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Research Paper

Evaluation of Smart City Criteria in Ahvaz City, Iran

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Abstract

Preset paper aims to recognize the most important factors in creating a smart city in the city of Ahvaz. For achieving this, all criteria, which play an important role in creating smart cities, were collected using different resources based on descriptive-analytical method. At the next stage, a survey of a number of 40 urban planning experts was accomplished in Ahvaz city, which is the case study of the research, to rank smart city criteria and sub-criteria in terms of importance using Fuzzy TOPSIS technique. The results showed that among six criteria, "smart government" with the score of 4 percent was ranked as the most important criterion and "smart environment" with the score of around 1.5 percent was recognized as the least important criterion in the regard of creating a smart city. Moreover, of the sub-criteria, "Stable economy and ability to transform", "Social and ethnic plurality", "Crisis management and ability to organize human resources", "local and regional accessibility", "Sustainable resource management", and "Individual Safety" were recognized as the most important factors in different aspects of making the city smart.

Keywords: *Smart city, Fuzzy TOPSIS, Criteria, Ahvaz.*

1. INTRODUCTION

With the rapid increase of the urban population worldwide, cities face a variety of risks, concerns, and problems. The unprecedented rate of urban growth creates a necessity to finding smarter ways to manage the accompanying challenges [1]. Nowadays, the large and small districts are proposing a new city model, called "the smart city", which represents a community of average technology size, interconnected and sustainable, comfortable, attractive, and secure. The smart city is a new way of leaving and considering the cities. The optimization of available and new resources, as well as of possible investments is required. The achievement of smart city objective can be reached through the support of various information and communications technologies [2].

This concept has recently been introduced as a strategic device to encompass modern urban production factors in a common framework and, in particular, to highlight the importance of Information and Communication Technologies (ICTs) in the last 20 years for enhancing the competitive profile of a city. Problems associated with urban agglomerations have usually been solved by means of creativity, human capital, cooperation (sometimes bargaining) among relevant stakeholders, and bright scientific ideas: in a nutshell, 'smart' solutions. The label 'smart city' should therefore point to clever solutions allowing modern cities to thrive, through quantitative and qualitative improvement in productivity [3].

Comparing with the other developed countries, Iran have a greater need for using smart system and urbanization, because it faces affluent problems related to traffic, air pollution, and urban economy, and smart system has more efficiency to solve them compared with the other ways [4]. In urban area, electronic cities and municipalities one after another are emerging in Iran and in near future provision of urban services will be completely transformed. Meanwhile, presentation of a proper life style regarding to cultural and social circumstances of the society and proportional with information society, is one of the main programs of electronic and smart governments [5].

Ahvaz city is also attempting to provide smart systems for improving life quality of people, promoting life standards, creating electronic government, and presentation of online services to the citizens in different aspects. Regarding Ahvaz is one of the metropolitan city

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in Iran and its increasing population as well as urban problems such as traffic, air pollution, water pollution, lack of public security, cultural problems, deficiency of services and facilities, and etc. smart solutions and providing smart systems to solve mentioned problems are essential.

Although some measures have been performed for smart-building in Ahvaz such as electronic banking services, electronic payments, electronic purchases, expanding use of credit cards, and applying Intelligent Transport System (ITS) studies and smart traffic systems, it seems that mentioned services are insufficient for creating a smart city and management of programs are not organized and integrated in this regard. Indeed, there are many parameters which create a smart city and whole of them is required. Hence, the present paper aims to evaluate smartness level of Ahvaz city regarding the most important smartness dimensions in order to recognize present deficiencies and promote smartness level of the city using Fuzzy TOPSIS model.

2. THEORETICAL PRINCIPLES OF THE RESEARCH

2.1. Concept of Smart City

20th century has been observing generation of digital and virtual environments distributed via World Wide Web or internet [6]. Actually, the concept of "Smart City" originated in a U.S. information technology company IBM. The CEO Sam Palmisano put forward this concept of smart earth in the roundtable after Obama took office in January 2009. Each technological innovation has brought a new round of stimulus for economic growth. 2010, 15 years after the Internet revolution, accompanied by the information-gathering techniques, communication technology, and information database intelligent, virtual information could be collected and integrated in real time at any place, anytime, anywhere and anyone. This technology concept is known as The Internet of Things (IOT) IBM's smarter planet concept was built on basis of the IOT technology, such as infrared sensors, global positioning systems, laser scanners and other information sensing device [7].

2.2. Definitions of a "Smart City"

The concept of smart communities is based on intelligent infrastructure such as the National Broadband Network, smart grids and other smart infrastructure [8]. There is a lot of confusion over what comprise a smart city. In reality, a true smart city must be all three types of "digital city", "knowledge city", and "eco-city" integrated in a holistic and systematic way [9].The most important definitions presented by different organizations and in different sources were listed as shown in Table 1.

Table 1 The most important definitions of a Smart City from different viewpoints

Row	Definition
1	IFLA: A Smart City provides an advanced ICT infrastructure to enables residents and organizations to make good and independent use of these technologies. To be "smart" the use of technology must be interactive or must lead to a transaction, that is, on-line activity must be more than a passive act [10].
2	Smart cities, by definition, appear to be 'wired cities', although this cannot be the sole defining criterion because progressively smart cities must seriously start with people and the human capital side of the equation, rather than blindly believing that IT itself can automatically transform and improve cities [11].
3	Smart city or electronic city transfers citizens from one-dimension world of traditional and today cities to two-dimension world which is the result of new technologies of information and the world of internet communications [12].
4	Ultimately, Researchers are envisioning "smart cities" in which technologies such as ambient intelligence permeate all aspects of urban life. The idea of ambient intelligence implies an intrinsic link between individuals and their environment, enabling individuals to access and interact with computing artifacts in ways that are intuitive and do not disrupt everyday activities[13].
5	Compared with the concept of digital city or intelligent city [14], smart city is not limited to the role of ICT infrastructure but is mainly on the role of human capital/education, social and relational capital, and environmental issues [15].
6	Simply put, we can define a Smart City, a public administration or authorities that delivers (or aims to) a set of new generation services and infrastructure, based on information and communication technologies [16].

Although the term "Smart City" is not very widely used yet in spatial planning literature or urban research, it is still possible to identify various aspects as a basis for further elaboration. Concluding from literature research the term is not used in a holistic way describing a city with certain attributes, but is used for various aspects which range from Smart City as an IT-district to a Smart City regarding the education (or smartness) of its inhabitants [17].

2.3. Smart City Components

The area of smart cities encompasses a number of different technology-led or -enabled advances, running from the hard infrastructure of smart grids through to a soft infrastructure of community engagement. An open, flexible and scalable architecture is the foundation for planning, designing and building a smart city. To improve the quality

and performance of cities is recommended to involve all interested parties to implement efficiently smart systems. The smart system represents a real support for an urban development which will generate a sustainable development of our cities [18]. 'Smart cities thinking' also addresses the new products, services, protocols, and governance layers enabled by these contemporary ICT, and so the area also addresses organizational and cultural aspects, including the relationship between behavioral change and such approaches [19]. A forward-looking development approach should consider issues as awareness, flexibility, transformability, synergy, individuality, self-decisive, strategic behavior. Especially awareness seems important for a smart city as certain potentials can only be mobilized if inhabitants, companies or the administration are aware of the cities' position – knowing the city from the inside but also being aware of the surroundings and the system of cities the city is located in. Logistics as well as new transport systems as "smart" systems which improve the urban traffic and the inhabitants' mobility. Moreover various other aspects referring to life in a city are mentioned in connection to the term Smart City like security/safe, green, efficient & sustainable, energy etc [16].

Although there is no agreement on the exact definition of a smart city, a number of main dimensions of a smart city have been identified through a literature review [20]. Actually a recent and interesting project conducted by the Centre of Regional Science at the Vienna University of Technology identifies six main 'axes'. These six axes connect with traditional regional and neoclassical theories of urban growth and development. In particular, the axes are based – respectively – on theories of regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of societies in cities [3], and include: smart economy; smart mobility; smart environment; smart people; smart living; and smart governance [15] which have been used in this research to evaluate smartness level of Ahvaz city.

2.4. Information Technology or Human Capital

The most important thing about information technology is not the capacity which it has to create smart cities, but the ability that such communications have to be part of a social, economic and cultural development. That is to say, serve as communications which are smart in the way the deployment of their information technologies allows cities to empower and educate people, allowing them to become members of society capable of engaging in a debate about the environment to which they relate those cities that really want to be smart will have to take much greater risks with technology, devolve power, tackle inequalities and redefine what they mean by smart itself, if they want to retain such a lofty title [11]. In smart cities technical progress is the support for a less consume of resources [18]. Ultimately it is the people, not the hardware and the software, who make IT work and work for the good of the people. The challenge of converting the ignorant or skeptical onlookers to the new technologies is already a major challenge. But an even greater challenge is to put IT in the service of humankind instead of using it for the subversion or the destruction of the values and ways of life people hold dear. As with the nuclear energy, IT can be a force for good or evil. The smart community should be smart enough to make the right choice [21].

2.5. Smart City in Iran

Developing information technology in Iran has been considered by people and authorities to recognize, transfer, absorption, localization, and accompany with the knowledge world. After changing the name of post, telegraph and telephone ministry into communication and information ministry and providing communication and national information strategy plan (self-sufficient plan) and circulars provided by management and planning organization and imparted by governmental agencies on one hand and extensive efforts by the private sector in this regard on the other hand Iranian society moved toward applying information technology. Execution of national projects of electronic business, electronic banking in this regard, and related legislations can provide suitable conditions for developing new economy and creating appropriate culture and reduce significant digital gap of Iran compared with developed countries in this sector. In 2000, electronic cities in Iran was discussed for the first time and subsequently world conference on electronic cities was hold in different areas in which more than 1500 participants including master experts and authorities of Iran were attended [12] It should be believed that the culture of electronic cities in the world and subsequently in Iran is gradually spreading and the authorities' belief is creating in perceiving need to move towards electronic or smart cities. Cities like Kish, Mashhad, Tehran, Esfahan, Bam, Tabriz, Shiraz, Kerman, Yazd, Behshahr, Sirjan, and Arak are also attempting to be electronic city [22].

Problems due to urbanization are becoming increasingly important and require smart solutions especially in the areas that are considered primary. Changes that occur each time and complexity of electronic technology society that uses a new type of electronic communication devices have resulted in continued growth in the volume, diversity and service activities carried out in any field [18].

3. CASE STUDY

Ahvaz as one of the largest cities of Iran and the center of Khuzestan province has located in the west of Iran and in 31 degrees and 20 minutes of north latitude and 48 degrees and 40 minutes of east longitude. This city has a population of 1,338,126 and area with 220 square kilometers. It also includes eight municipality districts [23]. Figure 1 shows geographical position of the city in Khuzestan province and Iran.

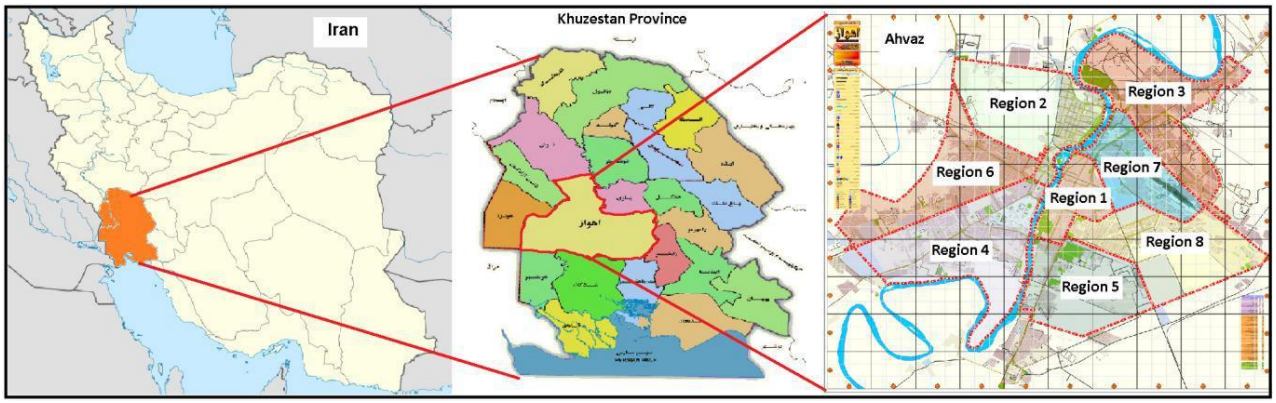


Fig. 1 Geographical position of Ahvaz city in Khuzestan province and Iran

4. METHODOLOGY

This paper has been accomplished based on descriptive-analytical method. In order to collect descriptive data, reference library resources were used on the research subject. In addition, a survey containing a number of 40 city and urban planning experts of Ahvaz municipalities was performed to collect analytical and case-study data. In this research, in order to evaluate and rank smartness level in Ahvaz city, Fuzzy TOPSIS technique was applied. All indicators in evaluating urban smartness have been presented in detail as follows (Table 2):

Table 2 Indicators studied in evaluating smartness of the Tehran metropolitan

level 1	level 2
criteria	Sub-criteria
smart economy	Innovation
	Economic images and logos or trademark in the City
	Entrepreneurship
	Flexibility of labor markets
	Stable economy and ability to transform
	Unemployment rate and false economy
smart people	Interest rate of long-life learning
	Social and ethnic plurality
	Cosmopolitan growth (Open-minding)
	Participation in Public Life
Smart government	Considering public participation in decision-making
	Ability of providing public services
	Crisis management and ability to organize human resources
Smart mobility	Innovation rate and sustainability of transport system
	Availability of smart transport equipment (ex. GIS and etc.)
	local and regional accessibility
	National and international accessibility
	Safe transport system
Smart Environment	Attractiveness of natural environment
	Public institutes for protecting environment
	The amount of emissions
	Sustainable resource management
Smart Living	Cultural and Social Facilities
	Health conditions
	Individual Safety
	Housing quality and accessibility
	Educational Facilities
	Touristic Attraction
	social Cohesion

5. DISCUSSION

1- Mathematical and functional structure of this technique in the present research is as follows:

Fuzzy TOPSIS model was first presented by Chen & Hwang to make decision on "n" criterion and "m" option. This model contains several stages to analyze data [24]. The first step is creating decision matrix, which has been shown as in equation (1).

$$\tilde{A} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \quad (1)$$

In this technique, if triangular fuzzy numbers are used for analyzing data, the performance will be as $\tilde{x}_{ij}\ (a_{ij}\ , b_{ij}\ , c_{ij})$.

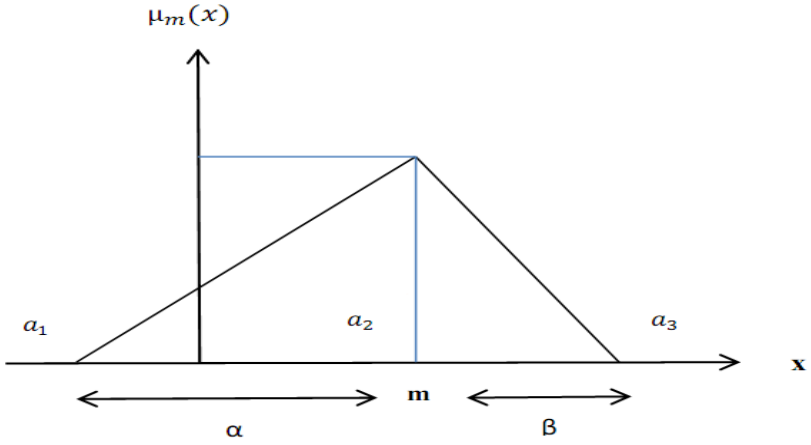


Fig. 2 Membership function of fuzzy numbers in fuzzy environment

Meanwhile, in order to classify research indicators in the research technique framework, fuzzy verbal variables have been used in the form of triangular numbers as shown in the Table 3:

Table 3 Verbal variables for analyzing importance of research indicators (Source: [24])

Fuzzy number	ID	Importance of indicator
(1,1,3)	VP	Very Poor
(1,3,5)	P	Poor
(3,5,7)	M	Medium
(5,7,9)	G	Good
(7,9,9)	VG	Very Good

In the second step, weight matrix of criteria is defined as specified in equation (2).

$$w_{j1} = min_k\{w_{jk1}\} w_{j2} = \frac{\sum_{k=1}^{k} w_{jk2}}{k} w_{j3} = max_k\{c_{jk1}\} \quad (1)$$

The third step is normalization of fuzzy decision matrix in which following equations are used:

$$\tilde{r}_{ij} = \left[\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right] \tilde{r}_{ij} = \left[\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{c_{ij}}\right] \quad (1)$$

In these equations $c_j^* = max_i\ c_{ij}$ and $a_j^- = min_i\ a_{ij}$. Normalized fuzzy matrix $(\tilde{R})$ would be as follows regarding the above equations:

$$\tilde{R} = \tilde{r}_{ij})_{m\times n} \text{ I=1, 2..., m} \quad (4)$$

At the next stage, of the studied criteria positive and negative aspects of criteria are calculated. In this model, following equations have been used to calculated values given:

$$\begin{aligned} &\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_{ij} = \left\{\frac{a_{ij}}{c_i^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right\}.(w_{j1}, w_{j2}, w_{j3}) = \\ &\left\{\frac{a_{ij}}{c_j^*}.w_{i1}\ \frac{b_{ij}}{c_j^*}.w_{i2}\ \frac{c_{ij}}{c_j^*}.w_{i3}\right\} \\ &\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_{ij} = \left\{\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right\}.(w_{j1}, w_{j2}, w_{j3}) = \\ &\left\{\frac{a_j^-}{c_{ij}}.w_{i1}\ \frac{a_j^-}{b_j^*}.w_{i2}\ \frac{a_j^-}{a_{ij}}.w_{i3}\right\} \end{aligned} \quad (1)$$

The fifth step in this model is to calculate Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS). These states are calculated using following equations:

$$\begin{aligned} A^+ &= [\tilde{v}_1^*, \tilde{v}_2^*, \dots \tilde{v}_n^*] \\ A^- &= [\tilde{v}_1^-, \tilde{v}_2^-, \dots \tilde{v}_n^-] \end{aligned} \quad (6)$$

In these equations, $\tilde{v}_i^*$ is the best amount of criteria and $\tilde{v}_i^-$ is the worst amount of criteria.

The next step contains calculation of distance of positive and negative ideal which are calculated respectively using the following equations:

$$\begin{aligned} S_i^* &= \sum_{j=1}^{n} d = (\tilde{v}_{ij}\ , v_j^*) \\ S_i^- &= \sum_{j=1}^{n} d = (\tilde{v}_{ij}, v_j^-) \end{aligned} \quad (7)$$

The last step in this model is calculation of the similarity index which is obtained through following equation:

$$cc_i = \frac{S_i^-}{S_i^* + S_i^-} \quad (8)$$

6. RESEARCH FINDINGS

A number of 40 urban planning experts were asked to weigh the research criteria and variables in a range of five scales from very poor to very good. In the table below, a sample of primary weights to the criteria and variables has been demonstrated (Table 4).

Table 4[1] An example of primary weights to the number of 6 criteria evaluated by experts

Indicator	$\mathbf{DM_1}$	$\mathbf{DM_2}$	$\mathbf{DM_3}$	$\mathbf{DM_4}$	$\mathbf{DM_5}$...
Smart Economy (A)	G	G	M	VG	VG
Smart People (B)	M	G	G	G	VG
Smart Government (C)	G	M	VG	VG	M
Smart Mobility (D)	VG	VG	G	G	G
Smart Environment (E)	G	G	VG	P	G
Smart Living (F)	G	VG	VG	G	G

Table 5 A sample of primary weights to the research variables by the experts

Sub indicator	$\boldsymbol{DM_1}$	$\boldsymbol{DM_2}$	$\boldsymbol{DM_3}$	$\boldsymbol{DM_4}$	$\boldsymbol{DM_5}$...
A_1	P	P	M	G	G
A_2	P	G	VG	M	G
A_3	G	VG	G	VG	VG
A_4	VG	G	M	M	G
A_5	G	G	VG	G	G
A_6	P	G	G	VG	M

After converting weights evaluated by experts into fuzzy triangular numbers, normalization and weighted standard matrix were calculated for the number of 6 criteria and 29 variables according to table 1. In the following table, a sample of weighted and normalized matrix for the number of 6 criteria has been shown.

Table 6 A sample of weighted and normalized matrix for the research criteria

Indicator	$\boldsymbol{DM_1}$	$\boldsymbol{DM_2}$	$\boldsymbol{DM_3}$	$\boldsymbol{DM_4}$	$\boldsymbol{DM_5}$....
A	0.29, 0.35, 0.53	0.21,0.45,0.67	0.11, 0.34, 0.5	0.27, 0.45, 0.69	0.23, 0.46,0.7
B	0.11, 0.32, 0.61	0.07, 0.23,0.52	0.12, 0.41,0.67	0.08,0.39,0.61	0.21, 0.43, 0.7
C	0.23,0.46,0.72	0.22, 0.39,0.51	0.28, 0.44,0.42	0.3,0.54,0.77	0.19, 0.36,0.61
D	0.25,0.46,0.73	0.09,0.33,0.43	0.13,0.36,0.59	0.09,0.34,0.5	0.12,0.41,0.62
E	0.08,0.3,0.57	0.14,0.29,0.4	0.16,0.38,0.56	0.08,0.22,0.38	0.23,0.44,0.6
F	0.18,0.35,0.54	0.16,0.37,0.52	0.08,0.3,0.44	0.17,0.46,0.7	0.11,0.33,0.53

Research findings

In the next step, (FPIS, A^+) and (FNIS, A^-) were calculated. In this section, the amount of both FPIS and FNIS for the research criteria has been presented as an example.

A^+=[(0.74,0.74,0.74)(0.71,0.71,0.71)(0.9,0.9,0.9)(0.84, 0.84,0.85)(0.62,0.62,0.62)(0.84,0.84,0.84)]

A^-=[(0.1,0.1,0.1)(0.08,0.08,0.08)(0.19,0.19,0.19)(0.14, 0.14,0.14)(0.06,0.06,0.06)(0.14,0.14,0.14)]

After calculating FPIS and FNIS, distance of indicators and variables from positive ideal solution (S^+) and negative ideal solution (S^-) and thereby similarity index (cc_i) were calculated as shown in the tables 7 and 8.

Table 7 Calculation of positive ideal solution and negative ideal solution, similarity index, and ultimate ranks of the research indicators

Indicator	$\mathbf{S^+}$	$\mathbf{S^-}$	$\mathbf{CC_i}$	Ranking
A	7.1	2.32	0.246	4
B	7.72	2.05	0.209	5
C	5.33	3.56	0.400	1
D	6.28	3.02	0.324	2
E	8.46	1.78	0.173	6
F	6.31	2.95	0.318	3

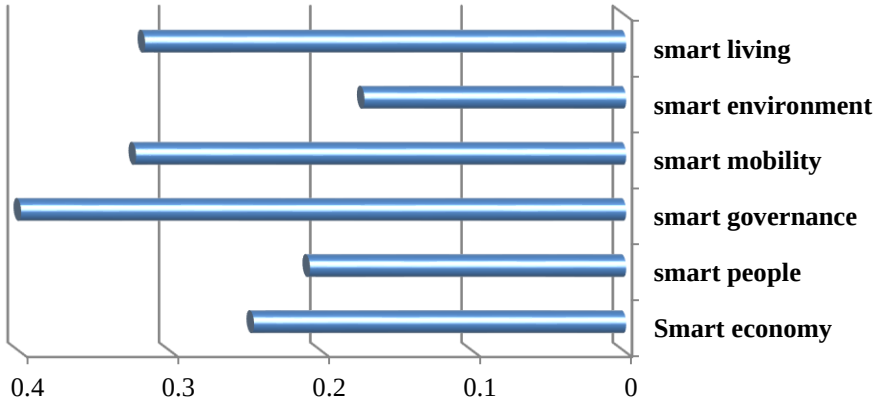
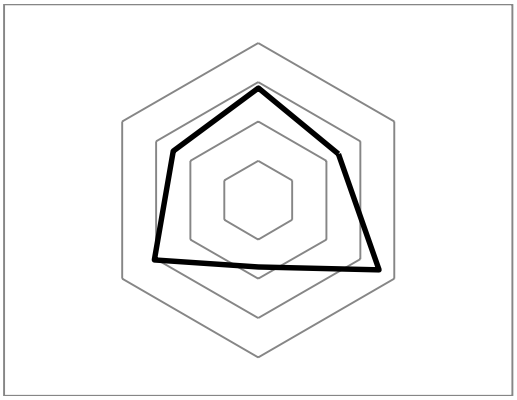


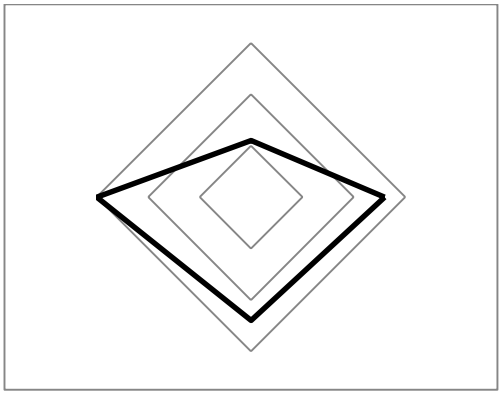
Fig. 3 weight and priority of smart city indicators

Final analysis of values to the criteria and indicators evaluated by the experts using Fuzzy TOPSIS model showed that "smart government" with the score of 4 percent has been ranked as the most important criterion and "smart environment" with the score of around 1.5 percent has been recognized as the least important criterion in the regard of achieving smart city. In addition, of the sub-criteria, "Stable economy and ability to transform" in smart economy dimension, "Social and ethnic plurality" in smart people dimension, "Crisis management and ability to organize human resources" in smart government dimension, "local and regional accessibility" in smart mobility dimension, "Sustainable resource management" in smart environment dimension, and "Individual Safety" in smart living dimension have been recognized as the most important factors in different aspects of making the city smart (see Table 8 and Fig. 4).

Table 8 Calculation of positive and negative ideal solution, similarity index, and final rank of the research variables

Sub criteria	S^+	S^-	CC_i	Ranking	Sub criteria	S^+	S^-	CC_i	Ranking	Sub criteria	S^+	S^-	CC_i	Ranking
A_1	4.56	6.78	0.597	12	C_1	4.56	7.03	0.606	8	E_3	4.15	6.12	0.595	**14**
A_2	4.21	6.06	0.590	16	C_2	5.00	7.8	0.609	7	E_4	3.17	6.09	0.657	**1**
A_3	4.13	6.23	0.601	9	C_3	4.06	7.06	0.634	2	F_1	3.37	5.01	0.597	**12**
A_4	4.1	5.54	0.574	22	D_1	3.99	4.89	0.550	25	F_2	4.23	5.67	0.572	**23**
A_5	5.65	8.9	0.611	6	D_2	4.01	5.65	0.584	19	F_3	3.24	5.4	0.625	**4**
A_6	4.89	6.97	0.587	17	D_3	4.11	6.92	0.627	3	F_4	4.56	6.81	0.598	**11**
B_1	4.18	5.8	0.581	20	D_4	5.12	7.14	0.582	18	F_5	3.14	5.01	0.614	**5**
B_2	4.33	6.5	0.600	10	D_5	5.29	7.2	0.576	21	F_6	5.04	7.11	0.585	**18**
B_3	5.19	7.61	0.594	15	E_1	4.13	6.23	0.601	9	F_7	4.7	6.11	0.565	**24**
B_4	4.05	5.99	0.596	13	E_2	4.33	6.9	0.614	5					





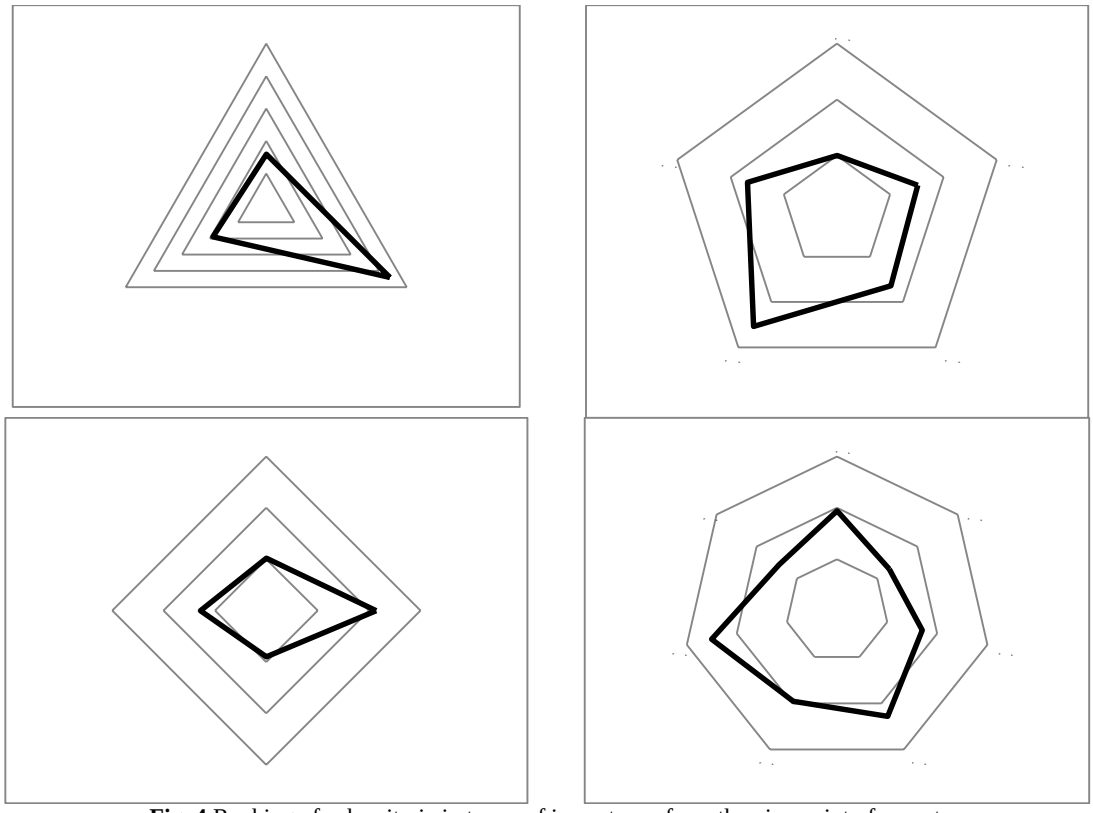


Fig. 4 Ranking of sub-criteria in terms of importance from the viewpoint of experts

7. CONCLUSION

According to the results obtained, smart government has been considered as an important factor in creating smartness in Ahvaz city. An appropriate governance and urban management contains several essential dimensions. One of the most important dimensions of smart government is encouraging public participation in different aspects of the society. Indeed, public awareness, consultation, public involvement and participation in urban issues, as well as public empowerment are essential tools to achieve a proper urban management. In addition, of the smart city sub-criteria, "Stable economy and ability to transform", "Social and ethnic plurality", "Crisis management and ability to organize human resources", which is one of the dimensions of Smart Government, "local and regional accessibility", "Sustainable resource management", and "Individual Safety" were also recognized as the most important components in making the city smart.

Smart city is a smart way to handle large-scale urbanization and to manage complexity, increase efficiency, reduce expenses, and improve quality of life. It also is considered as a key factor in achieving sustainability in the cities. One important point is that smartness in a city would not be created, unless all dimensions in creating a city smart are considered.

NOTE

1. DM stands for Decision Making

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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