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ORIGINAL PAPER

Utilization multi attribute decision making models for spatial prioritization and environmental decision making in new towns

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Abstract This study was conducted to determine some important factors of site selection for Esfahan 4th new town-Iran, with quantification of importance index for each factor and the effect of selected criteria in determination of the prioritized location for urban development. The study followed an explanatory analytical method based on field studies, analytical hierarchy process and technique for order preference by similarity to ideal solution model. This means that after defining the criteria and the significant parameters using Delphi technique and filling out the questionnaires by experts in environmental sciences and urban constructions, the rate of effectiveness of each factor and also the significant criteria in site priority and environmental decision making for new towns were determined by analytical hierarchy process model and "Expert choice" software. The results revealed that among the main defined criteria (i.e. physical, biological, economical-social, political and pollution dispersion) and sub-criteria selected by the experts for location of Esfahan 4th new town, the physical criteria with a weight of 0.453 designated nearly 45 % of the importance index to itself, standing at the first priority. Accordingly, the economical-social and pollution dispersion criteria were ranked at the second and the third place with weights of 0.307 and 0.116, respectively. The technique for order preference by similarity to ideal solution model, which is one of the methods for multi-criteria decision making, was then used to determine the best location scenario. Comparing the three proposed locations, alternative 1 was found to be more suitable as it was well-fitted to the defined criteria.

Keywords AHP · Esfahan 4th new town-Iran · Site selection · TOPSIS

Introduction

Following the occurrence of environmental, economic and social issues in metropolises and the decline in the quality of life due to heavy concentration of population and activities thereof, construction of new towns was considered to decentralize the population of metropolises. Urbanization has always been faced with issues as urban development, unemployment, migration, traffic, shortage of dwelling, marginal settlement, unprecedented population growth, land use and destruction of land, pollution of air, water and soil, rise in noises, etc. (Michell 1989). Therefore, the development of new towns has been considered as a remedy both throughout the world and Iran, to cope with the overflow of population which has, in turn, resulted in many consequences (Atash and Beheshtiha 1998). With respect to the governmental policies to control the rapid growth of metropolises, to attract and employ a part of their population and to soften the social, cultural and psychological issues resulting from the rapid population growth, construction of new towns was considered as an important issue (Hall 1992). This idea was first introduced in England during the late eighteenth century by construction of a new town, namely "Lech worth". This town was the fruit of the idea of a "garden city" with

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primary urban facilities (Galany and Wiley 1978). In Iran, the history of development of new town dates back to the beginning of the twentieth century when the consequences of the industrial revolution began to emerge and the new discoveries made immense changes in human life (Ziari 2006). Historically, the ability to develop a new town reflects the fact that the human societies have always been able to find new solutions to their problems (Madanipour 2005). The purpose of constructing new towns could be regarded as neutralization of the overflow of cities' population, reduction in economic activities within the metropolis, regional development, utilization of natural resources and optimum distribution of population, since the concept of new towns has been a direct response to "Mega polis" or overconcentration of population and economic activities within megacities (Eddie and Manfred 2005). Nowadays, the trend adopted in developing new towns is one of the important issues in urban planning and management, though it is always faced with many obstacles (Javadian et al. 2011). Analysis of performance of new towns shows that the main challenges as well as lack of success of new towns in Iran are attributed to:

1. Modeling based on foreign patterns which are not compatible with domestic establishment of new towns.
2. Having no specific position in hierarchical system of urban network.
3. Improper positioning of new towns.
4. Low-income people tend to reside in new towns.
5. Lack of efficient transportation system between mother city and new town.
6. Failure in accurate prediction of population.
7. Aggregation of traffic and air pollution as a result of increased density (Atash and Beheshtiha 1998; Ziari 2006).

Urban issues have a continuous relation with each other and in case of lack of proper attention to any of them other problems are bound to appear. The environmental issues in different scales are a result of incompatibility of the criteria used for site selection of new towns (Michell 1989).

Proper site selection is one of the key elements in development of new towns and its consequences shall be revealed in the long run (Onut et al. 2010). Allocating the proper significance to site selection of new towns with respect to their natural and environmental capabilities is of utmost importance, since if the natural environmental foundations of lands are not properly studied, new towns can face with secondary problems in their construction and development in future (Karimi et al. 2011). Proper site selection shall bear social and cultural effects on the region and, in addition, the economic effects on the operation of the establishments. Protection of the environmental specifications can be called as one of the establishments, which is the key element in site selection operations (Gordon et al. 2009). Land use programming is regarded as an intelligent space management to optimize the human activity distribution pattern, also regarded as site selection of the environmental spaces (Razavian 2002). Selection of a specific site from the existing choices is a function of exact evaluation of each district using proper tools and models and known factors providing the best opportunity for optimum site selection (Malczewski and Rinner 2005). Since decision making is regarded as a selection procedure between the existing choices, assumptions, sites, etc., the decision making supporting system can definitely strengthen the decision making process (Hansen 2005; Nouri et al. 2011). That is why multi-criteria decision making models during the site selection operation are well defined tools which support decision making with respect to the complex technologic, economic, environmental and social issues (Saaty 1980; Saaty and Vargas 1991). The most important challenges for the management of unified land use are:

1. Lack of developing the inventory of capacity building programs (CBP).
2. Privation of analysis, and evaluation of the past and present land use policies and planning practices, particularly through strategic environmental assessment techniques.
3. Unavailability of innovative planning tools, such as geographic information system, land market assessment and new zoning techniques, in contrast with conventional/indigenous planning tools (Taleai et al. 2008)

Hence double-comparisons for weighting the criteria within the multi-criteria evaluations shall lead to designation of sites with lowest environmental, economic and social problems (Marinoni 2004). The hierarchical analysis process for solving non-structural issues during different decision making operations is applicable in all issues from simple private decisions to complex economic and planning decision (Alkhalil 2002). The important issues in hierarchical analysis process are stability, compatibility and the time spent for decision making when there are a large number of alternative choices (Mamat and Daniel 2007). Generally, the hierarchal analysis is a process which can merely rank the alternatives as per their weights without differentiating between acceptable and unacceptable choices (Ghazinoory et al. 2007). There are a variety of forms and depths for deciding on the basis of specifications of each alternative. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which was first proposed by Hwang and Yoon (1981), is one of the multi-criteria decision making processes that enjoys the capability of evaluating each alternative on the basis of qualitative and quantitative criteria with relative speed and ease. The main purpose of such studies is making use of multi-criteria models in application of environmental issues in site selection of new towns. Therefore, a combined algorithm of TOPSIS and hierarchical analysis is proposed. The first step is to use Delphi technique to determine the significant criteria and sub-criteria in site selection of new towns. The second step is application of analytical hierarchy process (AHP) model through “Expert choice” (EC) software to rank the priority of the criteria. The third step involves the application of TOPSIS model and the ranked criteria by AHP to select the scenarios with respect to the environmental, economic and social parameters.

Materials and methods

To select the best site scenario for urban development and environmental assessment of the area under study, objectives were determined along with the boundaries of the area through the first phase of defining the scope of the study. The main objective of this study was to use the combined TOPSIS and AHP algorithms to define, evaluate and rank the criteria to be used for proper site selection of Esfahan 4th new town with the lowest environmental impacts and the highest economic and social justifications. Scope of the study, falling within latitude of 32°9′ to 33°2′N and longitude of 51°6′ to 52°1′E, covers an area of 31,000 acres of Esfahan province, including Borkhar, Meymeh and Ardestan cities. This area is hydrologically a part of Borkhar and Sagzi mountain sides of the great Zayandehrood River. Figure 1 illustrates borders of the study area in Esfahan province.

At the second phase, determination of the natural foundations and the status quo of the environmental issues were performed. Through the third phase, Delphi technique was used to extract the major criteria and the indicators related to the environmental and urban development. The most commonly used model in urban planning has been elaborated in Table 1.

The questionnaire forms were also filled up by the experts aiming at quantification of the selected criteria. Details of Esfahan 4th new town’s nature have been given in Table 2.

At the fourth phase, the drawing of tree diagram of the selected criteria and the weights of the major and sub-criteria were analyzed and processed by EC software. Since the hierarchical analysis process is based on three factors including model structure, criteria judgment and conclusion of priorities, the EC software was used to rank the priority of the combined major and sub-criteria of the environmental development issues (Dagdviren et al. 2009). Figure 2 shows the preference of factors and the criteria for double-comparison.

The important point in double (couple) comparison matrices is the rate of their incompatibility. This rate is in fact a mechanism used to evaluate the credibility of the experts’ answers with comparison matrices (Sharma and Bhagwat 2007). The random index can be extracted from Table 3 with respect to the number of the criteria.

The incompatibility rate is obtained by dividing the two indices into each other as below:

$$\text{Incompatibility index I.I.} = \frac{\lambda_{\text{Max}} - n}{n - 1} \tag{1}$$

$$\text{Incompatibility rate I.R.} = \frac{\text{I.I}}{\text{R.I}} \tag{2}$$

If this index is less than or equal to 0.1, then the compatibility of the decisions will be acceptable. Accordingly, the TOPSIS model can be used to rank the proposed alternatives. This means that, first the decision matrix must be quantified, usually by bi-polar comparison technique. However, this is not the case in this study since all indices are already quantified. To delete the discrepancy of different units of different indices and to allow for possibility of algebraic calculations, it is necessary to change the data of the decision matrix into standard form. This applies to where the elements of the decision making matrix lose their scales as shown by relation 3:

$$j = 1, 2, \ldots, n \left(r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \right) \tag{3}$$

Then, a weighted scale-less matrix is formed. Depending on the type of criteria and its influence on decision making (selection of the optimum site), the highest weights are allocated to the positively influencing indices and the lowest ones to the negatively influencing indices to achieve the following relations:

$$\begin{aligned} A^+ &= \{\vartheta_1^+, \vartheta_2^+, \ldots, \vartheta_n^+\} \\ &= \left\{ \left(\max_i \vartheta_{ij} | j \in j^+ \right), \left(\min_i \vartheta_{ij} | j \in j^- \right) | i = 1, 2, \ldots, m \right\} \end{aligned} \tag{4}$$

$$\begin{aligned} A^- &= \{\vartheta_1^-, \vartheta_2^-, \ldots, \vartheta_n^-\} \\ &= \left\{ \left(\min_i \vartheta_{ij} | j \in j^+ \right), \left(\max_i \vartheta_{ij} | j \in j^- \right) | i = 1, 2, \ldots, m \right\} \end{aligned} \tag{5}$$

Relation 6 shows the calculation of Euclid’s distance of each alternative from positive and negative foci of the indices:

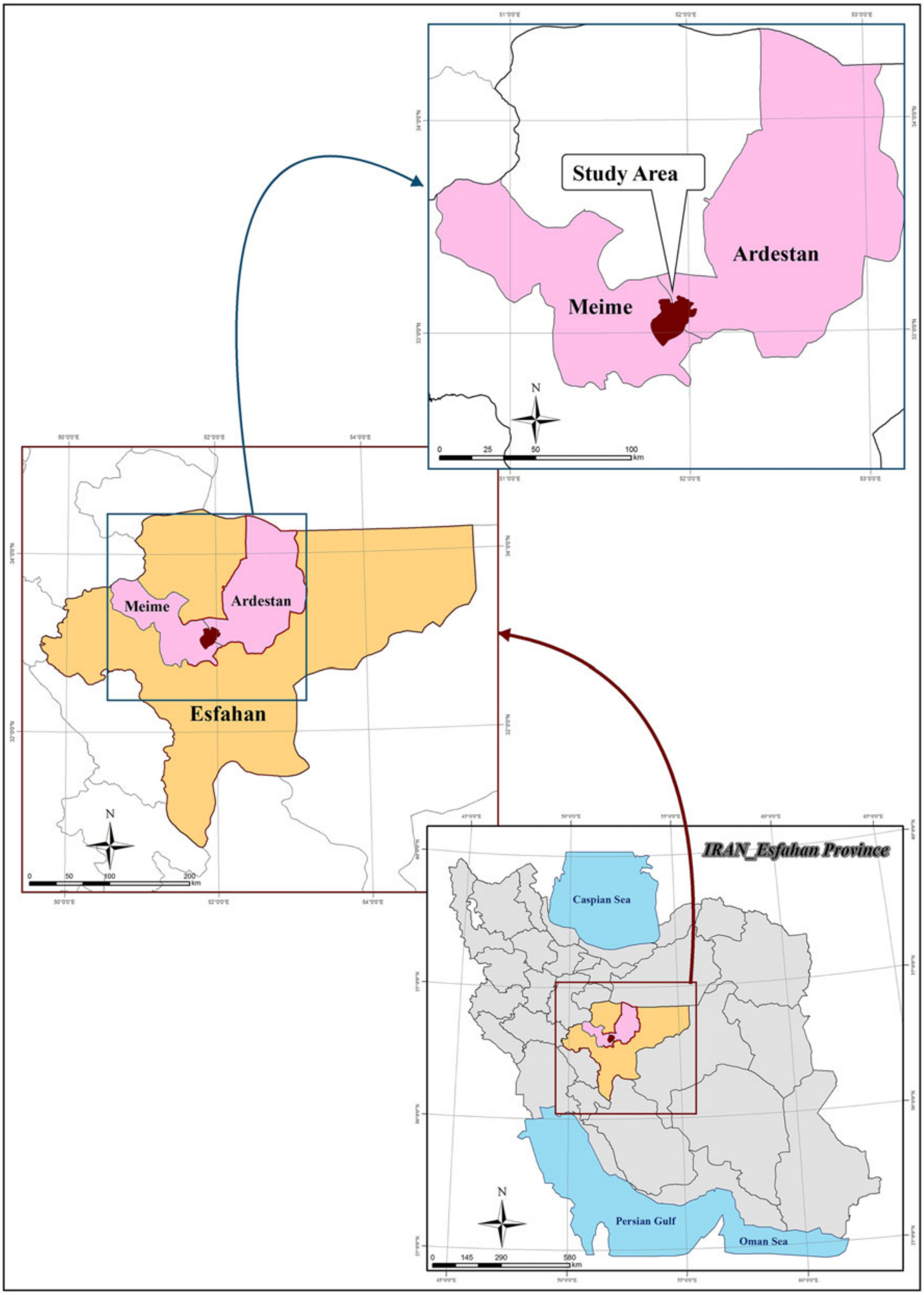

Fig. 1 Site location of Esfahan 4th new town

Table 1 Comparison of location models in urban planning

No.	Features and advantages	Model
1	Gravity model	Using Newton's gravity model using mathematical models, e.g., action and interaction between regions, cities and neighborhoods to portray, and to express to apply the concepts
2	Lory model	Lowry model, as economic activities in urban space and land on the other side of the organization
3	Accessibility model	In urban and regional planning, interaction between phenomena, a variety of facilities and access to the land and how the model is investigated
4	Boolin logic model	In this method, first the selection criteria and the criteria upon which the entire area units (the value of one or true) or inconsistent (value nil or false) are divided. Next, using logical functions such as NOT, OR, AND layers are combined
5	Geographic Information Systems model	Capabilities of Geographic Information System in management and analysis of spatial data, which leads to efficient analysis of the link between information systems and spatial decision making methods
6	Multi Attribute Decision Making model	This method involves a series of techniques including analysis of the convergence of the total weight or that allow a range of topics related criteria and weighted scoring and ranking by experts and interest groups

Table 2 Details of nature and socioeconomic of Esfahan 4th new town

No.	Parameter	Result
	Nature	
1	Temperature	15 < C°
2	The average annual rainfall	128.5 mm
3	Wind speed	4.02 m/s
4	Dominant wind direction	W–SW
5	Climate class based in Dumarten method	Dry
6	Status of surface water and groundwater resources	Parts of Esfahan-Borkhar and Kohpayeh-Segzi aquifer
7	Water regimes were in 2008–2009	603.9 million m3
8	Altitude	1,600–2,100 m
9	Slope	0–25 %
10	Geology and geomorphology	Limestone and shale, conglomerate and sandstone of Miocene
11	Pedology and land capability	Type plateau and upper terraces, hills, plains and alluvial fan
	Socioeconomic	
12	Population growth during 1996–2006	221,017–2,797,778 persons
13	Special economic centers (including industrial and agricultural centers)	More than 7,000 workshop units/diversified industrial activities, and more than 50 % agriculture activities

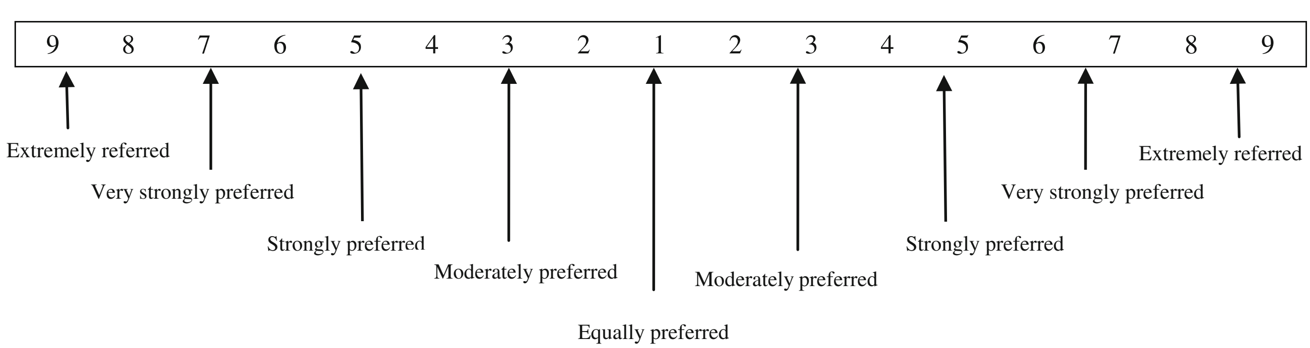

Fig. 2 Scale and relative importance of weights of criteria in respect to each other (Innes and Pascoe 2010)

Table 3 Random index for the criteria used in the decision making process (Sharma and Bhagwat 2007)

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

$$D_i^- = \sqrt{\sum_{j=1}^{n}\left(\vartheta_{ij} - \vartheta_j^-\right)^{2 \to i=1,2,\ldots,m}}$$
$$D_i^+ = \sqrt{\sum_{j=1}^{n}\left(\vartheta_{ij} - \vartheta_j^+\right)^{2 \to i=1,2,\ldots,m}}, \quad (6)$$

where J^+ and J^- refer to the index of positive and negative criteria for selection of the proper site. After determination of positive and negative distances for each alternative and calculation of relative distances, ranking of the priorities of site scenarios was performed. Consequently, the alternative having the longest distance, as compared to other alternatives, was ranked as the highest. Referring to relation 7, if the numerator is substituted by D_i^+, the alternative with the shortest relative distance shall be ranked as the highest (Stewart 1997).

$$\mathrm{CL}_i = \frac{D_i^-}{D_i^- + D_i^+} \to i = 1, 2, \ldots, m, \quad 0 \le \mathrm{CL}_i \le 1 \quad (7)$$

In this study, the selected criteria by the experts have first been processed using the EC software and then they were ranked. Consequently, using the TOPSIS model, the three proposed sites were analyzed, and finally the best scenario was determined.

Results and discussion

After collecting the data and summing up the opinions of experts about the environment and development using Delphi technique, the main fine criteria were defined as physical, biologic, economic-social, political and pollution dispersion, whereas each of which had their own sub-criteria. The hierarchical tree, the main dimensions and the selected sub-criteria regarding the site selection procedure are illustrated in Fig. 3.

The data derived from the major fine criteria for site selection of Esfahan 4th new town were then processed by EC software. The combined couple comparison matrix is shown in Table 4.

Considering the relative weights of the sub-criteria in relation with each major criterion, the couple comparison matrix of the experts was calculated on the basis of geometrical average, since in this method, the first step is to calculate the geometric average of each line of the

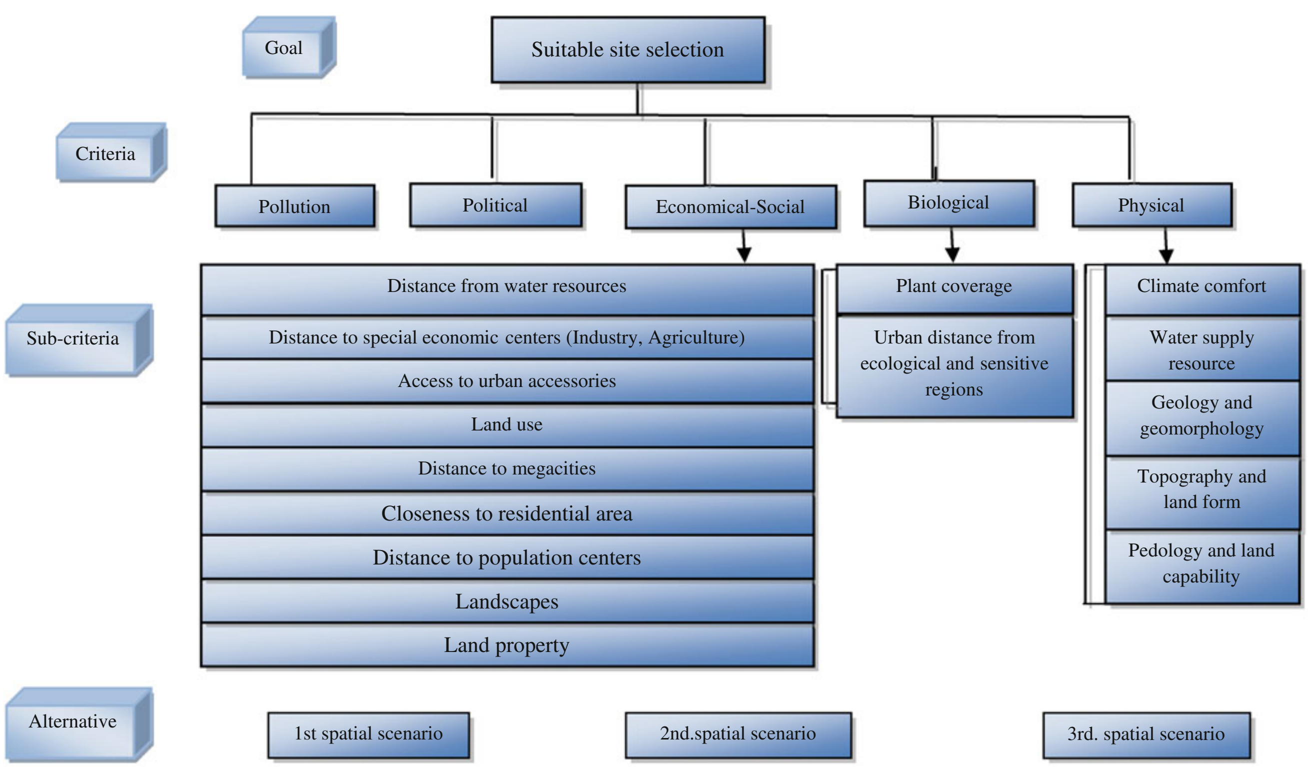

Fig. 3 The hierarchical structure of site selection for Esfahan 4th new town

Table 4 Couple comparison matrix of site selection of Esfahan 4th new town

No.	Main criteria	Pollution	Political	Economical-Social	Biological	Physical
1	Physical	3.90	5.70	2.60	5.30	1.00
2	Biological	0.36	0.77	0.31	1.00	
3	Economic-social	4.70	6.40	1.00		
4	Political	0.45	1.00			
5	Pollution	1.00				

Table 5 Couple comparison matrix of the physical sub-criteria of site selection for Esfahan 4th new town

No.	Physical sub-criteria	Index type	F1	F2	F3	F4	F5
1	Climate comfort	F1	1.00	3.70	2.90	3.20	1.50
2	Water supply resource	F2		1.00	0.71	0.56	0.45
3	Geology and geomorphology	F3			1.00	3.60	2.50
4	Topography and land from	F4				1.00	0.77
5	Pedology and land capability	F5					1.00

Table 6 Couple comparison matrix of the biological sub-criteria of site selection for Esfahan 4th new town

No.	Biological sub-criteria	Index type	B1	B2
1	Plant coverage	B1	1	1.26
2	Urban distance from ecological and sensitive regions	B2		1

matrix. Then, a column matrix was obtained by dividing the weights of each vector into the sum of the existing vectors, so that the matrix is normalized. The new column matrix was in fact the weight matrix of the defined indices in the site selection procedure for Esfahan 4th new town. To process the weights derived from the sub-criteria of site selection for Esfahan 4th new town, the extracted data were fed to the software separately. Tables 5, 6 and 7 show the couple comparison matrices of the sub-criteria for the main physical, biological and economic-social dimensions.

$$\begin{bmatrix} a_{11} & \cdot & \cdot & a_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ a_{n1} & \cdot & \cdot & a_{nn} \end{bmatrix} \xrightarrow{1} \begin{bmatrix} \sqrt[n]{a_{11}\cdots a_{1n}} \\ \cdot \\ \cdot \\ \sqrt[n]{a_{11}\cdots a_{1n}} \end{bmatrix} = \begin{bmatrix} \pi_1 \\ \cdot \\ \cdot \\ \pi_2 \end{bmatrix} \xrightarrow{2} \begin{bmatrix} \frac{\pi_1}{\sum_{i=1}^{1} \pi_i} \\ \cdot \\ \frac{\pi_1}{\sum_{i=1}^{1} \pi_i} \end{bmatrix} = \begin{bmatrix} w_1 \\ \cdot \\ \cdot \\ w_n \end{bmatrix} \tag{8}$$

After extracting and ranking the suitable criteria for site selection of Esfahan 4th new town, the fundamental maps and environmental status quo of the site were used to propose a suitable site for development. The perceived suitable site scenarios are as following.

Alternative site 1 for construction of Esfahan 4th new town

This alternative covers an area of 3,500 acres next to the Denbi and Jahan Abad villages in the study area. The area is located between latitudes of 32°58′ to 33°10′N and longitude of 51°44′ to 51°48′E at an approximate distance of 20 km from Esfahan city.

Alternative site 2 for construction of Esfahan 4th new town

This alternative covers an area of 3000 acres next to Margh and Aliabad villages. The area is located between latitude of 33°20′ to 33°32′N and longitude of 51°48′ to 51°52′E at an approximate distance of 33 km from Esfahan city.

Alternative site 3 for construction of Esfahan 4th new town

This alternative covers an area of 2,450 acres next to Shour Abadand village. The area is located between latitude of 33°35′ to 33°42′N and longitude of 51°53′ to 51°59′E at an approximate distance of 39 km from Esfahan city. Figure 4 shows the location of all three alternatives.

The criteria ranked at the preceding phase were used to rank the proposed sites. Due to the abundance of criteria and sub-criteria, a sieving scheme has been adapted to select the important factors in site selection. Using the experts' opinions and the results from the obtained graphs for the previous phase, ten important parameters were selected as: climate comfort, water supply resource, geology and

Table 7 Couple comparison matrix of economical-social sub-criteria of site selection for Esfahan 4th new town

No.	Economical-social sub-criteria	Index type	ES1	ES2	ES3	ES4	ES5	ES6	ES7	ES8	ES9
1	Distance from water resources	ES1	1.00	3.8	2.5	2.6	0.32	3.2	2.5	5.2	6.2
2	Distance to special economic centers (industry, agriculture)	ES2		1.00	0.27	2.4	4.3	0.62	0.45	0.41	0.26
3	Access to urban accessories	ES3			1.00	0.23	0.5	2.7	3.3	3.7	4.5
4	Land use	ES4				1.00	0.19	1.5	3.7	1.4	0.5
5	Distance to megacities	ES5					1.00	3.4	4.6	5.8	4.2
6	Closeness to residential area	ES6						1.00	1.7	3.2	0.5
7	Distance to population centers	ES7							1.00	2.3	1.4
8	Landscapes	ES8								1.00	0.76
9	Land property	ES9									1.00

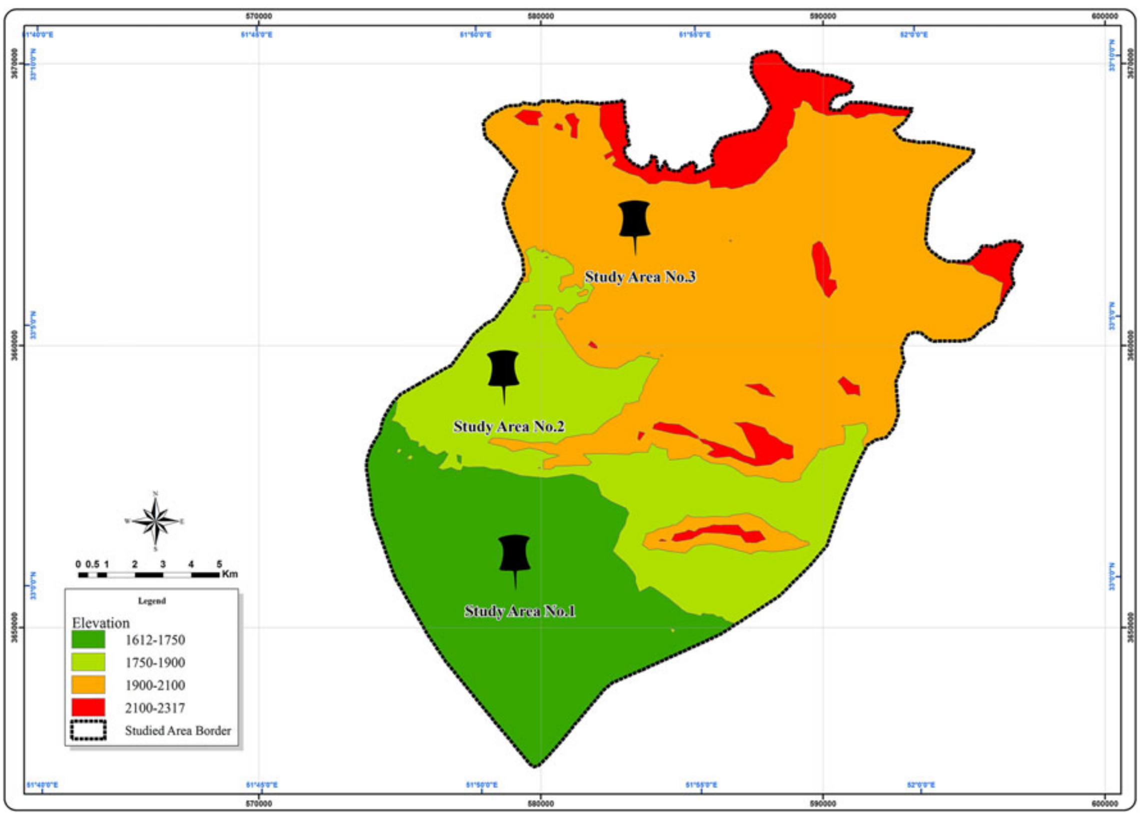

Fig. 4 Site selection map of various scenarios for Esfahan 4th new town

geomorphology, topography and land form, pedology and land capability, urban distance from ecological and sensitive regions, land use, distance to mega cities, and access to urban accessories, and landscapes. Table 8 shows the weights of all determined indices. The assessment valve due to the weight of each index from the lowest to the highest was found to be within 1–9. Table 9 shows Euclid's distance from each positive and negative focus relevant to the weighted indices, respectively. The effect of each index tabulated in the table is ranked as below:

Ideal positive The higher the increase in desirable indices, the higher the suitability of the site for 4th new town.

Ideal negative The higher the increase in undesirable indices, the lower the suitability of the site for 4th new town.

After the analysis of the couple comparisons and evaluation of the main selection dimensions, the incompatibility rate was calculated by EC software for macro criteria and ranked as shown in Fig. 5.

Table 8 Decision making matrix of combined weights of the selected indices for site selection of Esfahan 4th new town

No.	Index	Index type	Weight of study area no. 1 (λj)	Weight of study area no. 2 (λj)	Weight of study area no. 3 (λj)
X1	Climate comfort	+	5.3	6.5	7.5
X2	Water supply resource	–	3.9	4.7	6.3
X3	Geology and geomorphology	+	5.9	4.4	9.2
X4	Topography and land form	+	5.5	8.5	8.7
X5	Pedology and land capability	+	5.8	6.5	8.1
X6	Urban distance to ecological and sensitive regions	+	5.8	6.9	7.2
X7	Land use	+	7.2	7.8	6.9
X8	Distance to megacities	–	5.7	6.3	7.8
X9	Access to urban accessories	+	6.3	6.7	6.3
X10	Landscapes	+	7.8	7.2	6.5

The results of data analysis indicate that the physical index with relative weight of 0.453 has the highest importance. Therefore, it has also the highest influence on site selection of Esfahan 4th new town compared to other environmental, regional and urban planning dimensions. The second rank belongs to the macro economical-social criteria with relative weight of 0.307. The incompatibility rate of couple comparisons was found to be 0.06 and being less than 0.1, the compatibility of the comparisons was acceptable. The results obtained from processing of the physical index sub-criteria reveal that the climate comfort with a weight of 0.383 has the highest importance and can be, therefore, ranked as the best priority. Accordingly, the sub-criteria for geology and geomorphology with weight of 0.247 were ranked the second and sub-criteria of pedology and land capability with weight of 0.163 were ranked the third. The incompatibility rate of couple comparisons was found to be 0.08. Figure 6 shows ranking of the physical sub-criteria.

The couple comparison analysis of the two biological sub-criteria and the incompatibility rate were calculated by EC software as shown and ranked in Fig. 7.

The experts came to the conclusion that the main criteria of urban distance from ecological and sensitive regions with a weight of 0.722 had the highest importance and, therefore, ranked at the top. The main criteria for Plant coverage with a weight of 0.278 were ranked the second. From the sub-criteria of economic-social dimension, distance from the megacities with a weight of 0.280 was ranked the first, distance from water resources with a weight of 0.206 was ranked the second and

Table 9 Relative distance of each alternative from ideal positive and negative foci in ranking of site scenarios for Esfahan 4th town

Weighting the criteria	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
$A^+ = \{\vartheta_1^+, \vartheta_2^+, \ldots, \vartheta_n^+\}$	0.012	0.059	0.081	0.027	0.261	0.065	0.043	0.117	0.040	0.1495
$A^- = \{\vartheta_1^-, \vartheta_2^-, \ldots, \vartheta_n^-\}$	0.010	0.055	0.110	0.024	0.210	0.046	0.027	0.056	0.025	0.105

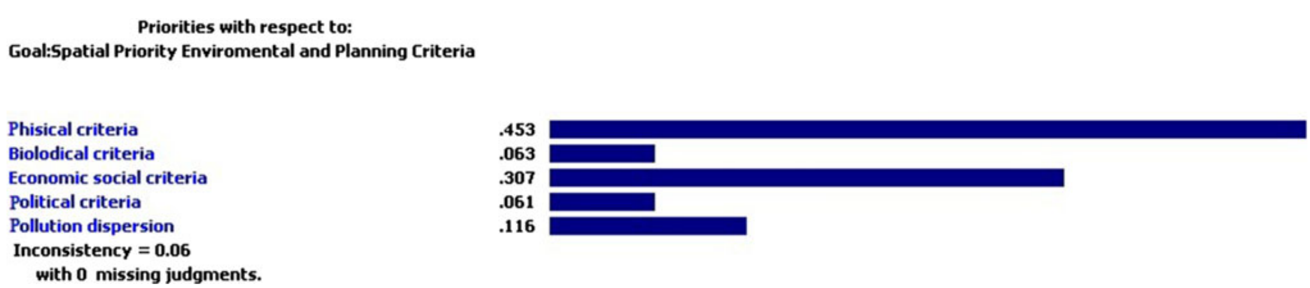

Fig. 5 Ranking and importance of selected dimensions for site selection of Esfahan 4th new town

Fig. 6 Ranking of the physical sub-criteria

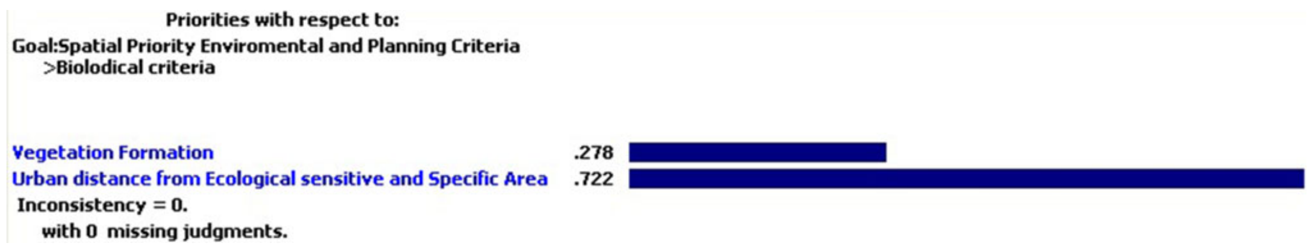

Fig. 7 Ranking of main biological criteria

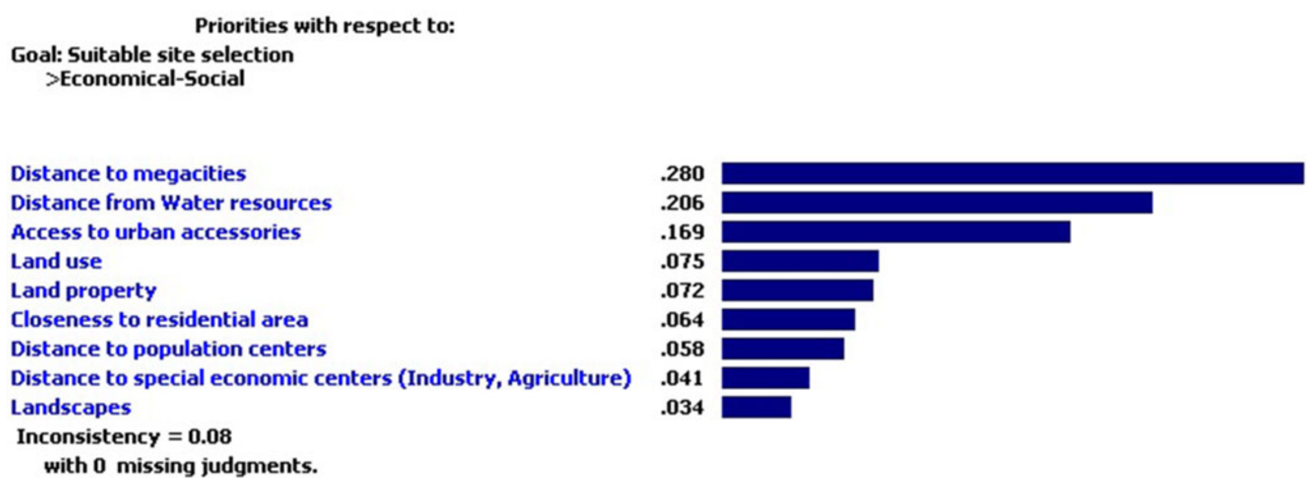

Fig. 8 Ranking of main economic-social criteria by EC software

Table 10 Ranking of site scenarios by TOPSIS

Alternative	D^-	D^+	$D^+ + D^-$	CL	Priority
Study area no. 1	0.095	0.30	0.125	0.759	1
Study area no. 2	0.054	0.067	0.121	0.444	2
Study area no. 3	0.035	0.084	0.119	0.296	3

D^+ Euclid's distance of each alternative to ideal positive, D^- distance of each alternative to idea negative, *CL* relative distance of each alternative to ideal solution

landscaping with a weight of 0.034 is ranked the third. The incompatibility rate of couple comparisons was found to be 0.08 and being less than 0.10, the comparisons were acceptable. Figure 8 illustrates the ranking of economic-social criteria.

Considering the 10 research criteria, 3 alternatives and also results from TOPSIS, site alternatives 1, 2 and 3 with importance weights of 0.759, 0.444 and 0.296 ranked at the first, the second and the third place, respectively

(Table 10). In overall, the alternative which has the longest relative distance stands in the highest rank.

Conclusion

The results from TOPSIS model and its combination with environmental and urban development indices, and ranking of site selections imply that alternative 1 has a better condition considering water resource, thereby a higher capability. Moreover, by assessing the study area maps, the land slope in alternative 1 found to be 5 %. Considering the fact that the most suitable slope for urban construction falls within 0–6 % and height of alternative 1's area is 1,600–1,800 m, it can be concluded that alternative 1 is more justifiable as compared to other two alternatives. This area also enjoys a safer position against potential earthquakes considering its underground plateau. The area is approximately 25 km away from metropolis which is also justifiable. However, it receives less point in light of suitable landscape shortcoming. The land use in this area is mainly graded in the range that is known to be suitable for urban development. The soil in this area comprises a mixture of lime, shale, conglomerate, stone and sand exhibiting suitable resistance to urban development. In this scenario, the distance from sensitive ecological and specific areas is very appropriate and justifiable. Therefore, considering the weights of the selected criteria and their combination in TOPSIS model, alternative 1 can be proposed as the best site since it enjoys more environmental, economic and social justifications.

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