Application of GIS, AHP, Fuzzy and WLC in Island Ecotourism Development (Case study of Qeshm Island, Iran)

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Abstract: Ecotourism is based on environmental abilities and natural resources that if it will be combined with specific planning and rehahabilitations due to ecotourism attraction potential it could be used as an approach to optimum use of area along its conservation. This study examines the applicability of an integrated spatial decision support framework which is according to geographic information systems (GIS), multicriteria evaluation (MCE) and fuzzy logic to suitable identify locations for ecotourism in Qeshm Island. In these research ecotourism criteria is classified in to 3 parts such as physical, biological and cultural socioeconomic criteria. Weight of criteria has been clarified based on AHP method. And criteria maps were digitized in GIS framework. Criteria of layer was standardized by fuzzy logic and map fuzzy of each criteria traced in GIS. According to WLC method suitable area of ecotourism development were clarified in Qeshm Island and the result showed that 35.58% of Qeshm Island where 530.50 km^2 is has high potential however 19.8% by 295.22 km^2 has no ecotourism potential.
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1. Introduction

Allong to the concept of sustainable development, many studies have concentrated on sustainable tourism development, including: Nash and Butler (1990), Jarvilouma (1992), Cater (1993), Stewart and Sekartjakrarini (1994), Driml and Common (1996), Weaver (1999, 2005) and Nouri and Malmasi (2004).

Sixty three percent of Europeans prefer to spend their holiday on seaside areas (Nouri et al., 2008).

Since the 1970s, tourism has been found as the strongest and fastest growing industry worldwide (Boo, 1990) and tourism can play an important role of a country's economy (Loperz and Monteros, 2002).

Tourism is considered as the most important cause of employment in the world. Which is directly or indirectly contained 200 million occupations or on the hand 10% of all jobs in the world and also approximately 10% of GDP belong to this industry in the world (Duha Buchsbaum, 2004).

The tourism industry is dramatically having an ecological impact on the world's protected areas and the increasing number of tourists shows both threats and opportunities (Goodwin, 1996)

Tourism which has sustainable natural resource is called ecotourism (Fung and Wong, 2007).

Ecotourism can play an important role in attracting support, in both fields of political and financial, to preserve threatened natural areas (Boo, 1990; Agardy, 1993; Dixon et al., 1993; Miller, 1993; Wall, 1993; Western, 1993; Burton, 1997; Instituto Nacional de Ecolog´ıa (INE), 1997; Ceballos-Lascura´in, 1998; Go¨ssling, 1999; Honey, 1999)

Ecotourism, which is known as ecological tourism, is a form of tourism that attracts to ecological and social conscious individuals (Ryngnga, 2008).

WTO is estimated that tourists using the Mediterranean coastal region alone will be reached to 350 million by 2020 (WTO, 2004).

A large number of tourists are attracted to coastal areas to look for sea air, beaches, sun, sea food and scenic views (Davenport and Davenport, 2006), influencing coastal area's resources and eco-systems, directly and indirectly (e.g. loss of wetlands and dunes, coastal erosion, etc.).

Approximately 60% of the world's population lives within 60 km of the coast. Which is rapidly increased due to the benefits of coastal areas offer for different activities such as tourism, fishing and sea transport activities (Sorensen and McCreary, 1990).

In sensitive environmental area specially coasts and Islands land use should be applied precisely. Sustainable development of Qeshm Island be attention to its situation along ecological and presence of special ecosystems such as coral reef, mangrove forest and areas like geopark has such a big deal. According to previous development disorder process and ambitiously developing plan which is predicted for this Island it's necessary to work on it by exact recognition of present position, offering the land use planning and environmental continuous management.

Over the previous years, studies of land-use management were mostly conducted within watershed and regional contexts (Ren,1997; Wang et al., 2004), concentrating on tourism area (Nouri et al., 2008; Fung and Wong, 2007; Aminu, 2007; Chhetri and Arrowsmith, 2008), agricultural area (Carsjens and Van der Knaap, 2002; Klocking et al., 2003), forest land (Sharawi, 2006) and land-use allocation of farming and forestry land (Riveiro et al., 2005).

A number of innovative approaches were applied in land-use management, covering land-use suitability assessment, land-use change predicting, land evaluation and land-use allocation. In the field of land-use suitability assessment, GIS techniques are known to be a powerful device that is implied by recent studies (Burrough, 1990; Pereira and Duckstein, 1993; Bojorquez-Tapia et al., 2001; Collins et al., 2001; Joerin et al., 2001; Ramandan and Aina, 2004; Phua and Minowa, 2005).

Many other approaches were also employed in past studies for coping with the allocation problems in land-use management, such as fuzzy allocation of forest land in British Columbia (Ells et al., 1997), GIS-based multicriteria evaluation and fuzzy sets to clarify priority sites for marine protection (Wood and Dragicevic, 2007), cost-benefit investigation on decision making for local land-use allocations (Mcdonald, 2001) and integer linear programming that is suitable for multi-site land-use allocations (Aerts et al., 2003).

The MCDM is a main approach that has been used to a wide range of natural resource management situations. From the scientific point of view and critical reviews of MCDM, it is clear that MCDM presents a suitable planning and decision-making framework for natural resources management and regional tourism planning, because it is inherently strong and not supposed to fail can lead to conflicting, multidimensional, incommensurable and incomparable objectives. (Anada and Herath, 2008; Mendoza and Martins, 2006)

Multiple Criteria Decision Support (MCDS) methods are decision analyses tools that have been developed for coping with all that information in order to support complex decision making with multiple objectives (Babaie-Kafaky et al., 2009).

So this study has attempted to determine the sustainable area for ecotourism development by MCDM method and GIS techniques.

2. Materials and methods

Site of Study

The Qeshm Island, with an area of 1491 km^2, is located in the farthest end eastern Persian Gulf in Hormoz Strait. It lies between 26 ° 32' and 27 ° 00' north latitude and between 55 ° 15' and 56 ° 16' east longitude. Its length is about 110 km and its width is less than 20 km and it is known as the biggest, richest and the most beautiful Island in Persian Gulf and its position in Hormozgan province in Iran was shown (Fig.1).

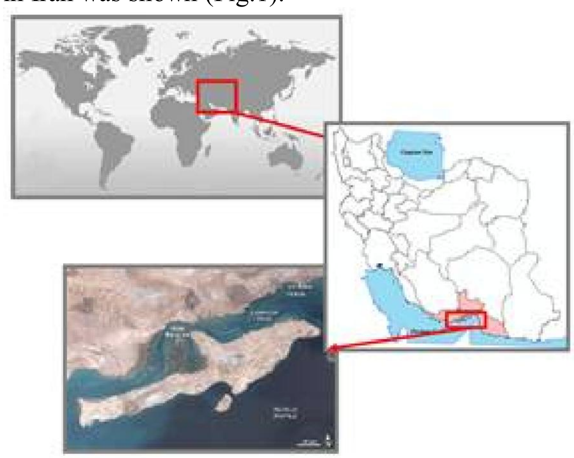

Fig. 1: The position of the Qeshm Island in Hormozgan province of Iran

Method

For the identification potential sites for ecotourism in Qeshm Island we applied a single-objective multi-criteria analysis methodology which is involving the following major steps:

(i) Identification of criteria and of their suitable ranges for each criterion;

(ii) Collection of necessary geographic data;

(iii) Weighthing of data layer

(iii) Standardization of each criterion

(iv) Obtaining Fuzzy maps of each criterion

(v) Calculation of the composite decision criterion for tourism potential sites.

Criteria that are impacting the suitability of land use for tourism were chosen by expert's judgment within reviewing relevant information from the literature. Criteria were mapped using accessible maps and data, fieldwork, RS, GIS and different methods.

All of criteria of land use for tourism were weighted with pair wise comparison by expert judgments within the analytical hierarchy process.

Saaty developed AHP in 1980, addresses how to determine the relative importance of a set of activities in a multi-criteria decision problem. AHP method makes it possible to incorporate judgments on intangible qualitative criteria alongside tangible quantitative criteria (Badri, 2001). The AHP process is based on three principles: first, structure of the model; second, comparative judgment of the alternatives and the criteria; third, combination of the priorities. In the literature, AHP, has been widely used in solving many complex decision-making problems (Xuling et al., 2009; Hsu et al., 2009; Dag˘deviren and Yüksel, 2008; Boroushaki and Malczewski, 2008; Onut and Soner, 2008 ; Chan et al., 2007; Kulak and Kahraman, 2005; Kahraman et al., 2003).

The AHP framework questionnaires was developed. In the questionnaire, respondents were determined relative importance of each criterion with respect to other, for example, importance of soil with respect to water.

These criteria maps are the input to multicriteria decision analysis. The map of criteria attributes are measured in different units. The criterion maps can be used in multicriteria decision analysis after they are standardized in multicriteria decision rules (Djenaliev, 2007).

The use of fuzzy logic theory by developing criterion layers is considered to let more flexible MCE operations, and explicitly take into account the continuity and uncertainty in the relation between the criteria and the decision set (Jiang and Eastman, 2000).

For instance, standardizing criterion layers to fuzzy measures means that the criterion value for each cell is standardized according to by measure of the possibility of belonging to the set along a continuous scale from 0 to 1 (real number scale) or 0 to 255 (byte scale) (Eastman, 2003).

To catch this continuous scale has been used the decision support module Fuzzy factor standardization. This module has the type of membership function like Sigmoid, J-shaped, Linear and the type of shape of membership function like monotonically increasing, monotonically decreasing, and symmetric. GIS is used for fuzzy operations which are based several algebraic operations on fuzzy numbers to showing fuzzy sets (Djenaliev, 2007).

The fuzzy set operation has been used in IDRISI for the solving of the problem to find a suitable location of a tourism site.

The simple additive weighting methods, also is known as weighted linear combination, is the most usual type of decision rule that is used in GIS-based on decision making (Malczewski, 1999).

A priority map for tourism was created by using GIS-based Weighted Linear Combination (WLC) model along with MCE analyzes. GIS could be used to identify specific developmental sites based on a set of criteria which is using economic, social and environmental data (Rachel and Chen, 2007).

3. Result

In this paper, we attempt to explore the potential of using GIS for ecotourism planning in Qeshm Island. As it was mentioned selecting of criteria for tourism in Qeshm Island was done according to literature and judgment (Beedasy and Whyatt, 1999; IUCN/WCPA, 1999 ; Kliskey, 2000 ; Steiner et al., 2000; lee, 2001; Katiyar and Nidhi, 2001; Tanzania coastal management partnership, 2003; Proctor and Drechsler, 2003; Perez et al., 2003; Brody et al., 2004; Ramand and Aina, 2004; Erkinand Usul, 2005; Yaakup et al., 2006; Garrod et al., 2006; Alvarez and French, 2006; National marine sanctuaries, 2006; Nouri et al., 2008; Ryngnga, 2008 ; Babaie-Kafaky et al., 2009; Bestard and Font, 2009; Luberichs, 2009; Windupranata and Hayatiningsih, 2009; Bukenya, 2012).

A GIS is set up for this study incorporating both spatial and non-spatial data. Layer of criteria was digitized in GIS. That slope map and hypsometry of Qeshm Island was done in GIS by using of DEM and most of criterion maps are digitized in GIS by using fieldwork and RS. Map of ecotourism criteria was shown in Qeshm Island (Fig 2 – 6).

The weights of each criteria was done by AHP method and judgment questionnaires. Saaty (1980) explain the development 9-point ratio response scale that is integral to the AHP. The decision maker can express his/her preference between every 2 factors verbally as equally important, moderately more important, strongly more important, very strongly more important, and extremely more Important.These descriptive preferences would then be changed into numerical ratings 1, 3, 5, 7, and 9, respectively, with 2, 4, 6, and 8 as intermediate values for compromising two successful qualitative judgments (Saaty, 1980). The composite weights of the alternatives are then determined by aggregating the weights throughout the hierarchy. One important benefit of using AHP is that it can measure the degree to which the pair wise comparisons are consistent (Hsu et al., 2009). This measure, consistency ratio (CR), let managers to detect inadvertent misjudgments in comparisons. If CR<0.1, then the comparisons are acceptable. If the CR is larger than 0.1, it is suggested that the decision maker reevaluate the comparisons, because some of the judgments are contradictory (Saaty, 1980).

Weight of factors are then used to each specific factor with a total sum equal to one. The weights show the relative degree of importance each factor plays in determining the suitability for an objective (Fung and Wong, 2007).

Because of scale differences upon which each criterion is measured, all criteria are standardized based on the fuzzy algorithm in which the shape of membership functions. After selecting the shape of membership functions, control points are used to define the suitable range of data value to be standardized into a 0–1 byte scale. The criteria for ecological modeling and MCE, weight of criteria and shape of membership function is shown in Table 1.

After determination of factor weights and standardization of map of criteria in IDRISI software, process of multicriteria evaluation was done. By use of WLC (weight linear combination) which is the most current method is decision multicriteria the evaluation of ecotourism in Qeshm Island was applied. At first criteria fuzzy value is multiplied by this own weight. Then by summing up the result, regional suitable map was shown for land use (Malczewski, 1999).

$$\mathbf{A_i = \sum_j W_j X_{ij}}$$

$\mathbf{A_i}$ **:** Final Utility

$\mathbf{W_j}$ **:** Factor Weight

$\mathbf{X_{ij}}$ **:** Factor Fuzzy Value

In this research, the external map is as a result of multicriteria evaluation for land suitability due to ecotourism development in Qeshm Island. Which is a combinations of number from values between 0-1.The number, the more land suitability and the less number, the less land suitability for tourism development we have.

Table 2 is suggested for the better showing of tourism capability in Qeshm Island and Fig. 7 shows tourism capability according to WLC method.

Table 1: criteria for ecological modeling and MCE, weight of criteria and shape of membership function

Criteria	Limits of Criteria Layer	weight of criteria	shape of membership function	Final Utility
Slope (%)		0.019	Monotonically decreasing (linear)	0-25% equal 1, 25- 50% between 1-0, more than 50% equal to 0
Elevation (m)		0.011	Monotonically increasing (linear)	0-100m equal 0, 100- 400m between 0-1, more than 400m equal to 1
Distance from Coast Line (km)		0.097	Monotonically decreasing (linear)	0-1 km equal 1, 1- 4 km between 1-0, more than 4 km equal to 0
Distance from Water Resources (m)	0-200 (m) Buffer	0.063	Monotonically decreasing (linear)	200-500 m equal 1, 500- 1500m between 1-0, more than 1500m equal to 0
Coast Combination		0.020	discrete	Sandy shore equal 1, Rocky shore equal 0.7, Muddy shore equal 0.4
Geology		0.040	discrete	Sandy Stone equal 1, Alluvium Sediment, Lime Stone, Clay Stone between 1-0, Marn equal to 0
Distance from Fault (m)		0.160	Monotonically increasing (linear)	0-500 m equal 0, 500- 1500m between 0-1, more than 1500m equal to 1
Soil		0.016	discrete	Depth Loam equal 1, Sand Loam Clay, Loam Clay, Loam Clay (Depth - Sub Depth) between 1-0, Low Depth Clay equal to 0
Ground Cover		0.013	Trapezoidal	0-5% equal 0, 5- 40% between 0-1, 40-60% equal 1, 60- 80% between 1-0, more than 80% equal to 0
Distance from Protected area (m)	0-200 (m) Buffer	0.101	Monotonically decreasing (linear)	200-500 m equal 1, 500- 3000 m between 1-0, more than 3000 m equal to 0
Distance from Sensitive habitat (m)	0-200 (m) Buffer	0.057	Monotonically decreasing (linear)	200-500 m equal 1, 500- 3000 m between 1-0, more than 3000 m equal to 0
Distance from Landscape (m)		0.108	Monotonically decreasing (linear)	0-200m equal 1, 200- 1500m between 1-0, more than 1500m equal to 0
Distance from Archaeological, istorical, Cultural Literary (m)		0.127	Monotonically decreasing (linear)	0-200m equal 1, 200- 1500m between 1-0, more than 1500m equal to 0
Distance from road (m)	0-150 (m) Buffer	0.031	Monotonically decreasing (linear)	150-300 m equal 1, 300- 1000 m between 1-0, more than 1000 m equal to 0
Distance from Port & Jetty (m)		0.028	Monotonically decreasing (linear)	0-200m equal 1, 200- 1000 m between 1-0, more than 1000 m equal to 0
Distance from Airport (km)		0.011	Monotonically decreasing (linear)	0-5 km equal 1, 5- 30 km between 1-0, more than 30 km equal to 0
Distance from Built – up Areas (m)		0.021	Monotonically decreasing (linear)	0-500 m equal 1, 500- 1500m between 1-0, more than 1500m equal to 0
Distance from Tourism facilities (m)		0.029	Monotonically decreasing (linear)	0-1500 m equal 1, 1500- 3000 m between 1-0, more than 3000 m equal to 0
Distance from Indusry Areas (m)		0.023	Monotonically decreasing (linear)	0-500 m equal 0, 500- 3000 m between 0-1, more than 3000 m equal to 1
Distance from Agricalture Areas and Garden (m)		0.024	Monotonically decreasing (linear)	0-50 m equal 1, 50- 1500 m between 1-0, more than 1500 m equal to 0

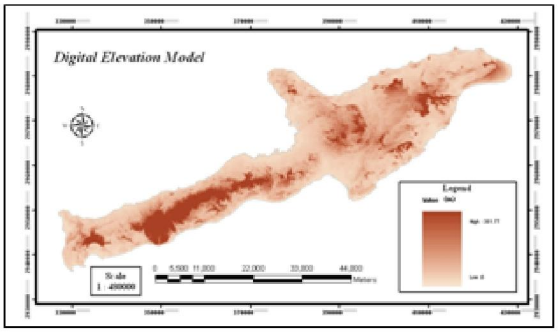

Fig. 2: Digital Elevation Model

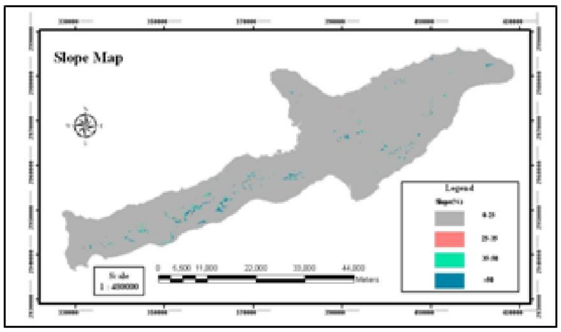

Fig. 3: Slope Map

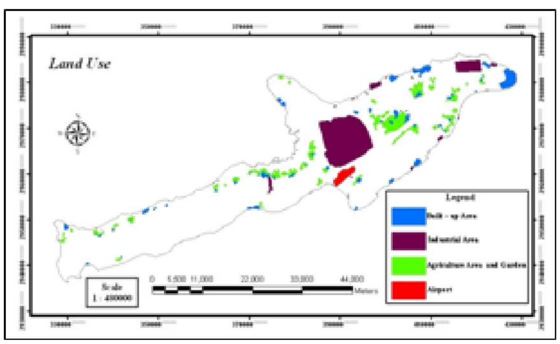

Fig. 4: Land Use

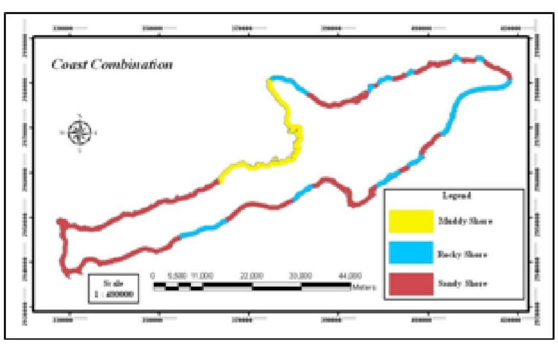

Fig. 5: Coast Combination

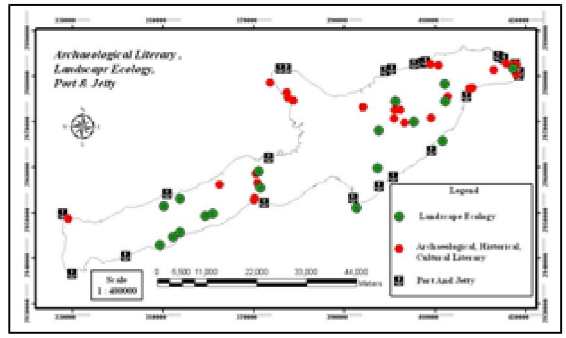

Fig. 6: Archaeological Literary, Landscape Ecology, Port & Jetty

Table 2: Qeshm Island Tourism Capability Classification

Final value for each pixcell	Tourism Capability	Class
0.8 - 1	Extremely Capability	1
0.6 - 0.8	High Capability	2
0.4 - 0.6	Moderate Capability	3
0.2 - 0.4	Low Capability	4
0 - 0.2	Unsuitable	5

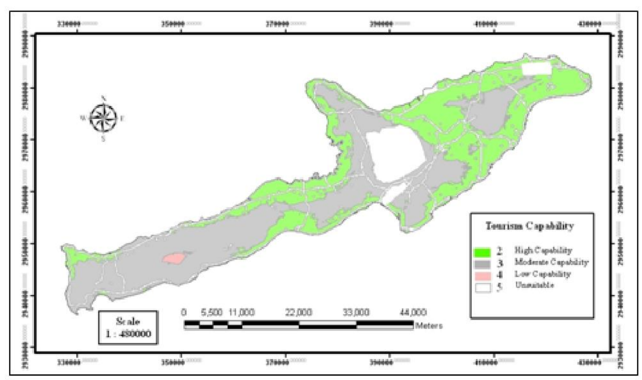

Fig. 7: Tourism Capability in Qeshm Island according to WLC

4. Conclusion

The objective of this study is to evaluate the potential for ecotourism planning in Qeshm Island.

Existing the monumental places, historical and cultural from Hakhamaneshian, Ashkanian and Sasanian dynasty, the beginning of Islam, Ilkhanian, Saljoghian, Teymorian, Safaviyeh, Ghajariye and Pahlavian dynasty, landscape of ecology such as Kaseh_ Salakh, Tandis valley (from Geopark region), Naz Island, coral reef, rocky and sandy shore, mangrove forest area which is located in the north of

Qeshm Island which is considered as a habitat of many living things and planting community that are able to continue their life in a special feeding environment, sea turtle breeding site, existing port and jetty for transferring passengers, having an access to tourism facilities and accommodation for tourists, existing of ground availability road and agricultural and gardening area in this region and not having any fault in this area causes that 35.58% of Qeshm Island with 530.50 km^2 has the highest capability tourism.

Ecological landscape contain Namakdan_ Mountain, Namak spring, Tang_ e _ Ali, Tang_ e_ Chahkooh, Shoor valley, Stair valley (from Geopark region), Kargah and Goori spring by having water healing, being near to the airport, existing agricultural lands and palms, having slope of 25-35%,being near to the fault in this area caused that 44.13% in Qeshm Island by 657.98 km^2 has the moderate capability.

By considering of high slope near 35% and lack of marine and ground availability roads and being far from the shore seaside, 0.49% of Qeshm Island with 7.31 km^2 has the lowest capability.

By considering to existing of Gavarzin gas source, industrial area, airport, buffer layer for availability road which are known as limited layers. 19.8% of Qeshm Island with 295.22 km^2 doesn't have any capability.

For identifying priority sites for marine protection we used GIS_ based multicriteria evaluation and fuzzy sets. These study shows that MCE is a suitable process which is used widely for land suitability region and it is directed the decision that both of them could be practiced in marine area planning (Wood and Dragicevic, 2007).

Ecotourism planning using multiple criteria evaluation with GIS was in used in Yan Chau Tong and closest ambient. In this study by using MCE process we clarified suitable are for conservation and recreational are which contains (camping, snorkel diving, heritage visit, hiking) and for each kind of land use suitable criteria was suggested (Fung and Wong, 2007).

The study under the name Methods of Spatial analysis in GIS was done. That in research it was clarified that WLC process can be performed by GIS overlaying capability.Overlaying techniques in GIS shows that external map is combination criteria of map (Burrough, 1990).

The results can show as a guideline and support for ecotourism planning. The use of GIS and MCE techniques impressively helps ecotourism planning. MCE is a sound device for ecotourism planning, since it takes into consideration the various criteria that have a significant impact on the decision. MCE has also effectively been applied the most suitable areas for the different activities with specific sets of criteria.

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