The Foresight of Infrastructural Development of the City of Ardabil with the Integrating Approach of Scenario Planning and the Analytical Models of SOWT and QSPM

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Abstract

The main aims of the present research are to determine the possible scenario of infrastructural development in the city of Ardabil and develop effective strategies according to the integration of the results of using Delphi method through SWOT and QSPM analyses. Scenario planning is the main tool applied to the research. First, according to the 6 steps of scenario planning, the method of selecting the respondents of Delphi questionnaire and their combination as well as entering the data into MicMac software were operated and by forming the SWOT matrix, the strengths, weaknesses, opportunities, and threats of suggested scenarios were ranked and prioritized. In the final step, different strategies were studied through the quantitative strategic planning matrix (QPSM) and the best strategy was selected. Finally, 7176 mixed scenarios were extracted, which included all the possible future situations ahead of the urban development foresight of Ardabil. Among these, 22 scenarios were highly compatible, 7012 were poorly compatible, and 142 scenarios were incompatible. The final results indicate that 5 scenarios are more possible in the urban development of Ardabil. Of the 5 strong scenarios, 3 scenarios are more possible to occur in the future urban development in the city of Ardabil. Among these 3, two scenarios are of favorable and ideal conditions and one scenario has a relatively favorable and interstitial state. The suggested scenarios in this paper indicate that the city of Ardabil has different possible situations to achieve the urban development in infrastructural terms. Best scenarios to achieve the favorable goals are strong ones which are more possible to occur. Among the large number of scenarios in the present paper, 5 strong scenarios were selected that 3 of them have presented optimistic situations and 2 scenarios have forecast pessimistic situations. Since pursuing the aim in this research is based on a positive attitude, positive strategies have been presented to achieve optimistic scenarios.

Key-words: Development of Infrastructural Affairs, City of Ardabil, Foresight, Scenario Planning, QSPM, SWOT.

1. Introduction

Nowadays the speed of changes is so high that traditional methods cannot deal with them. Thus, newborn knowledge attempts to monitor factors affecting the future changes and prepare the society for encountering them. Therefore, studying the future is one of the most crucial sciences required by any phenomenon (Abedi Jafari, Salmani & Radmand, 2010). Cities especially large cities and metropolitan areas are of highly significant role and performance in the present era and it can be stated that the latest technology usually emerges from large cities. In 1900, only 10 percent of the world's population were living in cities, while in 2007, the urban world's population grew by 50% and it is estimated that by 2050, it will grow by 75%, i.e. more than 7 billion people will live in cities (UNIDO, 2005). On the other hand, lack of infrastructural facilities and services needed for urban life and lack of coordination between the development of aforementioned and the growing development of large cities in recent decades are considerable. Moreover, urban planners and decision-makers have realized that current approaches are not sufficient to meet the needs of citizens. Thus, new ways and acting and thinking creatively about the future are required. At the beginning of the third millennium, the science of foresight has transformed the incoherent literature on future planning into coherent science with compelling principles, which is responsible for analyzing the past and present procedures as well as discovering and assessing possible and favorable futures.

Foresight is a modern paradigm with the aim of dealing with unpredictable, complicated, and uncertain issues through long-term planning. Regarding the effect of rapid changes on raising new urban issues, the emergence of surprising discontinuity in the age of information and communication, and the rapid globalization of revolutions and communications, it is absolutely necessary to change the fundamental attitude toward the procedures of urban planning and develop urban development plans based on ignoring prediction and replacing foresight in decision-making. Although applying "foresight" to urban development planning dates from 1960s in the West, since 1990s, following the evolution of strategic planning in urban development, various methods have been devised for planning the future of cities based on present demands (Abbasi Shahkooh, Soltani Delgosha, Vahedian & Abdollahi, 2008). Foresight at a higher level of prediction provides managers and planners with identifying the needs of cities with respect to the future situation and needs and developing ways to achieve these goals.

2. Problem Statement

In the recent decade, the world's population growth, especially in urban areas, as a significant phenomenon has created many problems with urban development planning. In traditional methods of planning, first, planners pose the question 'what will happen in the long-term future?' and predict, then they make decisions and adopt policies on the basis of their predictions; in other words, they begin with the present, move toward the future, and develop specific methods for development through studying the past and present (Pashang & Mobini Dehkordi, 2008). At the present time developing foresight methods in the urban planning is significant and it is expanding as an independent discipline under the title of "foresight-based planning in urban studies". As mentioned before, future prediction methods are various, based on different assumptions, and useful for various goals. However, there are still people presenting the simplest foresight by analyzing the past and present on the assumption that the past and future events are the same. On the contrary, there are people who provide a detailed description of the future by considering all the relevant variables, interrelations, and the possible effects of components on one another. In the present research, it is believed that relying on the past procedures and analyzing the present situation cannot solve the present and future problems and the solution for meeting the future needs is to apply foresight-based methods (Zali, 2011). Throughout the history of Iran, urban planning thinking has suffered various vicissitudes, from budget allocation planning for short-term periods to formulating annual and five-year plans and preparing the country for the next 20 years. Meanwhile, planning thinking has been transformed from traditional perspective into strategic planning and finally strategic thinking. In traditional planning, it was heavily relied on the analysis of the past data and in future planning, the same procedures and tendencies were pursued as well, while today, planning thinking is more significant than the past and present and it is not necessarily the continuation of the past procedures (zali, 2011).

Nowadays, understanding the features of the space through exploring the system and its relations as well as the structure of spatial system has obliged researchers to apply quantitative models and methods to determining the legality and adapting it to the space. Scenario planning or planning based on scenarios is one of these models, which has many applications in strategic planning and foresight (Zali, 2011). Scenario is a description of possible and multiple events, which are likely to occur and through which, it can be seriously thought about the future and what must be done. The aim of applying scenarios is to create a space full of possibilities, within which the

effectiveness of adopted policies toward the future challenges is tested. Scenarios also help to identify potential but unexpected challenges and opportunities (Abedi Jafari et al., 2010).

Scenario planning, as one of the foresight methods, originates from cinema and theater. Scenarios in foresight are defined as observing the future from a special perspective that their story is logically compatible. They are stories, pictures, or models of the emergence of the future. Scenario planning is a regular and disciplined method used to discover key driving forces in the context of rapid changes of the environment, great complexities, and several uncertainties. This method is useful for understanding the surrounding environment, thinking about the alternative futures, and strategic decision-making (Alizadeh, Nazemi & Vahidi Motlaq, 2008). Therefore, scenario planning is a method of enhancing decision-making about the possible future; unlike some of the methods of foresight, scenario planning does not claim to predict the future accurately. This method uses the information and facts of different sciences to develop a number of logical and coherent stories about the future. In other words, scenario planning is the explanation of alternative futures (Alizadeh et al., 2008). In developing scenarios, three kinds of future are evaluated: possible future, plausible future, and probable future.

Possible futures include all possible situations that may happen in the future. These futures are a set of pictures that human considers for their future; moreover, they are mainly imaginary and derived from the human mind's imagination. They are also beyond the today's knowledge.

Plausible futures include cases that may happen in the future according to the present knowledge, and unlike possible future that are contrary to human's present knowledge and principles, these are based on these principles. Plausible futures are the subset of possible futures.

Probable futures refer to futures that are likely to happen. They are the subset of plausible futures. In scenario planning of the future, the combination of possible, plausible, and probable futures is illustrated as the preferable future (Lindgren & Bandhold, 2003).

In the present paper, it is attempted to formulate the scenarios of the city of Ardabil through foresight with the emphasis on infrastructural development and determine the favorable scenarios of urban development based on the modern planning perspective through the integrative approach to scenario planning and the analytical model of SWOT according to the future changes.

3. Research Methodology

A broad set of methods is used in foresight. The number of methods applied to foresight in various resources is different and between 30 and 50. They are divided into two groups of qualitative

and quantitative. Quantitative methods are based on numbers and the most common ones are as follows: temporal series, simulation models, and scenario planning models. Qualitative methods are based on qualitative views and judgments and contain some sort of a perspective on the future; foresight is operated with regard to this perspective. These methods are based on the principle that the expert's viewpoint is the most reliable resource. Some of the most important methods includes: brainstorming, SWOT method, Delphi method, scenario planning, road mapping, and key technologies. According to Bonabeau (2002), in agent-based modeling, the system is modeled as a set of independent decision-making identities named agents. In agent-based modeling, the system includes agents created by the computer and interacting with one another in accordance with special behavioral rules (Gordon, 2009). In utility theory, a wise decision-maker selects an alternative product, policy, or action with the highest adaptability to success from their viewpoint. Delphi method is two- or multiple-round measurement that in the second round, the results of the first round are available to the participants, so that they can amend their initial evaluations or add something to their previous viewpoints. It is considered as an advantage that when experts realize their mistakes through convincing reasons they can revise their viewpoints without destroying their reputation (UNIDO, 2005).

Cross impact matrix analysis was suggested by Theodore Gordon and Olaf Helmer in 1966. The steps of this method include: initial discovery, probability-generation, integration, and using MICMAC software to calculate the matrix. In MICMAC software, first the important variables and components of the desired field are identified, then they are entered into cross impact matrix and their interrelations are studied by the experts. The variables in rows affect the variables in columns; thus, the former is affecting and the latter is affected (Godet, 2008). There are four numbers to measure the interrelations: zero means there is no effect, one refers to small effect, two indicates moderate effect, and three refers to large effect. If the number of identified variables is equal to n, a n×n matrix is calculated, which indicates the effects of variables on one another. This matrix can be illustrated through its correspondent diagram; in this diagram, the direction of each group's affecting is shown through arrows and the degree of affecting is shown by a number at the top of arrows. Finally, whether the variables are affecting or affected, the software can rank and extract the key factors (Godet, Durance & Gerber 2008). The way factors are dispersed in the diagram indicates that whether the system is stable or unstable. This initial realization of the state of the system affects the way factors are analyzed. In stable systems, the dispersion of factors is shown as L; i.e. some factors are highly affecting and some are highly affected. Thus, in stable systems, there are three groups of affecting, affected, and independent factors. However, unstable systems are more complicated than

stable systems. In these systems, factors are dispersed around the diagonal axis of the vector and throughout the page and in most cases, they have an interstitial state. Analyzing these systems is more complicated than stable systems, since they include more factors. These factors are divided into five groups: 1) determining or affecting factors, 2) two-dimensional factors which have two subsets of risk and target factors, 3) affected factors or the result of the system, 4) independent factors which are divided into discrete and secondary leverage factors, and 5) regulatory factors. MICMAC software is devised to implement and analyze this matrix (Godet et al., 2008).

Figure 1 - The Steps of Research Methodology (Resource: Author, 2020)
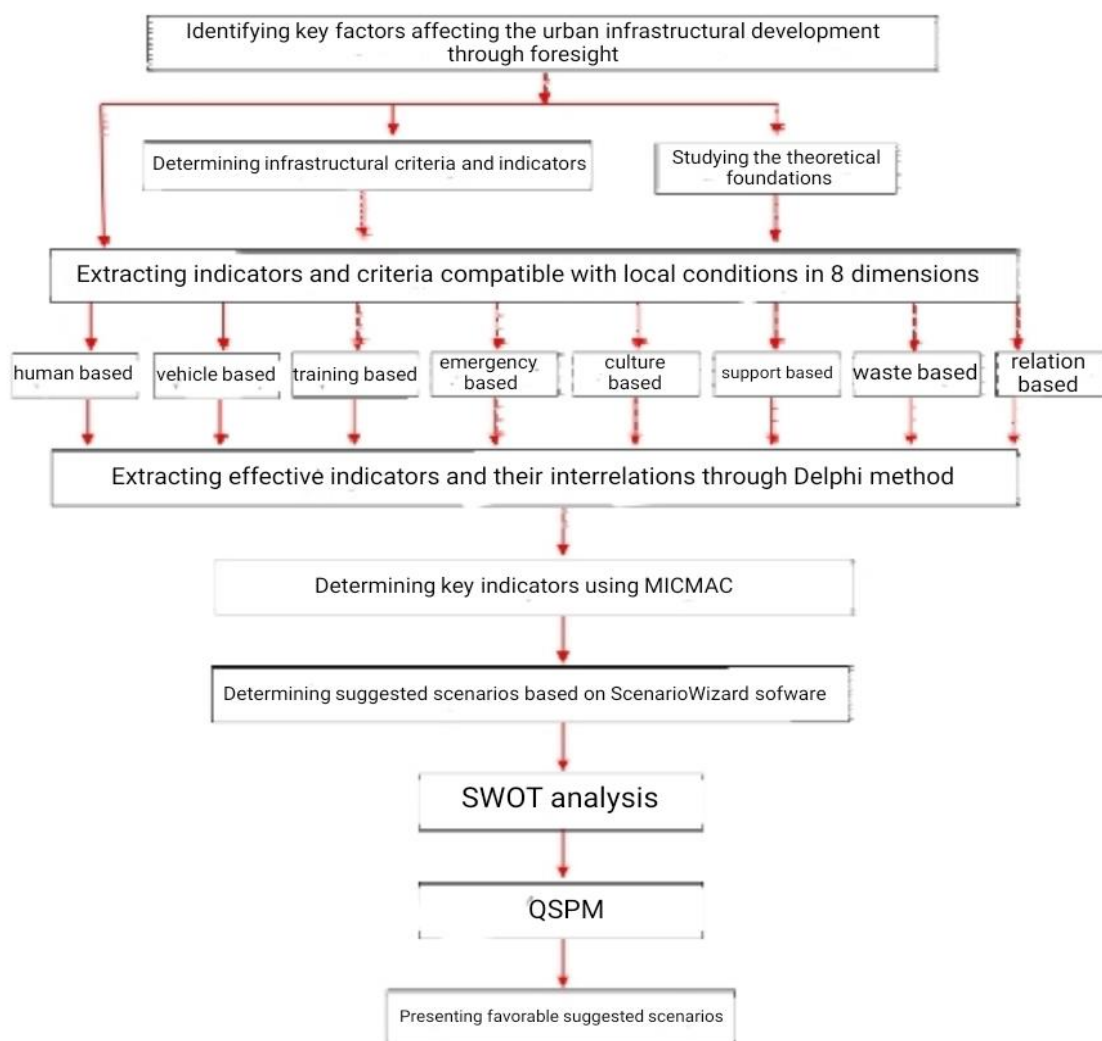
4. SWOT Model

SWOT analysis is one of the best available tools to make optimal decisions and it is applied to analyzing the external and internal environments of systems. SWOT analysis was first developed by

George Albert Smith and Roland Christensen in 1950. It is one of the important methods in the process of strategic planning (Lee, Huang & Teng, 2007). SWOT is the abbreviation of strengths, weaknesses, opportunities, and threats and an extremely important tool to systematically study the internal and external factors of a system. The output of this model attempts to change the weaknesses to strengths and exploit the opportunities by reducing the internal weaknesses and external threats (Arslan & Deha Er, 2008). This technique includes an 8-step process as:

- Listing the significant external opportunity points in the studied population
- Listing the external threat points in the studied population
- Listing the main strength points in the studied population
- Listing the main weakness points in the studied population
- Adapting the strength and opportunity points and counting SO strategies
- Adapting the weakness and opportunity points and counting WO strategies
- Adapting the strength and threat points and counting ST strategies
- Adapting the weakness and threat points and counting WT strategies

5. QSPM Model

Quantitative strategic planning matrix is applied to analyzing information through which the relative attractiveness of strategies is determined. This method explicitly identifies the best strategies. To form quantitative strategic planning matrix, the output of internal and external factor assessment matrix and the results of SWOT matrix are used; i.e. significant external opportunities and threats and internal strengths and weaknesses are included in the right column of quantitative planning matrix and weight or coefficient are added to each of these internal and external factors effective in the final success. These coefficients act as the coefficients of internal and external factor assessment matrix. In the top row of strategic planning matrix, strategies derived from SWOT matrix are included. Then, the score of attractiveness is determined. To do this, the internal and external factors effective in the final success are studied and for each factor the following question is answered: does this factor play an important role in selecting the strategies? If the answer is yes, then the strategies are compared according to this key factor, so that the relative importance of each strategy is determined in comparison to other strategies. The score of attractiveness for each factor is categorized as: 1. No attractiveness, 2. relatively attractive, 3. average attractiveness, and 4. extremely attractive. If the answer is no, the mentioned factor has no important role in selecting the strategies and no score of attractiveness. At the next step, we add the scores together. The higher the total number, the more

attractive the strategies are. Finally, the scores of attractiveness of each quantitative matrix columns are calculated. Different strategies are prioritized simultaneously. Prioritizing strategies in terms of the level of effectiveness, when the situation is analyzed and the favorable strategy is selected, provides a clearer and simpler way to implement suggestions and take effective measures.

6. Case Study

The city of Ardabil is the center of Ardabil Province in Iran. It is located in the southwest of the Caspian Sea between Mount Sabalan and the city of Talesh. Ardabil is at 1263 meters above sea level and it is at a distance of 40 kilometers from Mount Sabalan. The latitude of Ardabil is 38.2498 and the longitude is 48.2933. Ardabil with an area of 6500 hectares has a population of 529374 people according to the 2016 census. This city includes 5 municipal districts according to the latest political and administrative divisions. Considering that the city of Ardabil has a population over 500 thousand people and its growth rate is significant in recent decades, it seems that it will become a regional metropolis in the near future. Moreover, according to the economic, social, and geopolitical capabilities of Ardabil, its role in national and strategic development process for favorable and harmonic development of the city can be redefined trough identifying the effective future spaces and urban infrastructural needs (Management and Planning Organization of Iran, 2020).

Figure 2 - Map of the Location of Ardabil Province in Iran and the city of Ardabil in this Province
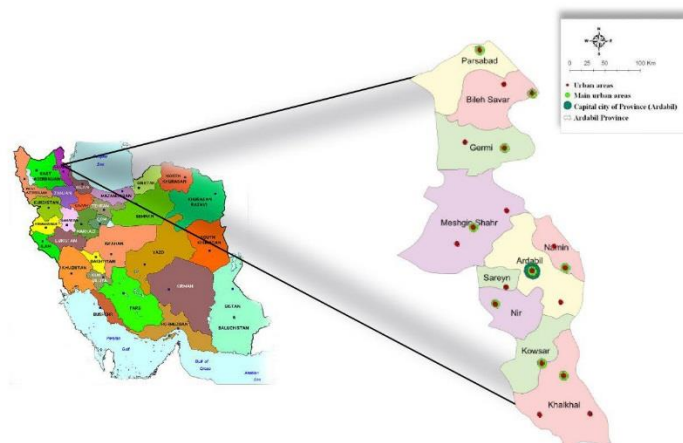
Since 1976, various development plans for balanced urban development have been developed and implemented in the city of Ardabil. Some of these plans are as follows: the comprehensive plan of the city of Ardabil, the guide plan of suburb development in Ardabil, the national plan of land and

housing in the northwest side of Iran (East Azerbaijan, West Azerbaijan, and Ardabil provinces), the national plan of Ardabil province preparation, the plan of managing dangerous jobs in the city of Ardabil, the plan of urban traffic management, the Mehr Housing plan of Ardabil, and other local and periodic plans. These plans have had significant effects through structural and infrastructural development of the city of Ardabil and paved the way for development.

7. Indicator Selection Processes

The indicators of the present research were selected based on the current situation and their availability in official statistical resources. Since the infrastructural development of Ardabil will be studied in this research, the related urban facilities were prioritized. After selecting Delphi method for discovering the relationship between the selected indicators, Delphi first-step questionnaire was developed and presented to the experts. Afterwards, according to the responses of this questionnaire, the second-step questionnaire was developed and the required data was extracted by referring to the mentioned experts. The data collected from Delphi method on indicators affecting the urban infrastructural development was determined. Finally, 30 affecting indicators were listed (Table 1).

Table 1 - 30 Factors Affecting the Infrastructural Development of Ardabil

Criterion	Sub-criterion
Human-based	Sidewalk
	Green space
	Squares
	Disabled special paths
	Bike paths
	Public toilets
	Number of public bikes
Vehicle-based	car
	Taxi
	Bus
	Traffic cameras
	Parking
	Fire trucks
Training-based	Training citizens
	Training municipal employees
Emergency-based	Fire hydrants
	Special paths for rescue workers
	Urban population's access time to emergency services
	Urban population's access time to firefighting services
Culture-based	Uncovered cultural spaces (lobbies, paving, squares)
	Covered cultural spaces (conference halls)
	Children's entertainment facilities in parks
	Sporting equipment in parks
Support-based	Beds in urban warm and safe houses
	Police stations
Waste management-based	Garbage trucks
	The proportion of recycled garbage to the total urban garbage
Relation-based	Public Wi-Fi
	Payphone
	Newsstands

(Resource: authors)

8. Results and Discussion

The present research is descriptive-analytical in terms of methodology and of applied type. In this research, first, the theoretical literature on urban development planning was studied systematically and structurally, then factors and variables affecting the urban infrastructural development were extracted based on theoretical foundations and through Delphi method. At the next step, they were ranked using cross impact technique (structural analysis method) and studied through MICMAC software. At the end, key urban development factors in infrastructural affairs were selected based on the score of being affecting or affected. To develop scenarios, Scenario Wizard software and to present strategies, SWOT and QSPM model were used. The strategies obtained from SWOT analysis are prioritized through different techniques that QSPM is one of the most important ones.

Table 2 - Quantitative Strategy Planning Matrix (QSPM) of Strong Scenarios

Internal and external factors	Normalized weight	Wo_1		Wo_2		Wo_3		Wo_4		Wo_5	
Strengths		S	T	S	T	S	T	S	T	S	T
S_1	0.062	2	0.124	2	0.124	1	0.062	1	0.062	1	0.062
S_2	0.060	2	0.12	2	0.12	1	0.060	1	0.060	1	0.060
S_3	0.046	2	0.92	3	0.138	1	0.046	1	0.046	1	0.046
S_4	0.057	3	0.171	2	0.114	1	0.057	1	0.057	1	0.057
S_5	0.041	2	0.082	2	0.082	1	0.041	2	0.082	2	0.082
S_6	0.050	2	0.1	2	0.1	1	0.050	3	0.15	2	0.1
S_7	0.077	2	0.154	2	0.154	2	0.154	2	0.154	2	0.154
S_8	0.060	1	0.060	1	0.060	1	0.060	1	0.060	1	0.060
Weaknesses											
W_1	0.062	3	0.186	3	0.186	1	0.062	1	0.062	1	0.062
W_2	0.066	3	0.198	3	0.198	1	0.066	1	0.066	1	0.066
W_3	0.076	3	0.228	3	0.228	1	0.076	1	0.076	1	0.076
W_4	0.080	3	0.240	3	0.240	1	0.080	1	0.080	1	0.080
W_5	0.096	2	0.192	2	0.192	1	0.096	1	0.096	1	0.096
W_6	0.062	2	0.186	2	0.186	1	0.062	1	0.062	1	0.062
W_7	0.063	2	0.126	2	0.126	1	0.063	1	0.063	1	0.063
W_8	0.042	2	0.084	2	0.084	1	0.042	1	0.042	1	0.042
Total	1	3.171		2.332		1.077		1.259		1.209	
Opportunities											
O_1	0.098	2	0.196	2	0.196	1	0.098	1	0.098	1	0.098
O_2	0.099	2	0.198	2	0.198	1	0.099	1	0.099	1	0.099
O_3	0.095	2	0.19	2	0.19	1	0.095	1	0.095	1	0.095
O_4	0.125	2	0.25	2	0.25	2	0.25	2	0.25	2	0.25
O_5	0.119	1	0.119	1	0.119	2	0.238	2	0.238	2	0.238
O_6	0.047	1	0.047	1	0.047	2	0.094	2	0.094	2	0.094
Threats											
T_1	0.070	1	0.070	1	0.070	1	0.070	1	0.070	1	0.070
T_2	0.094	1	0.094	1	0.094	1	0.094	1	0.094	1	0.094
T_3	0.11	1	0.11	1	0.11	1	0.11	1	0.11	1	0.11
T_4	0.125	1	0.125	1	0.125	1	0.125	1	0.125	1	0.125
Total	1	1.399		1.399		1.273		1.273		1.273	

(Resource: the results of author's field study, 2010)

Table 3 - The Prioritization of Conservative Strategies of Strong Scenarios

Priority	Strategies of strong scenarios (WO)	Attractiveness score of internal factors	Attractiveness score of external factors	Total attractiveness score of strategies
1	Improving sidewalks, streets, and emergency paths (wo_1)	3.171	1.399	4.57
2	Improving emergency and firefighting services with the aim of surviving citizens and their properties with the emphasis on improving emergency paths (wo_2)	2.332	1.399	3.731
3	Improving infrastructural services to improve the life of disabled people (wo_4)	1.259	1.273	2.532
4	Laying the groundwork for changing citizens' general insight to understand the rights of citizens (the right of having a city with developed infrastructures) (wo_5)	1.209	1.273	2.482
5	Culturalization and training citizens with the aim of improving infrastructural services and emphasis on training citizens (wo_3)	1.077	1.273	2.350

(Resource: the results of author's field study, 2010)

According to the table of QSPM, among 5 selected conservative strategies, the highest attractiveness belongs to the strategy of "laying the groundwork for changing citizens' general insight to understand the rights of citizens" with the score of 4.57 and the lowest one belongs to "Culturalization and training citizens with the aim of improving infrastructural services and emphasis on training citizens" with the score of 2.350.

9. Conclusion

In the present paper, the general process of the research has been stated briefly and the infrastructural development variables were extracted from the theories and models of foresight and analyzed through scenario planning. According to the research methodology, the desired data was gathered and analyzed to achieve the final goal of the research, i.e. determining the probable scenario of infrastructural development of the city of Ardabil and favorable strategies based on integrating the results with SWOT and QSPM analyses. Scenario planning is the main tool used in this research; first, according to the 6 steps of scenario planning, the method of selecting the respondents of Delphi questionnaire and their combination as well as entering the data into MicMac software were operated,

then by forming the SWOT matrix, the strengths, weaknesses, opportunities, and threats of suggested scenarios were ranked and prioritized. In the final step, different strategies were studied through the quantitative strategic planning matrix (QPSM) and the best strategy was selected. Finally, 7176 mixed scenarios were extracted, which included all the possible future situations ahead of the urban development foresight of Ardabil. Among these, 22 scenarios were highly compatible, 7012 were poorly compatible, and 142 scenarios were incompatible. The final results indicate that 5 scenarios are more possible in the urban development of Ardabil. Of the 5 strong scenarios, 3 scenarios are more possible to occur in the future urban development in the city of Ardabil. Among these 3, two scenarios are of favorable and ideal conditions and one scenario has a relatively favorable and interstitial state. The suggested scenarios in this paper indicate that the city of Ardabil has different possible situations to achieve the urban development in infrastructural terms. Best scenarios to achieve the favorable goals are strong ones which are more possible to occur. Among the large number of scenarios in the present paper, 5 strong scenarios were selected that 3 of them have presented optimistic situations and 2 scenarios have forecast pessimistic situations. Since pursuing the aim in this research is based on a positive attitude, positive strategies have been presented to achieve optimistic scenarios.

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