

Short Communication

Development assessment of cities using Fuzzy AHP (Case study: Sistan and Baluchestan, Iran)

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ABSTRACT:

This research aimed to investigate the development of cities in Sistan and Baluchestan province according to some development indicators. The applied results are used in regional decision-making and planning. This is a descriptive-analytical study. The statistical population consisted of all cities with more than 25 residents in Sistan and Baluchestan province, Iran. All data were extracted from the Statistical Yearbook 2011. A total of 24 indicators were selected in four categories: Education, Health, Transportation, and Service. The data were collected for the cities. The data were analyzed using fuzzy AHP in terms of development. The results showed that Zahedan (capital) (the capital of Sistan and Baluchestan Province, Iran) scored the top (utilization coefficient: 8.12), while Sarbaz (a county in Sistan and Baluchestan Province in Iran) scored the 9th (utilization coefficient: 2.96) position. Finally, the cities were ranked based on development into three categories: utilized, semi-utilized, and deprived. The maps were drawn using GIS.

Keywords:

Utilization Coefficient, Development, F-AHP Model, Sistan and Baluchestan province.

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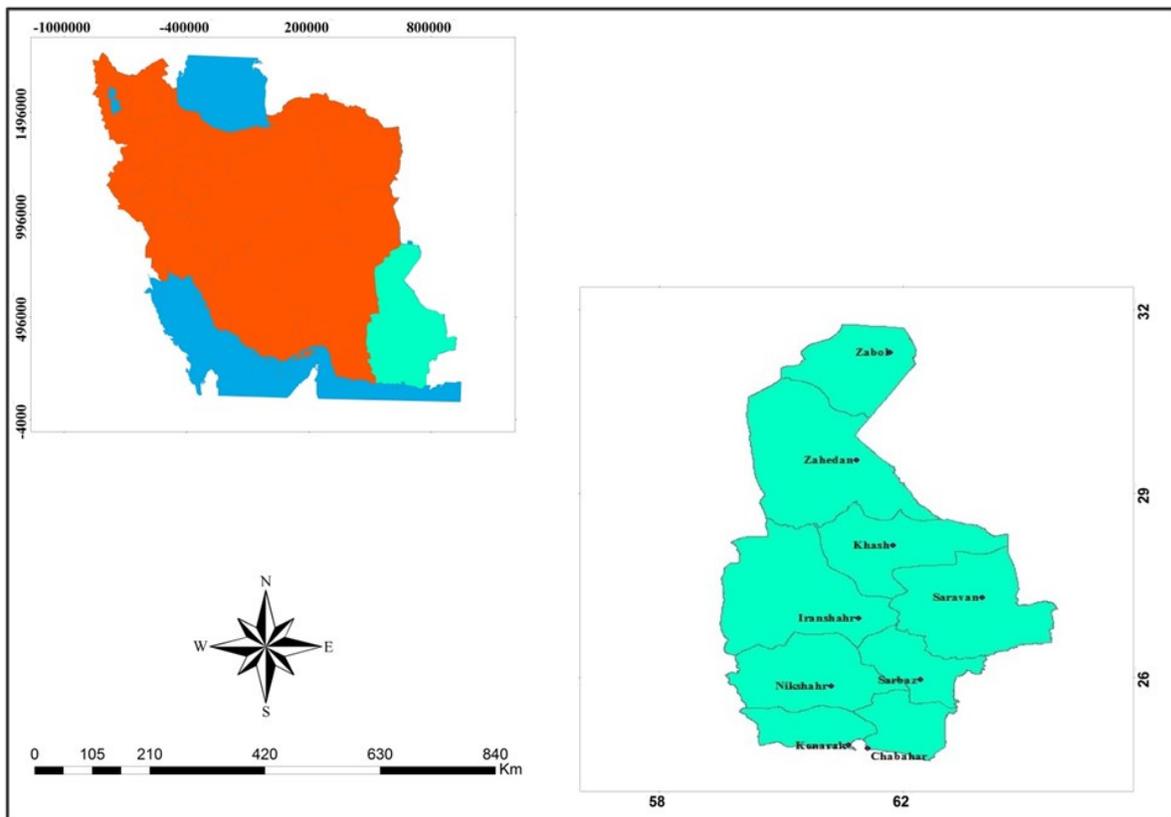
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INTRODUCTION

Development is an ideal goal for most countries. Development is a detailed process of economic, social, cultural, and political activities aiming to continuously improve life. Activity, proper participation, and fair distribution of benefits are the main elements (Rahnama and Ababszadeh, 2008). Balanced development of geographical spaces requires a detailed review of economic, social, and cultural affairs, a better understanding of community needs, and their improvement. This requires complete and processed information (Moradi and Darvishi, 2016). In third world countries, political and social developments in the past century caused rapid urban life changes, increased pressure on infrastructures, and reduced rural population. This has caused unequal distribution of resources and lack of harmonious development between cities and villages. Such inequalities caused a growing gap between developed and deprived areas. Therefore, economic and social justice has be-

come meaningless, the deprivation of poor areas continues, and central areas absorb most of the facilities. Not only does it cause the growth, but also slower and more unfair development is expected (Ziyari et al., 2010).

Environmental imbalance in a region- partially caused by growth pole policies, by lack of coordination between economic sectors and improper operation of regional capabilities, and socioeconomic and cultural condition ignorance- highlights the importance of regional and local planning. Morgan and Walden believed that regional planning is a process trying to provide consistency between social, economic, and political plans of the central government, on the one hand, and local government, on the other hand (Husseinzadehdalir, 2005). Since planning requires assessment, models need to be used for a better understanding. Socio-economic methods and models are Morris developed methods, standard score, taxonomy, Scalogram, Gutmann, and AHP for determining the degree of development. These



Map 1. Sistan and Baluchestan Province (Source: Author)

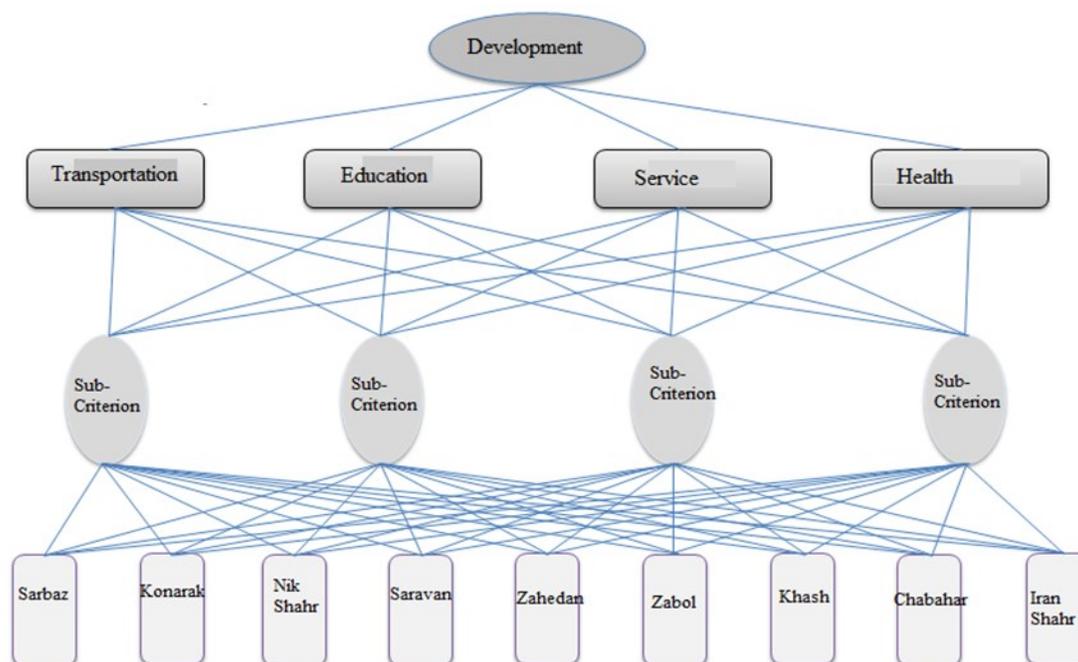


Figure 1. Schematic view of AHP for criteria, sub-criteria and city (Source: Author)

widely-used models apply mathematical language and are capable of combining indicators and variables in order to determine the regional utilization. We used fuzzy AHP in our study. AHP is useful because it provides a more logic and more simple approach for the analysis of difficult and complex issues (Zabardast, 2001). Since, Sistan and Baluchestan province is one of marginal and deprived ones, planning is required in line with the regional capacities in order to develop all sectors and utilize the maximum potential for reducing the relative poverty and strengthening the potentials. There-

fore, it is essential to rank the utilization in order to allocate budget. Develop assessment of cities with over 25 thousand residents. Ranking Sistan and Baluchestan cities concerning utilization coefficient (Utilized, Semi-utilized, and Deprived).

MATERIALS AND METHODS

Case study area

Sistan and Baluchestan province, located in south east of Iran, stretches from 25°3' to 31°29' N 58° 49' to 63°20' N. The area is 187502 km², accounting for

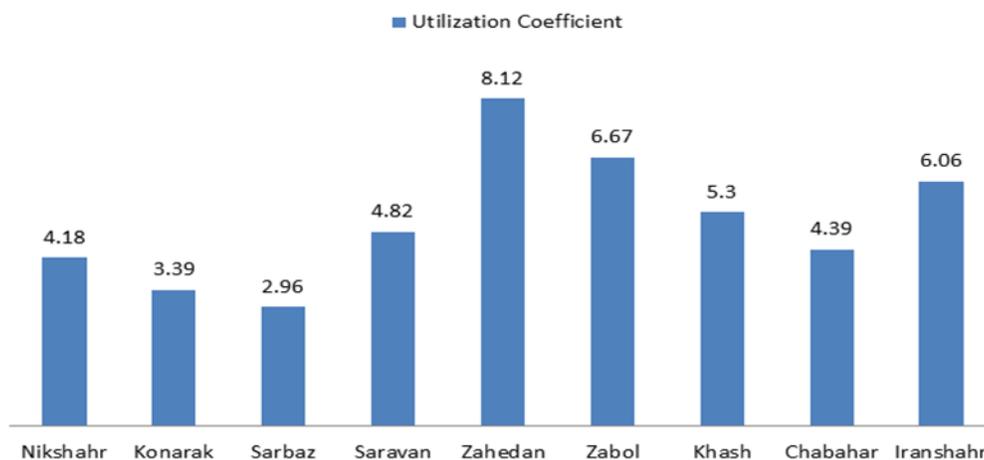


Figure 2. Final utilization coefficient of Sistan and Baluchestan cities concerning development indicators

Table 1. Criteria and their corresponding indicators (Source: Kalantari, 2013)

Criterion	Indicator	Criterion	Indicator
Education	1-Number of classes/100 students	Service	1-Post Office/100 km ²
	2-Number of schools/ 10000 residents		2-Bank/10000 residents
	3- Teacher/student ratio		3-Bank/100 km ²
	4- Total literacy rate		4-Number of industrial power subscriber/10000 residents
	5-Urban literacy rate		5-Length of public sewerage network/ 10000 residents
	6- Rural literacy rate		6-Number of slaughter house/100000 residents
Health	1-Number of physicians/ 10000 residents	Transportation	1-Length of roads/10000 residents
	2-Number of dentists/10000 residents		2-Length of rural roads/ 100km ²
	3-Number of midwives/10000 residents		3-Railway/10000 residents
	4-Number of hospital/100000 residents		4-Number of flights/ 10000 residents
	5-Number of hospital beds/10000 residents		5-Number of transportation corporations/ 10000 residents
	6- Number of labs/100000 residents		6-Number of passenger terminal/10000 residents

11.5% of area of Iran. The province borders with southern Khorasan to north, Oman Sea to south, Afghanistan and Pakistan to east, and Kerman and Hormozgan provinces to west (Map 1).

Methodology

This is an applied, descriptive-analytical study. The statistical population consisted of all cities over 25

thousand residents according to 2011 political division. Statistical Yearbook 2011 was used to determine the development using 24 indicators in four dimensions (education, health, service, and transportation) (Kalantari, 2013) (Table 1). Paired comparison was performed using fuzzy AHP. Finally, the cities were ranked. Maps were drawn by GIS.

Table 2. Triangular fuzzy number conversion (Source: Balouchi, 2011)

S. No	Linguistic Variables	Positive Triangular Fuzzy Numbers	Positive Inverse Triangular Fuzzy Number
1	Extremely Important	9, 9, 9	1/9, 1/9, 1/9
2	Very Important to Extremely Important	7, 8, 9	1/9, 1/8, 1/7
3	Very Important	6, 7, 8	1/8, 1/7, 1/6
4	Important to Very Important	5, 6, 7	1/7, 1/6, 1/5
5	Important	4, 5, 6	1/6, 1/5, 1/4
6	Relatively Important to Important	3, 4, 5	1/5, 1/4, 1/3
7	Relatively Important	2, 3, 4	1/4, 1/3, 1/2
8	Equal Importance to Relatively Important	1, 2, 3	1/3, 1/2, 1
9	Equal Importance	1, 1, 1	1, 1, 1

Table 3. Paired comparison of major criteria

S. No	Criterion	Education	Transportation	Health	Service
1	Education	(1, 1, 1)	(2, 3, 4)	(1, 2, 3)	(2, 3, 4)
2	Transportation	(0.25, 0.33, 0.5)	(1, 1, 1)	(0.33, 0.5, 1)	(1, 2, 3)
3	Health	(0.33, 0.5, 1)	(1, 2, 3)	(1, 1, 1)	(1, 2, 3)
4	Service	(0.25, 0.33, 0.5)	(0.33, 0.5, 1)	(0.33, 0.5, 1)	(1, 1, 1)

Table 4. Normalized coefficients of major criteria from paired comparison matrix

S. No	Criteria	Triangular Fuzzy Coefficients		
		Ui	Mi	Li
1	Education (S1)	0.86	0.43	0.2
2	Transportation (S2)	0.4	0.18	0.09
3	Health (S3)	0.58	0.26	0.11
4	Service (S4)	0.25	0.11	0.06

In this method, education, health, service, and transportation criteria are determined in order to rank the development of cities in Sistan and Baluchestan. Each criterion was divided into some sub-criterion. AHP is as follows (Figure 1):

The utilization of each of the cities were determined. The city with the least utilization was ranked 1. Other cities were then ranked accordingly. The most utilized city was ranked 9 because the number of cities with more than 25 thousand residents were 9. The ranks ranged between 1 and 9. (Table 2) shows the preference of criteria according to triangular fuzzy numbers.

Next, the relative weights were determined. Paired comparison was performed (Table 6-9). After weighting criteria, paired comparison was performed (Table 3)

Accordingly, to form pairwise comparisons matrix, we first determine the importance coefficient of criteria and sub-criteria and them compare them in pair.

Pair comparisons are recorded in the n×n matrix and this matrix is called binary matrix of criteria M=[mij] n×n. In pairwise comparisons between indices and options relative to each of indices, it is assumed that Mij=[lij , mij , uij] representing a triangular fuzzy number. If, Mij represents ith index preference to jth index, Mij will represent jth index preference to ith index and the following equation will be hold between them always (Equation 1) (Akbari and Keyvan, 2008).

$$M_{ji} = M_{ij}^{-1} = [L_{ij}, m_{ij}, u_{ij}]^{-1} = \left[\frac{1}{u_{ij}}, \frac{1}{m_{ij}}, \frac{1}{L_{ij}} \right] \quad (1)$$

In following, Equation 2 was used to calculate S_i for each of the rows of paired comparison matrix of major criteria (Table 4).

$$S_i = \sum_{i=1}^m M_{gi}^i \times \left[\sum_{i=1}^n \sum_{i=1}^m M_{gi}^i \right]^{-1}$$

$$\sum_{j=1}^m M_{gi}^j = \left(\sum_{j=1}^m L_j \text{ , } \sum_{j=1}^m m_j \text{ , } \sum_{j=1}^m u_j \right)$$

$$\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j = \left(\sum_{i=1}^n L_i \text{ , } \sum_{i=1}^n m_i \text{ , } \sum_{i=1}^n u_i \right)$$

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^n u_i} \text{ , } \frac{1}{\sum_{i=1}^n m_i} \text{ , } \frac{1}{\sum_{i=1}^n L_i} \right) \quad (2)$$

Table 5. Non-normalized and final weights of major criteria

S. No	Criteria	Education	Transportation	Health	Service
1	Non-normalized weight	1	0.44	0.69	0.14
2	Final weight	0.44	0.20	0.30	0.06

Table 6. Relative and final weight of education

Criterion	Relative Wight of Criterion	Sub-Criterion	Relative Weight	Final Weight	Utilization Rate								
					Iranshahr	Chabahar	Khash	Zabol	Zahedan	Saravan	Sarbaz	Konarak	Nikshahr
Education	0.44	Number of classes/100 students	0.15	0.066	9	7	4	5	8	4	6	6	3
		Number of schools/ 10000 residents	0.16	0.07	5	3	6	2	7	8	7	4	9
		Teacher/student ratio	0.3	0.132	7	8	7	6	9	8	7	5	8
		Total literacy rate	0.3	0.132	7	2	6	8	9	5	1	4	3
		Urban literacy rate	0.05	0.022	6	3	7	8	9	5	1	4	2
		Rural literacy rate	0.04	0.018	5	3	7	9	8	6	2	2	4
		Rank compared to criterion				2	7	4	5	1	3	8	9
Utilization coefficient					3.01	2.11	2.68	2.66	3.74	2.76	2	1.99	2.4

Then, Equation 3 was used to calculate the magnitude of S_i to each other (Table 5).

$$V(M_2 > M_1) = \text{her}(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } L_1 \geq u_2 \\ \frac{(L_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)} & \end{cases} \quad (3)$$

Final weight was calculated by mixing the relative weights of criteria and options.

RESULTS

To obtain the utilization rate of studied development indicators by Sistan and Baluchestan Province, final weight was multiplied by utilization rate. The total

sum of multiplications led to the calculation of utilization (Table 6-9).

The results of Table 6 show that Zahedan and Iranshahr were the utilized cities concerning education with utilization coefficients of 3.74 and 3.01, respectively. Sarbaz and Konarak were the least utilized ones in terms of education (2 and 1.99, respectively).

The results of Table 7 showed that Zahedan and Zabol scored the top with utilization coefficients of 1.47 and 1.1, respectively. Khash and Nikshahr were the least utilized cities with utilization coefficients of 0.45 and 0.37, respectively.

Concerning health (Table 8), Zabol and Zahedan

Table 7. Relative and final weight of transportation

Criterion	Relative wight of criterion	Sub-criterion	Relative weight	Final weight	Utilization rate								
					Iranshahr	Chabahar	Khash	Zabol	Zahedan	Saravan	Sarbaz	Konarak	Nikshahr
Transportation	0.2	Length of roads/10000 residents	0.32	0.064	3	5	2	6	7	8	9	1	4
		Length of rural Roads/ 100km ²	0.1	0.02	1	7	6	9	2	5	8	3	4
		Railway/10000 Residents	0.15	0.03	0	0	0	0	9	0	0	0	0
		Number of flights/ 10000 residents	0.21	0.042	6	0	0	7	9	0	0	8	0
		Number of transportation corporations/ 10000 residents	0.07	0.014	5	8	4	9	7	6	0	0	0
		Number of passenger erminal/10000 residents	0.15	0.03	7	9	5	4	8	3	2	6	1
		Rank compared to criterion					6	3	8	2	1	5	4
Utilization coefficient					0.74	0.84	0.45	1.1	1.47	0.79	0.8	0.64	0.37

Table 8: Relative and final weight of health

Criterion	Relative weight of criterion	Sub-criterion	Relative weight	Final weight	Utilization rate								
					Iranshahr	Chabahar	Khash	Zabol	Zahedan	Saravan	Sarbaz	Konarak	Nikshahr
Health	0.3	Number of physicians/10000 residents	0.22	0.07	7	5	6	9	8	3	1	2	4
		Number of dentists/10000 Residents	0.05	0.015	5	6	7	9	8	4	0	6	0
		number of Midwives/10000 residents	0.11	0.033	7	2	8	9	4	5	0	3	6
		Number of Hospital/100000 residents	0.37	0.111	7	4	6	8	9	3	0	0	5
		Number of hospital Beds/10000 residents	0.17	0.051	7	5	6	8	9	4	0	0	3
		Number of labs/100000 residents	0.08	0.024	6	4	9	8	7	5	1	2	3
		Rank compared to criterion			3	7	4	1	2	6	9	8	5
Utilization coefficient				2.07	1.08	1.98	2.55	2.44	1.09	0.09	0.38	1.26	

scored the top with utilization coefficients of 2.55 and 2.44, respectively. Konarak and Sarbaz were the least utilized cities with utilization coefficients of 0.38 and 0.09, respectively.

Concerning service (Table 9), Zahedan and Zabol scored the top with utilization coefficients of 0.47 and 0.45, respectively. Nikshahr and Sarbaz were the least utilized cities with utilization coefficients of 0.15 and 0.07, respectively.

Table 10 shows utilization coefficients of all cities by adding education, health, service, and transportation. According to (Table 10), Zahedan was the most utilized city (utilization coefficient: 8.12) and Sarbaz was the least utilized city with utilization coefficient of

2.96 (Figure 2).

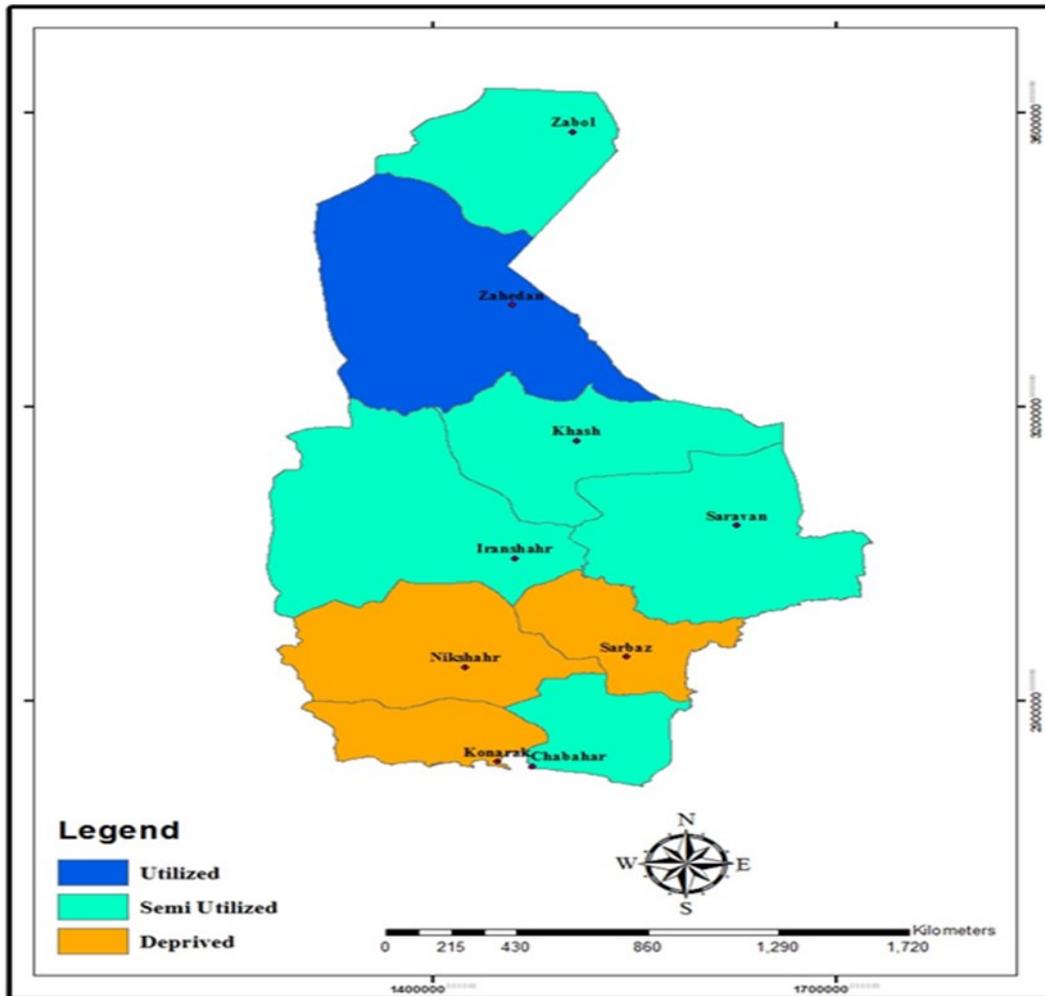
Finally, Table 11 shows Sistan and Baluchestan provinces concerning development in three categories: Utilized, Semi-Utilized, and Deprived (Map 2).

DISCUSSION

Rapid population growth coupled with urbanization and world urbanization has created various problems in different countries especially third world countries. Urban and urbanization pace and size is far more in developing countries than the developed ones (Raffeian and Shali, 2012). This requires detailed regional and local planning. Regional planning is a process through which various social and economic

Table 9. Relative and final weight of service

Criterion	Relative Weight of Criterion	Sub-Criterion	Relative Weight	Final Weight	Utilization rate								
					Iranshahr	Chabahar	Khash	Zabol	Zahedan	Saravan	Sarbaz	Konarak	Nikshahr
Service	0.06	Post office/100 km ²	0.04	0.002	6	7	5	9	4	5	0	0	8
		Bank/10000 residents	0.3	0.018	7	6	3	8	9	4	1	5	2
		Bank/100 km ²	0.15	0.009	6	7	3	9	8	5	5	4	4
		Number of industrial power subscriber/10000 residents	0.05	0.003	3	5	7	6	9	4	2	8	1
		Length of public sewerage network/ 10000 residents	0.3	0.018	0	6	0	9	7	0	0	8	0
		Number of slaughter House/100000 residents	0.16	0.01	4	5	8	2	7	3	0	9	6
		Rank compared to Criterion					5	4	6	2	1	7	9
Utilization Coefficient					0.24	0.36	0.19	0.45	0.47	0.17	0.07	0.38	0.15



Map 2. The utilization of Sistan and Baluchestan cities concerning development (Source: Author)

Table 10. Utilization coefficient and rank of cities

Utilization coefficient	Iranshahr	Chabahar	Khash	Zabol	Zahedan	Saravan	Sarbaz	Konarak	Nikshahr
Education	3.01	2.11	2.68	2.66	3.74	2.77	2	1.99	2.4
Transportation	0.74	0.84	0.45	1.1	1.47	0.79	0.8	0.64	0.37
Health	2.07	1.08	1.98	2.55	2.44	1.09	0.09	0.38	1.26
Service	0.24	0.36	0.19	0.45	0.47	0.17	0.07	0.38	0.15
Total	6.06	4.39	5.3	6.76	8.12	4.82	2.96	3.39	4.18
Rank	3	6	4	2	1	5	9	8	7

Table 11. Utilization of Sistan and Baluchestan cities concerning development

Degree of utilization	City	Number of cities	Percentage of utilization
Utilized	Zahedan	1	11.11
Semi-utilized	Zabol, Iranshahr, Khash, Saravan, Chabahar	5	55.56
Deprived	Nikshahr, Sarbaz, Konarak	3	33.33
Total		9	100

plans are coordinated with local and regional facilities and requirements. Here, planners consider the optimal use of resources and regional capabilities in order to remove the regional imbalances (Asayesh, 1996). Today, development and recognition of shortcomings in different regions are the most important subjects in urban affairs (Nastaran and Fatahi, 2009). In this regard, most scientists believed that the following steps need to be taken into account to assess the urban and regional development:

1. Set the objective and develop the framework

In this stage, researchers need to clearly determine the goals. The development dimension needs to be considered: General or certain development is desired such as industrial, social, etc. Then, we need to operationally define the concept (Kalantari, 2013).

2. Area

After setting the goals, it is essential for researcher to clarify the region for the study. Regional studies are performed in village, town, city, province, or larger ones. This stage prepares the ground for the next stage. Availability of statistics and information is the most important part in this stage (Kalantari, 2012).

3. Accessible statistics

In this stage, the researcher must evaluate the accessible information and statistics. Such information helps the researchers determine the development indicators. Such information is found in Statistical Center of Iran (Kalantari, 2013).

4. Development indicator selection

Determining the development indicators is the most important step in regional development studies. Development indicators, in fact, are essential for stating the importance and their roles in interpreting statistical data in order to deeply investigate the variables to find the differences. Basically, indicators are obtained by dividing the variables into an appropriate denominator (Kalantari, 2012).

CONCLUSION

In the study, we used fuzzy AHP to rank the cities with over 25 thousand residents in Sistan and Baluchestan Province, Iran using 24 indicators in four criteria (education, health, service, and transportation) according to 2011 administrative-political divisions. A dramatic difference and inequality is seen among the cities. As we move from the northern Province to southern sections, the gap increases concerning education, health, service, etc. facilities. The results showed that the development status of Sistan and Baluchestan province indicates better utilization of Zahedan and Zabol in all 4 fields. Utilization coefficient was 8.12 for Zahedan (Top) and 2.96 for Sarbaz (last). Homogeneous cities were grouped together in three categories: Utilized, Semi-Utilized, and Deprived.

SUGGESTIONS

1. In order to reach regional balance in Sistan and Baluchestan cities, it is necessary to consider decentralization policy for providing services, investing in different sectors, and creating infrastructures for policy makers, planners, and senior executives.
2. In order to eliminate deprivation in Sistan and Baluchestan cities, it is essential to direct existing facilities and potentials towards the less developed cities. In this regard, poor indicators need more attention.
3. Setting priorities is required for each of cities according to the indicators.
4. It is important to prepare the land sue for various regions of Sistan and Baluchestan and optimally use the capabilities for the elimination of deprivations and sustainable development.

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