Middle-East Journal of Scientific Research 10 (4): 501-507, 2011
ISSN 1990-9233

Multicriteria Decision Making Based on Analytical Hierarchy Process (AHP) in GIS for Tourism

[1]M. Ghamgosar, [1]M. Haghyghy, [2]F. Mehrdoust and [1]N. Arshad

[1]Academic Center for Education, Cultural and Research, Rasht, Iran
[2]Departments of Applied Mathematics, University of Guilan, Rasht, Iran

Abstract: The environmental assessment has been used as a basis for decision making and planning of land use in all parts of the world. This is due to the necessity of choosing the optimal performance and places it in the planning and environmental management to achieve sustainable development. Now a day's high accuracy and speed of analysis are the achievement of using new methods and technologies such as GIS and MCDM (Multiple criteria Decision Making). MCDM is the right tool for the prediction of interaction between science and optimal utilization of land. Analytical Hierarchy Process (AHP), as a multiple criteria decision making tools especially in the problems with spatial nature or GIS-based were used in this study to evaluate the environmental assessment of tourism. This paper explains a systematic approach and analytical means for tourism revival strategic marketing planning with Analytic Hierarchy Process (AHP). At first the ecological resources in the process (physical and biological) and the influential factors were identified. Then the relationships between various factors were obtained by the expertise. Then with modulation and overlay the layers in ArcGIS 9.3, due to influencing factors and the evaluated weight in AHP, the suitable map of the area for tourism was prepared and the environmental assessment was done.

Key words: AHP · Multicriteria decision making · GIS · Environmental assessment · Tourism

INTRODUCTION

Some spatial planning or spatial problems like site selection can be considered as a multiple criteria decision making or multiple MCDM problems involve a set of alternatives that are evaluated on the basis of conflicting and incommensurate criteria [1].

Spatial Multi-criteria decision problems usually involve a series of spatial situations that should be evaluated based on several different criteria [2]. GIS-based multicriteria analysis is used in a wide range of decision and management situations like environment planning and ecology management, Urban and regional planning, Hydrology and water resources, Forestry, Transportation, Agriculture, Natural hazard management, Health care resource allocation and etc. In GIS technology, usually the alternatives are a collection of point, line and aerial objects, attached to which are criterion values (criterion map). Fig. 1 illustrated a schema of spatial multicriteria decision analysis.

MADM as a class of MCDM is the approach dealing with the ranking and selection of one or more sites from

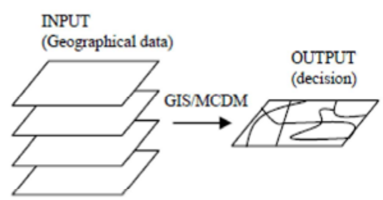

Fig. 1: Spatial multicriteria decision analysis

the alternatives. Some important characteristics of MADM are having restricted set of alternatives and explicitly defined set of alternatives, requiring a priori information on the decision maker's preferences and being outcome oriented [3]. In MADM, the aim is to rank a finite number of alternatives with respect to a finite number of attributes. In solving a MADM, one needs to know the importance or weights of the not equally important attributes and also the evaluations of the alternatives with respect to the attributes. There have been different methods on MADM and the most known is Analytical Hierarchy Process (AHP) which especially is based on pair wise comparisons on a ratio scale [4].

Corresponding Author: M. Ghamgosar, Academic Center for Education, Cultural and Research, Rasht, Iran.

On the other hand, in incidence of environmental crises, destruction of resources and barriers in the way of obtaining sustainable development, It is necessary to take place the development plan according to recognition and assess the development environment to access a suitable and continuous utilization of environment also protection the natural values [5].

Tourism is one of the most dynamic and fastest growing global industries. It has been recognized as an important economic development tools generating revenue and employments for nations' economies [6]. However, tourism is fragile and vulnerable to external fluctuations. It is more susceptible to disasters, either natural or human-involved [7, 8].

Like all types of development, tourism has positive and negative effects on the environment, culture and economy of the host society. So one of the key strategies to minimize negative impacts and enhance positive impacts of it is land use planning considering the natural talent of the area for the specified land use. Nature guides consistent with environmental talent of the land, as an effective tool and strategy, has a fundamental role in sustainable development, improving living standards in human societies and obtaining natural balance [9].

The environmental assessment of a city in Guilan Province in north of Iran (Langrood) for tourism has been evaluated with analytic hierarchy process (pair wise comparison of impact factors) and ArcGIS 9.3 and appropriate areas for tourism has been identified.

MATERIALS AND METHODS

Study Area: Langrood city has about 900 kilometers in extent and location of longitude 50 degrees 10 minutes and 30 seconds and latitude 37 degrees 11 minutes East region and is located in Guilan Province and its distance is 60 km to the capital city of the province. Langrood is located in the South cost of Caspian Sea. Langrood city has two terraces of topography; moderate to low mountainous in the south and south shores of the Caspian Sea in the north. The highest point on the mountain is 1933 meters height above sea level and the lowest point is-20 m height. City gradient is variable between 0.5 to more than 50 percent which is been added with height of the beach to the mountains. The city is considered to be junior at tourism according to development plan of tourism in coastal areas of Guilan and Mazandaran.

Table 1: Characteristics of soil units Langrood city

Soil unit code	Soil texture	Soil depth
1.3	heavy texture soils	Acidic soils of the semi-deep and deep uniform
1.5	heavy texture soils	Deep to semi uniform deep soil
4.1	Heavy fabric with colorful spots of iron oxide	Acidic soils of the semi-deep and deep uniform
4.2	heavy texture soils	Acidic soils of the semi-deep and deep uniform
5.3	Moderate to heavy texture with some color Mnqvth	Deep soil
6.1	Heavy fabric with lots of organic and Gleyic class with marine clays	Deep soil
6.2	Heavy texture with Gleyic class and the amount of organic material	Deep soil
7.2	Moderate to heavy texture on the sidelines of stream bed	Deep clay acidic soil
X.1	Moderate to heavy texture	Deep sandy soil
X.2	Dark to dark brown and lots of organic matter	Uniform deep sandy soil

Table 2: Land use of Langrood city

Land use	Area-square cover	Area-hectare
Semi-dense forest	42/304558235	82/3045
Thin forest	3/24593830	38/2459
Rangeland	39/2198049	8./219
Dry land and irrigated agriculture	6/234645141	51/2346
Residential area	59/18092188	22/1809
Dense forest	125389159	92/12538

Table 3: Rock Langrood city

ID	Rock ID	Area-hectare	Area-square cover
1	Limestone and lime tuff, acidic lime andesite tuff	174132130.40	17413.21
2	Limestone and sandstone layers and shale and volcanic alkaline rock	27682982.71	2768.298
3	Alluvial deposits, flood and delta plains	24246297.63	2424.63
4	Marine-beach deposits, Wind sand with Large and small alluvial river	167179705.73	16717.97
5	Andesite acidic-alkaline lava and lime and sand, Conglomerate and volcanic rocks	42135486.16	4213.549

Criteria Evaluation: According to studies conducted in Iran, especially by [10-12] the most important criteria used to determine the suitability of land for different uses in Iran, were recognized. With the base model of Makhdoom, the slope of the altitude, the elevation, aspect, land use, soil and geology of the area was chosen as the effective factors.

Classification and Standardization the Criteria: At this stage all the criteria of ecological models of Iran [12] were classified and according to experts and studies, per wised evaluation among factors and land use numerical value was assigned.

Weighting Criteria: There are different evaluation criteria to determine the suitability of the land; however, the importance of these criteria is different for different land uses. Therefore it is necessary to determine the importance of each of these criteria in the suitability of land for special use than at this stage to determine the weighting of the criteria analytical hierarchy process was used. AHP is a multi-criteria decision method that uses hierarchical structures to represent a problem and then develop priorities for alternatives based on the judgment of the user [4]. The AHP procedure involves six essential steps [13]:

- Define the unstructured problem
- Developing the AHP hierarchy
- Pair wise comparison
- Estimate the relative weights
- Check the consistency
- Obtain the overall rating

Obtain the Overall Rating: In last step the relative weights of decision elements are aggregated to obtain an overall rating for the alternatives as follows:

$$W_i^s = \sum_{j=1}^{j=m} w_{ij}^s w_j^a, \quad i = 1, 2, ..., n \qquad (1)$$

where
W_i^s : Total weight of site i,
w_{ij}^s : Weight of alternative (site) i associated to attribute (map layer) j,
w_j^a : Weight of attribute j,
m: Number of attribute
n: Number of site

Mapping the Standardized Measure of Weight: The standard map of the study area according to assigned weight ratio and classification was produced in ArcGIS 9.3.

Table 5: Scales for pair wise comparison (Saaty, 1980)

variables	Preferences expressed in linguistic variables
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values between adjacent scale values

Table 5: Matrix weighting of criteria

	elevation	slope	aspect	soil	rock	Land use
elevation	1.00	3.00	5.00	7.00	7.00	9.00
slope	0.33	1.00	3.00	5.00	5.00	7.00
aspect	0.20	0.33	1.00	3.00	5.00	3.00
soil	0.14	0.20	0.33	1.00	3.00	5.00
rock	0.14	0.20	0.20	0.33	1.00	3.00
Land use	0.11	0.14	0.20	0.20	0.33	1.00
sum	1.93	4.88	9.73	16.53	21.33	28.00

Table 6: Calculation of the coefficient matrix of priorities in each column

	elevation	slope	aspect	soil	rock	Land use	sum
elevation	1.00	3.00	5.00	7.00	7.00	9.00	2.72
slope	0.33	1.00	3.00	5.00	5.00	7.00	1.47
aspect	0.20	0.33	1.00	3.00	5.00	3.00	0.80
soil	0.14	0.20	0.33	1.00	3.00	5.00	0.53
rock	0.14	0.20	0.20	0.33	1.00	3.00	0.31
Land use	0.11	0.14	0.20	0.20	0.33	1.00	0.17
sum	1.93	4.88	9.73	16.53	21.33	28.00	6

Table 7: Weight ratio of factors

The factor	Weight
elevation	0.302
slope	0.164
aspect	0.089
soil	0.059
rock	0.034
Land use	0.019

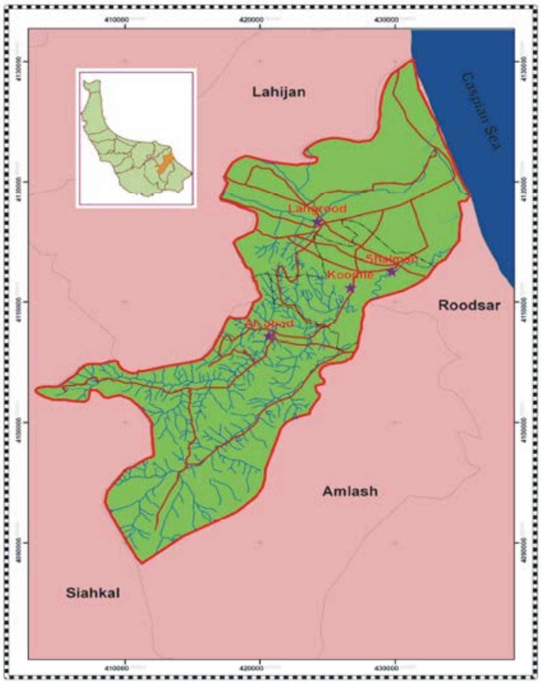

Fig. 2: Study area location, Langrood city

To prepare these maps topographical maps 1:25000 of Iran surveyor's company and image of the DEM was used to make slope map, aspect and elevation classes.

Integrating the Final Composition, Determining Land Use and Prioritize According to the Regional Conditions: At this stage, the final composition and zoning was done according to final composition and determination of land use. One of the most important aspects of the model results is comparison and matching with the existing condition and status of tourist attractions that already exist in the region. In addition to determine the priority among land use, a major criterion is the current situation and land use of the region [14].

Check the Consistency: In this step the consistency property of matrices is checked to ensure that the judgments of decision makers are consistent. For this end some preparameter is needed. Consistency Index (CI) is calculated as:

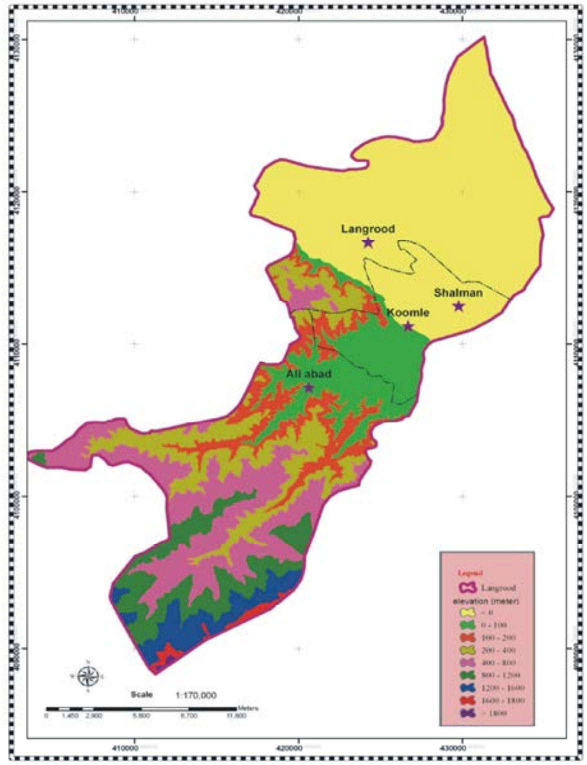

Fig. 3: Elevation classes map

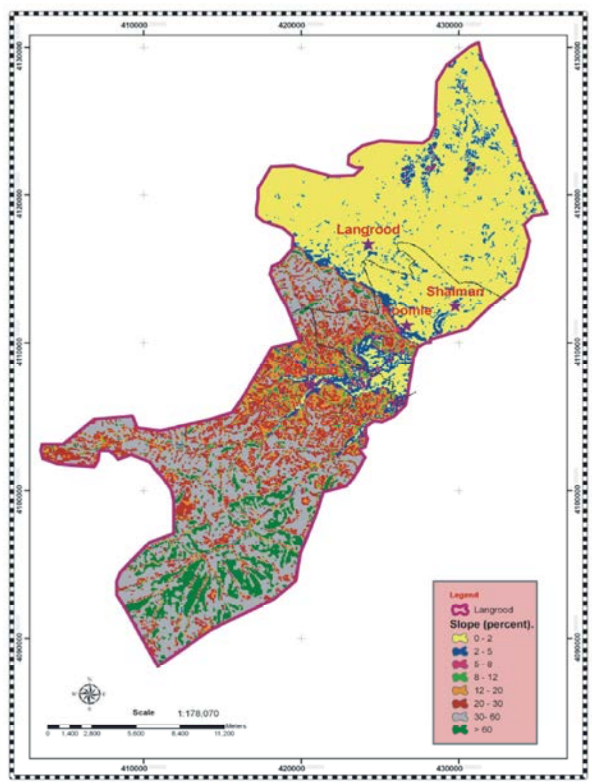

Fig. 4: Slope classes map

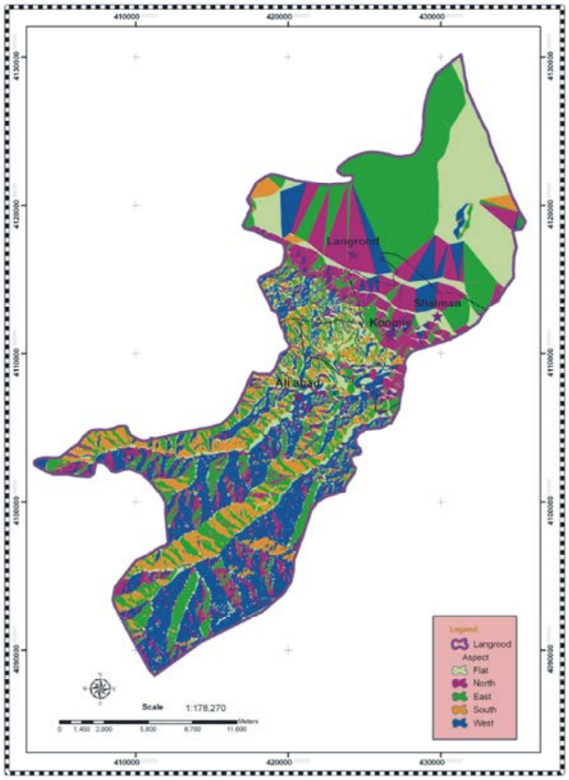

Fig. 5: Aspect classes map

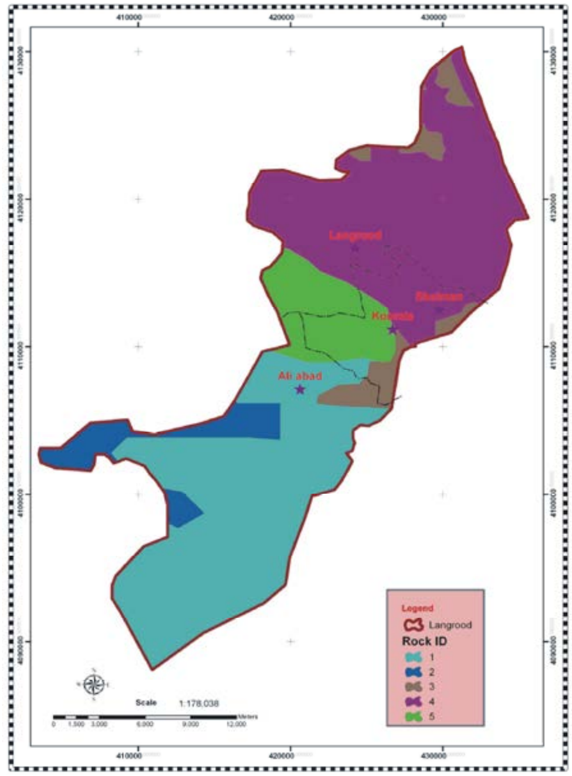

Fig. 7: Rock classes map

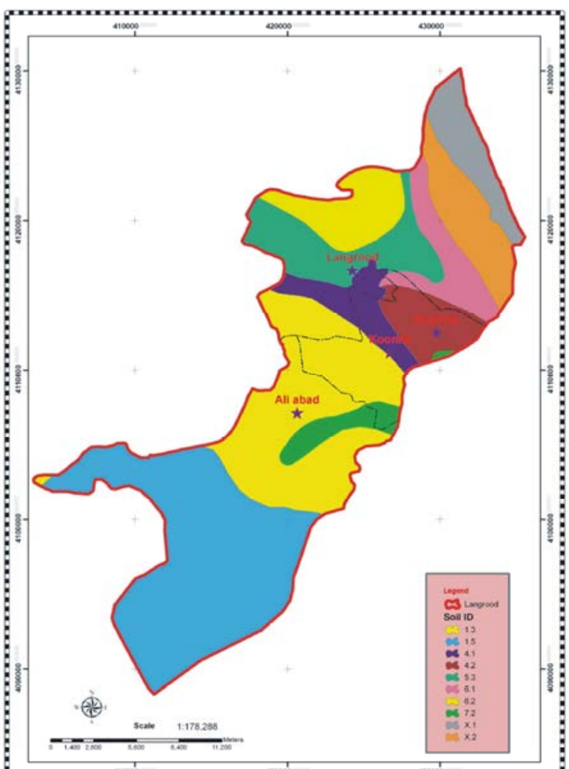

Fig. 6: Soil classes map

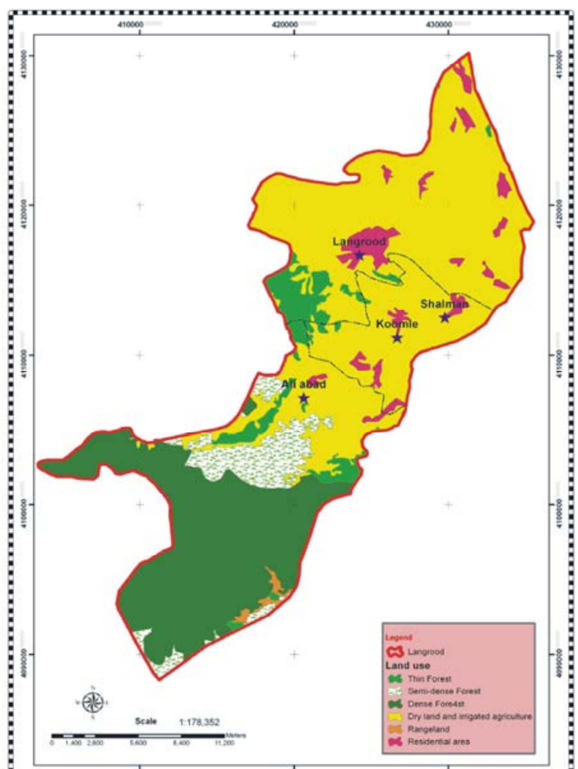

Fig. 8: Land use classes map

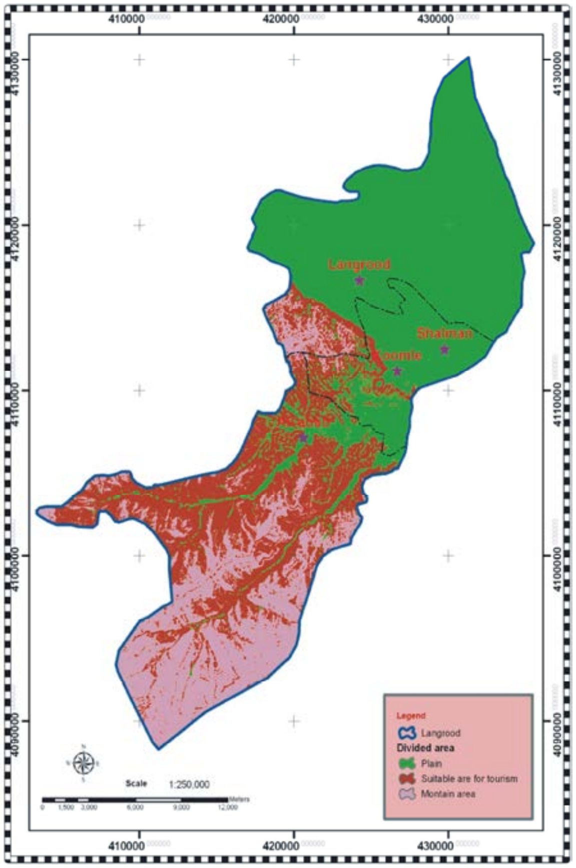

Fig. 9: Map of suitable areas for tourism development in the region.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

The consistency index of a randomly generated reciprocal matrix shall be called to the random index (RI), with reciprocals forced. An average RI for the matrices of order 1-15 was generated by using a sample size of 100 [15]. The table of random indexes of the matrices of order 1-15 can be seen in [4]. The last ratio that has to be calculated is CR (Consistency Ratio). Generally, if CR is less than 0.1, the judgments are consistent, so the derived weights can be used. The formulation of CR is:

$$CR = \frac{CI}{RI} \quad (3)$$

CONCLUSION

In this paper the application of multicriteria decision making in spatial problems and GIS application is discussed and in resumption AHP as a most applicable tool in this context was introduced. This study brings up a systematic approach and analytical means for tourism revival strategic marketing planning in tourism literature.

Parameters used to evaluate the potential for ecotourism development in the ecological model in GIS shows that 28.24 percent of land area equivalent to 12288.47 hectares is suitable zone to develop tourism.

Pairwise comparisons between the influential factors in AHP, showing the superiority of factor elevation with weight 0.302 and slope factor with weight 0.164 in order to limit the suitability of land for tourism development and as figure 9 shows With height and dense forests in the southern parts of the city and slope and vegetation are the limitation factors to tourism development. Compliance rate (CR) was calculated in this study, 0.083, respectively, which indicates the correctness of the 6valuation factor. We intend to distribute our method using the fuzzy TOPSIS and ELECTRE methods for tourism industry [16-20].

REFERENCES

1. Malczewski, J., 1999. GIS and Multicriteria Decision Analysis, Wiley and Sons INC, pp: 395.
2. Rajabi, M.R., A. Mansourian and M. Talei, 2011. A comparing study between AHP, AHP-OWA and fuzzy AHP-OWA multi-criteria decision making methods for site selection of residental complexes in Tabriz-Iran, Journal of environmental studies. Tehran, 37(57): 77-92.
3. Chakhar, S., 2003. Enhancing Geographical Information Systems Capabilities with Multi-Criteria Evaluation Functions, Journal of Geographic Information and Decision Analysis, 2: 47-71.
4. Saaty, T.L., 1980. The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation, McGraw-Hill, New York, NY, pp: 437.
5. Banan, Gh., 1981. Human environment and it's pollution protection, National Association for Protection of Natural Resources and Environment, Tehran, Iran, 1th edition, pp: 168.
6. Goeldner, C.R. and J.R.B. Ritchie, 2003. Tourism: Principles, Practices, Philosophies, 9th ed. NY, John Wiley and Sons, Inc.
7. Sonmez, S., Y. Apostolopolous and P. Tarlow, 1999. Tourism in Crisis: Managing the Effects of Terrorism, Journal of Travel Research, 38(1): 13-18.

8. Wickramasinghe, V. and S. Takano, 2007. A Model to evaluate the response and travel motivations to visit Tourist Destinations in Disastrous Regions, Proceedings of the 11th World Conference on Transportation Research (WCTR), 24-28 June, Berkeley, USA.
9. Bahrain, H. and R. Maknoon, 2001. Urban sustainable development from tought to act, Journal of environmental studies. Tehran, 28: 41-60.
10. Jafari, H. and A. Onagh, 2005. Zonning the protected area og Geno in GIS, Journal of environmental studies, Tehran, 38: 39-46.
11. Mahfoozi, M., A. Darvishsefat and F. Makhdoom, 2001. Watershed land use planning of Dadghan-Tafresh with Geographic information system, Journal of environmental studies. Tehran, 27: 99-108.
12. Makhdoum, M.F., 2008. Fundamental of land use planning. Tehran University publication, 8th edition.
13. Lee, A.H.I., W.C. Chen and C.J. Chang, 2008. A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan, Expert Systems with Applications, 34: 96-107.
14. Noori, S.H. and A. Norouzi, 2005. Tourism assessment of Chaghakhour Journal of Esfahan university. Esfahan, N., 1: 13-28.
15. Nobre, F.F., L.T.F. Trotta and L.F.A.M. Gomes, 1999. Multi-criteria decision making: An approach to setting priorities in health care, Symposium on statistical bases for public health decision making: from exploration to modeling, 18(23): 3345-3354.
16. Jafari Samimi, A., S. Sadeghi and S. Sadeghi, 2011. Tourism and Economic Growth in Developing Countries: P-VAR Approach, Middle-East Journal of Scientific Research, 10(1): 28-32.
17. Derakhshandeh, S. and N. Mikaeilvand, 2011. Fuzzy method for identification of aggregate weight in ordered weight averaging operators, Middle-East Journal of Scientific Research, 7(3): 293-295.
18. Rajaiee, Y., S.S. Hosseini, M. Boustani and E. Heidari, 2011. A Study of the Status Quo of Sports Tourism Industry in Western Provinces of Iran and Strategies for its Development, Middle-East Journal of Scientific Research, 9(6): 749-754.
19. Gandomi, Y., A. Shadi and A. Savari, 2011. Classification of Gomishan Lagoon (Caspian Sea, Iran) by Using the Coastal and Marine Ecological Classification Standard (CMECS), Middle-East Journal of Scientific Research, 8(3): 611-615.
20. Momeni, M., M.R. Fathi, M.K. Zarchi and S. Azizollahi, 2011. A fuzzy TOPSIS-based approach to maintance strategy selection: a case study, Middle-East Journal of Scientific Research, 8(3): 699-706.