mu_2, \eta_1 + \eta_2 - \eta_1\eta_2, v_1 + v_2 - v_1v_2\right) \tag{5}$$

$$\lambda p_1 = \left(1-\left(1-\mu_1\right)^{\lambda}, \left(\eta_1\right)^{\lambda}, \left(v_1\right)^{\lambda}\right),\ \lambda > 0 \tag{6}$$

$$p_1^{\lambda} = \left(\left(\mu_1\right)^{\lambda}, 1-\left(1-\eta_1\right)^{\lambda}, 1-\left(1-v_1\right)^{\lambda}\right),\ \lambda > 0 \tag{7}$$

The score (S) and accuracy (H) functions can be used for comparing two Picture fuzzy numbers (Wang *et.al*, 2017),

$$\begin{aligned} &S(p) = \frac{1}{2}(1+\mu-v), \quad S(p) \in [0,1] \\ &H(p) = \mu+\eta+v, \qquad H(p) \in [0,1] \end{aligned} \tag{8}$$

is calculated with the Equation (8). Picture fuzzy numbers $p_1 = \left(\mu_1, \eta_1, v_1\right)$ and $p_2 = \left(\mu_2, \eta_2, v_2\right)$ are sorted according to the following conditions (Wei, 2018).

$$\begin{aligned} &if\ S(p_1) > S(p_2) \Rightarrow p_1 > p_2 \\ &if\ S(p_1) = S(p_2)\ and\ H(p_1) > H(p_2) \Rightarrow p_1 > p_2 \\ &if\ S(p_1) = S(p_2)\ and\ H(p_1) = H(p_2) \Rightarrow p_1 = p_2 \end{aligned} \tag{9}$$

Distance between $p_1 = \left(\mu_1, \eta_1, v_1\right)$ and $p_2 = \left(\mu_2, \eta_2, v_2\right)$ picture fuzzy numbers (Dutta, 2018),

$$\begin{aligned} d(p_1, p_2) = &\frac{1}{4}\left(\left|\mu_1-\mu_2\right| + \left|\eta_1-\eta_2\right| + \left|v_1-v_2\right| + \left|\pi_1-\pi_2\right|\right) \\ &+\frac{1}{2}\max\left(\left|\mu_1-\mu_2\right|, \left|\eta_1-\eta_2\right|, \left|v_1-v_2\right|, \left|\pi_1-\pi_2\right|\right) \end{aligned} \tag{10}$$

is calculated by Equation (10).

4. Picture Fuzzy VIKOR

The VIKOR method developed by Opricovic (1998), as an MCDM approach which determine a compromise solution which is acceptable for all decision makers and solve a discrete multi-criteria decision problems. In VIKOR method compromise solution takes into account conflict and imponderable criteria Due to its potential benefits in compromise solution based ranking, the VIKOR method has been used in many of areas, singular or hybrid with other MCDM methods and extend with many system theories, in recent years. An extension of VIKOR to determine the compromise solution on uncertain, imprecise and non-commensurable decision process is Picture Fuzzy VIKOR (PF-VIKOR) approach. PF-VIKOR basically uses picture fuzzy numbers (PFNs) to construct the decision matrix and picture arithmetic operators in the decision process.

The principal characteristic of the PF-VIKOR method is that it calculates the separation measures from the fuzzy positive and the fuzzy negative values with the developed picture fuzzy distance operators, and herewith, the best alternative can be determined by the decision maker according to more precise information. The steps of the purposed PF-VIKOR approach are given as follows:

Step 1. Determine of the picture fuzzy (PF) decision matrix.

For the decision problem, *m* alternatives and *n* criteria are determined. The decision matrix is formed by combining the picture fuzzy performance scores of each alternative with $r_{ij} = \left(\mu_{ij}, \eta_{ij}, v_{ij}\right)$ according to each criteria in the *R* matrix.

$$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{11}$$

Step 2. Determination of picture fuzzy positive and negative values

According to each criterion, picture fuzzy positive values which is the best $f_j^*=\left(\mu_j^*,\eta_j^*,v_j^*\right)$ and picture fuzzy negative values which is worst $f_j^-=\left(\mu_j^-,\eta_j^-,v_j^-\right)$ are determined using Equations (12) and (13) according to the optimization direction (benefit or cost) of the criterion. In the equations, J_1 and J_2 represents the set of benefit criteria and cost criteria respectively.

$$f_j^*=\begin{Bmatrix} \max_i r_{ij} \mid j\in J_1 \\ \min_i r_{ij} \mid j\in J_2 \end{Bmatrix},\ j=1,2,\ldots,n \tag{12}$$

$$f_j^-=\begin{Bmatrix} \min_i r_{ij} \mid j\in J_1 \\ \max_i r_{ij} \mid j\in J_2 \end{Bmatrix},\ j=1,2,\ldots,n \tag{13}$$

The *max* and *min* values in the equations are determined according to the conditional statements in Equation (9) by using the PF score function and PF accuracy function are defined in Equation (8).

Step 3. Calculation of normalized picture fuzzy differences

Normalized picture fuzzy differences $\bar{d}_{ij}$ (*i* = 1, 2,..., *m*; *j* = 1, 2,..., *n*) are calculated using Equation (14).

$$\bar{d}_{ij}=\frac{d\left(f_j^*,r_{ij}\right)}{d\left(f_j^*,f_j^-\right)} \tag{14}$$

The $d\left(f_j^*,r_{ij}\right)$ and $d\left(f_j^*,f_j^-\right)$ values in the equation are calculated with the distance formula shown in Equation (10) (Dutta, 2018).

$$\begin{aligned} d\left(f_j^*,r_{ij}\right)=&\frac{1}{4}\left(\left|\mu_j^*-\mu_{ij}\right|+\left|\eta_j^*-\eta_{ij}\right|+\left|v_j^*-v_{ij}\right|+\left|\pi_j^*-\pi_{ij}\right|\right)\\ &+\frac{1}{2}\max\left(\left|\mu_j^*-\mu_{ij}\right|+\left|\eta_j^*-\eta_{ij}\right|+\left|v_j^*-v_{ij}\right|+\left|\pi_j^*-\pi_{ij}\right|\right) \end{aligned} \tag{15}$$

$$\begin{aligned} d\left(f_j^*,f_j^-\right)=&\frac{1}{4}\left(\left|\mu_j^*-\mu_j^-\right|+\left|\eta_j^*-\eta_j^-\right|+\left|v_j^*-v_j^-\right|+\left|\pi_j^*-\pi_j^-\right|\right)\\ &+\frac{1}{2}\max\left(\left|\mu_j^*-\mu_j^-\right|+\left|\eta_j^*-\eta_j^-\right|+\left|v_j^*-v_j^-\right|+\left|\pi_j^*-\pi_j^-\right|\right) \end{aligned} \tag{16}$$

Step 4. Obtaining *S*, *R* and *Q* values

S, *R* and *Q* values are calculated using the following equations, respectively. The *v* and (1-*v*) values in Equation (19) are the degree of importance of the strategy to be determined for maximum group benefit and minimum individual regret, and it is generally accepted as 0.50 in studies (Zhao et. al, 2017).

$$S_i=\sum_{j=1}^{n}w_j^c\bar{d}_{ij} \tag{17}$$

$$R_i=\max_j\left(w_j^c\bar{d}_{ij}\right) \tag{18}$$

$$Q_i = v\frac{S_i - S^*}{S^- - S^*} + (1-v)\frac{R_i - R^*}{R^- - R^*} \quad (19)$$

$$S^* = \min_i S_i$$
$$S^- = \max_i S_i$$
$$R^* = \min_i R_i \quad (20)$$
$$R^- = \max_i R_i$$

Step 5. The rankings of alternatives by the *S*, *R*, and *Q* values

Three separate rankings are obtained by ordering the *S*, *R* and *Q* values of the alternatives from smallest to largest.

Step 6. Propose a compromise solution, the alternative ($A^{(1)}$), which is the best ranked by the measure min *Q* if the *acceptable advantage* and *acceptable stability* conditions are satisfied.

In order for the obtained result to be considered valid, the following two conditions must be met. However, in this case, it is stated that the alternative ($A^{(1)}$) with the minimum *Q* value and in the first place in the ranking is the most ideal alternative.

- *C1. Acceptable advantage*: $Q\left(A^{(2)}\right) - Q\left(A^{(1)}\right) \geq \frac{1}{(m-1)}$
- *C2. Acceptable stability*: The best alternative $A^{(1)}$ must also be in the first order by S or, and R. The compromise solution is stable within a decision-making process, which could be: “voting by majority rule” (when $v > 0.5$ is needed), or “by consensus” $v \approx 0.5$, or “with veto” ($v < 0.5$).

The following compromise solutions can be proposed if one of the C1 and C2 conditions is not satisfied:

Alternatives $A^{(1)}$ and $A^{(2)}$ if only condition C2 is not fulfilled OR Alternatives $A^{(1)}$, $A^{(2)}$,..., $A^{(M)}$ if condition C1 is not fulfilled. $A^{(M)}$ is calculated by using equation $Q\left(A^{(M)}\right) - Q\left(A^{(1)}\right) < \frac{1}{(m-1)}$

5. Application

Turkish Statistics Institute (TUIK) has been conducted the Life Satisfaction Survey (LSS) since 2003. LSS is a key indicator to measure the general happiness perception of citizens, their social value judgments, their general satisfaction in basic living areas and their satisfaction with public services. While LSS was carried out on an urban-rural scale until 2013, since 2014 it was carried out throughout Turkey. As a result of TUIK’s revision -for a homogenous examination- the period of 2014-2019 was selected in this study.

In part of LSS, there are 20 questions based on municipal services that measure citizens’ satisfaction level. Items were scored using 5 points Likert scale, with additional options for “no idea” or “no service”, used as an alternative set in this paper and shown in Table 2.

Table 2. Alternative set for municipal services

A_i	Service alternative	A_i	Service alternative

Ai	Service alternative	Ai	Service alternative
A1	Garbage and environmental cleanliness	A11	Arrangements for the disabled
A2	Drainage	A12	Social aids
A3	Drinking water	A13	Cultural activities
A4	Public transport	A14	Public education centers
A5	Municipal police	A15	Street and road lighting
A6	Road and pavement construction	A16	Cleanliness
A7	Parks and gardens	A17	Fire-fighting
A8	Minimization of noise and air pollution	A18	Graveyard
A9	Health, fitness center facilities	A19	Address information systems
A10	Zoning and city planning	A20	Control of food producing facilities

Before giving application steps, so that make it more easily understandable, the flowchart of the PF-VIKOR method presented in Figure 1.

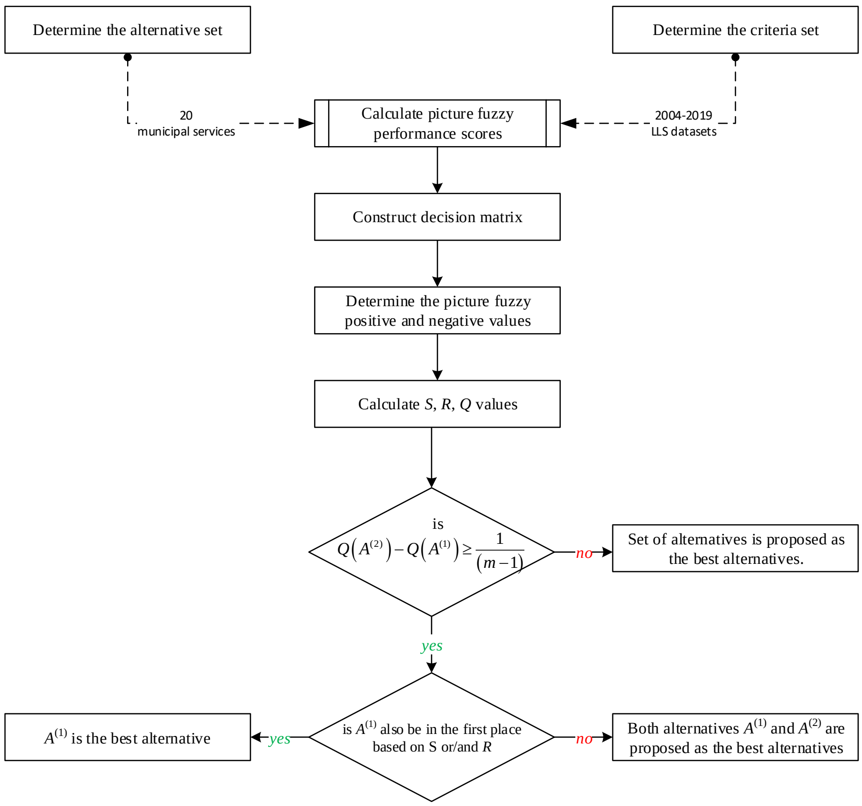

Figure 1. PF-VIKOR methodology for evaluating satisfaction level from municipal services

Step 1. Construct the PF decision matrix.

For analyzing the effect all opinion types on decision process, we construct the decision matrix from PFNs which are calculated from citizens' responses. 5 point Likert options use for calculate PFN's *positive, neutral* and *negative membership degrees* and additional options use for calculate *refusal membership degree*. As an example, the calculation of picture fuzzy performance score of A_1 alternative for year 2019 is shown in Table 3.

Table 3. Calculation of picture fuzzy performance score of A1 service alternative for year 2019

Expressions	Options	Count of response	Total		Membership Degrees
Positive expression	Very satisfied	405	6120	0.70	positive membership degree (μ)
	Satisfied	5715			
Neutral expression	Neutral	1007	1007	0.12	neutral membership degree (η)
Negative expression	Dissatisfied	1149	1476	0.17	negative membership degree (ν)
	Very Dissatisfied	327			
Ineffective expression	No idea	38	92	0.01	refusal membership degree (π)
	No service	54			
	Grand Total		8695	1.00	

After calculating the picture fuzzy performance scores for overall alternative set according all years, the picture fuzzy decision matrix shown in Table 4 was constructed.

Table 4. PFS decision matrix.

	2014	2015	2016	2017	2018	2019
A1	(0.71, 0.08, 0.18, 0.03)	(0.73, 0.10, 0.15, 0.02)	(0.74, 0.09, 0.15, 0.02)	(0.73, 0.09, 0.17, 0.01)	(0.72, 0.10, 0.17, 0.01)	(0.70, 0.12, 0.17, 0.01)
A2	(0.66, 0.08, 0.18, 0.08)	(0.67, 0.09, 0.15, 0.08)	(0.71, 0.08, 0.15, 0.06)	(0.66, 0.09, 0.17, 0.07)	(0.65, 0.10, 0.18, 0.07)	(0.66, 0.10, 0.18, 0.07)
A3	(0.70, 0.08, 0.19, 0.02)	(0.72, 0.10, 0.16, 0.02)	(0.75, 0.08, 0.15, 0.02)	(0.57, 0.11, 0.30, 0.01)	(0.57, 0.12, 0.29, 0.01)	(0.59, 0.12, 0.27, 0.01)
A4	(0.59, 0.09, 0.21, 0.12)	(0.59, 0.11, 0.19, 0.11)	(0.63, 0.09, 0.17, 0.11)	(0.59, 0.11, 0.20, 0.10)	(0.60, 0.12, 0.19, 0.09)	(0.59, 0.13, 0.20, 0.08)
A5	(0.54, 0.09, 0.11, 0.26)	(0.52, 0.09, 0.10, 0.29)	(0.60, 0.08, 0.11, 0.22)	(0.55, 0.09, 0.11, 0.25)	(0.53, 0.11, 0.13, 0.24)	(0.55, 0.11, 0.11, 0.23)
A6	(0.56, 0.10, 0.29, 0.05)	(0.56, 0.12, 0.27, 0.05)	(0.59, 0.11, 0.26, 0.03)	(0.54, 0.12, 0.30, 0.04)	(0.54, 0.12, 0.31, 0.03)	(0.55, 0.14, 0.28, 0.03)
A7	(0.54, 0.10, 0.27, 0.09)	(0.55, 0.12, 0.23, 0.09)	(0.59, 0.10, 0.24, 0.06)	(0.54, 0.12, 0.28, 0.06)	(0.54, 0.13, 0.28, 0.05)	(0.52, 0.14, 0.29, 0.04)
A8	(0.42, 0.09, 0.22, 0.26)	(0.42, 0.12, 0.20, 0.26)	(0.47, 0.09, 0.20, 0.24)	(0.41, 0.12, 0.21, 0.26)	(0.40, 0.13, 0.23, 0.25)	(0.40, 0.13, 0.22, 0.25)
A9	(0.45, 0.09, 0.17, 0.28)	(0.46, 0.11, 0.16, 0.27)	(0.52, 0.10, 0.15, 0.24)	(0.48, 0.11, 0.15, 0.25)	(0.48, 0.13, 0.16, 0.23)	(0.47, 0.12, 0.17, 0.24)
A10	(0.36, 0.08, 0.17, 0.39)	(0.34, 0.09, 0.15, 0.43)	(0.43, 0.08, 0.14, 0.35)	(0.37, 0.09, 0.15, 0.38)	(0.38, 0.11, 0.15, 0.36)	(0.39, 0.10, 0.15, 0.36)
A11	(0.44, 0.09, 0.20, 0.27)	(0.46, 0.10, 0.20, 0.24)	(0.51, 0.09, 0.18, 0.22)	(0.47, 0.11, 0.19, 0.23)	(0.48, 0.12, 0.19, 0.20)	(0.46, 0.12, 0.21, 0.21)
A12	(0.50, 0.09, 0.16, 0.26)	(0.52, 0.10, 0.14, 0.23)	(0.56, 0.09, 0.13, 0.22)	(0.54, 0.11, 0.13, 0.22)	(0.53, 0.11, 0.14, 0.22)	(0.49, 0.12, 0.15, 0.23)
A13	(0.49, 0.10, 0.12, 0.29)	(0.50, 0.11, 0.10, 0.29)	(0.55, 0.10, 0.10, 0.25)	(0.53, 0.11, 0.11, 0.25)	(0.53, 0.12, 0.11, 0.24)	(0.52, 0.13, 0.11, 0.24)
A14	(0.51, 0.07, 0.09, 0.33)	(0.52, 0.08, 0.08, 0.32)	(0.57, 0.08, 0.08, 0.27)	(0.55, 0.09, 0.08, 0.28)	(0.55, 0.10, 0.08, 0.27)	(0.53, 0.10, 0.09, 0.28)
A15	(0.71, 0.10, 0.15, 0.04)	(0.72, 0.11, 0.14, 0.03)	(0.75, 0.09, 0.13, 0.03)	(0.74, 0.10, 0.14, 0.03)	(0.74, 0.10, 0.13, 0.03)	(0.75, 0.11, 0.12, 0.03)
A16	(0.67, 0.11, 0.18, 0.04)	(0.69, 0.12, 0.15, 0.04)	(0.72, 0.10, 0.14, 0.03)	(0.69, 0.12, 0.17, 0.02)	(0.68, 0.13, 0.17, 0.02)	(0.67, 0.14, 0.17, 0.02)
A17	(0.64, 0.07, 0.06, 0.23)	(0.66, 0.08, 0.05, 0.22)	(0.71, 0.06, 0.05, 0.18)	(0.70, 0.06, 0.05, 0.19)	(0.69, 0.07, 0.04, 0.20)	(0.70, 0.07, 0.05, 0.18)
A18	(0.72, 0.06, 0.04, 0.18)	(0.74, 0.05, 0.04, 0.17)	(0.79, 0.05, 0.04, 0.13)	(0.78, 0.05, 0.03, 0.14)	(0.79, 0.05, 0.03, 0.13)	(0.79, 0.05, 0.04, 0.11)
A19	(0.73, 0.08, 0.12, 0.07)	(0.72, 0.09, 0.10, 0.09)	(0.77, 0.08, 0.09, 0.06)	(0.75, 0.08, 0.10, 0.07)	(0.73, 0.10, 0.11, 0.07)	(0.74, 0.09, 0.10, 0.07)
A20	(0.35, 0.08, 0.18, 0.39)	(0.33, 0.09, 0.17, 0.42)	(0.42, 0.08, 0.15, 0.35)	(0.36, 0.10, 0.15, 0.39)	(0.35, 0.11, 0.18, 0.36)	(0.35, 0.10, 0.17, 0.38)

Step 2. Determination of picture fuzzy positive and negative values

Based on Table 4, score and accuracy function values are obtained from Equation (8). All evaluation criteria belong to beneficial criteria set. The fuzzy positive and the fuzzy negative values are determined according to the conditional statements in Equation (9), and listed in Table 5.

Table 5. Picture fuzzy positive and negative values

	2014	2015	2016	2017	2018	2019
f_j^*	(0.72, 0.06, 0.04, 0.18)	(0.74, 0.05, 0.04, 0.17)	(0.79, 0.05, 0.04, 0.13)	(0.78, 0.05, 0.03, 0.14)	(0.79, 0.05, 0.03, 0.13)	(0.79, 0.05, 0.04, 0.11)
f_j^-	(0.35, 0.08, 0.18, 0.39)	(0.33, 0.09, 0.17, 0.42)	(0.47, 0.09, 0.20, 0.24)	(0.41, 0.12, 0.21, 0.26)	(0.40, 0.13, 0.23, 0.25)	(0.35, 0.10, 0.17, 0.38)

Step 3. Calculation of normalized picture fuzzy differences

The normalized picture fuzzy differences calculated by using Equation (14), based on Equations (15-16). Calculated normalized PF difference values are given in Table 6.

Table 6. Calculated normalized PF differences

	2014	2015	2016	2017	2018	2019
A1	0.074	0.064	0.071	0.070	0.070	0.059
A2	0.067	0.055	0.068	0.072	0.074	0.059
A3	0.076	0.063	0.069	0.134	0.125	0.100
A4	0.083	0.074	0.089	0.093	0.089	0.081
A5	0.082	0.088	0.099	0.104	0.109	0.090
A6	0.122	0.106	0.136	0.135	0.131	0.106
A7	0.113	0.094	0.121	0.128	0.124	0.114
A8	0.134	0.129	0.167	0.167	0.167	0.146
A9	0.121	0.113	0.142	0.133	0.133	0.121
A10	0.162	0.162	0.188	0.183	0.172	0.153
A11	0.127	0.115	0.148	0.137	0.131	0.125
A12	0.102	0.088	0.120	0.105	0.109	0.112
A13	0.103	0.098	0.123	0.112	0.108	0.103
A14	0.097	0.091	0.115	0.104	0.103	0.100
A15	0.066	0.060	0.061	0.059	0.053	0.040
A16	0.076	0.065	0.070	0.076	0.076	0.065
A17	0.037	0.034	0.042	0.036	0.043	0.035
A18	0.000	0.000	0.000	0.000	0.000	0.000
A19	0.050	0.038	0.040	0.037	0.042	0.030
A20	0.167	0.167	0.191	0.187	0.186	0.167

Step 4. Obtaining S_i, R_i, and Q_i values

S_i, R_i, and Q_i values calculated based on Equations (17–20), respectively. It was assumed that there was no superiority between the years, so all criteria weights were considered as equal and used equal in Equations (17-18).

Step 5. The rankings of alternatives by the S_i, R_i, and Q_i values

The values of S_i, R_i, and Q_i for each alternative and the ranking of municipality services based on these values are given in Tables 7.

Table 7. S, R and, Q values and municipality services ranking

	S_i	Rank	R_i	Rank	Q_i	Rank
A1	0.406	6	0.074	5	0.384	6
A2	0.396	5	0.074	6	0.380	5

	S_i	Rank	R_i	Rank	Q_i	Rank
A3	0.568	9	0.134	14	0.618	12
A4	0.509	8	0.093	8	0.484	8
A5	0.572	10	0.109	9	0.555	9
A6	0.737	15	0.136	15	0.703	15
A7	0.693	14	0.128	13	0.660	14
A8	0.909	18	0.167	18	0.863	18
A9	0.764	16	0.142	16	0.732	16
A10	1.020	19	0.188	19	0.970	19
A11	0.783	17	0.148	17	0.754	17
A12	0.635	12	0.120	11	0.613	11
A13	0.648	13	0.123	12	0.625	13
A14	0.610	11	0.115	10	0.588	10
A15	0.340	4	0.066	4	0.333	4
A16	0.428	7	0.076	7	0.401	7
A17	0.226	2	0.043	2	0.218	2
A18	0.000	1	0.000	1	0.000	1
A19	0.237	3	0.050	3	0.243	3
A20	1.063	20	0.191	20	1.000	20
S^*	0.000	R^*	0.000			
S^-	1.063	R^-	0.191			

Step 6. Propose a compromise solution

Based on Table 7 and *acceptable advantage* and *stability* conditions, "A18 Graveyard" alternative determined as the most appreciated municipal service. The variations in the ranking patterns with respect to changes in weights of the strategy of the majority of attributes (v values) are exhibited in Table 8.

Table 8. The degree of possibility of each alternative over others depending on the values of v

Municipal	v = 0,25	v = 0,5	v = 0,75
Services	Rank	Rank	Rank
Garbage and environmental cleanliness	6	6	6
Drainage	5	5	5
Drinking water	13	12	10
Public transport	8	8	8
Municipal police	9	9	9
Road and pavement construction	15	15	15
Parks and gardens	14	14	14
Minimization of noise and air pollution	18	18	18
Health, fitness center facilities	16	16	16
Zoning and city planning	19	19	19
Arrangements for the disabled	17	17	17
Social aids	11	11	12
Cultural activities	12	13	13
Public education centers	10	10	11
Street and road lighting	4	4	4

Cleanliness	7	7	7
Fire-fighting	2	2	2
Graveyard	1	1	1
Address information systems	3	3	3
Control of food producing facilities	20	20	20

Based on Table 8 we observe that the PF-VIKOR method is robust and provides rational ranking order. It is clearly seen that the order of the municipal service alternatives in the first and last places has not changed. The rankings contain very minor differences for only a few alternatives depending on the different *v* values.

6. Conclusion and Future Studies

This study introduces an alternative approach for satisfaction level assessment for municipal services and gives a real case study from Turkey for the evaluation of twenty municipality services. We assumed that the ratings of municipality service alternatives on the given attributes are expressed using PFNs. The importance degrees (weights) were assumed to be equally in this case study. Sensitivity analysis is performed over weights of the strategy of the majority of attributes (*v* values), and from the analysis, as a result, it was found that the PF-VIKOR method is robust and provides consistent ranking order. In future research, we would like to proceed in the following facets. First, we can determine the importance degrees' (weights) of years (criteria set) by using a weight assessment model like AHP, ANP, BWM etc., or using these methods with fuzzy extensions. Second, we can target the decision-making environment where picture fuzzy information is captured by interval valued picture fuzzy numbers. Third, an optimization method can develop or other MCDM techniques can be used to determine the importance degrees of criteria objectively.
Evaluation of municipal services is a strategic decision-making problem for municipal administrations. So, the analysis results can be used by local authorities to benchmark municipal service alternatives.
The proposed PF-VIKOR can be applied to solve many other decision making problems specially in different areas of management science with convenient modifications or hybrid usage with other MCDM methods. In future studies, researchers interested in this field can extend this assessment approach by using different systems theories (spherical, intuitionistic, pythagorean, fermatean, q-rung orthopair fuzzy, neutrosophic or rough sets) and, other MCDM techniques and investigate specific municipality services from selected country's perspective.

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