Iranian Journal of Fisheries Sciences 19(4) 1728-1748 2020
DOI: 10.22092/ijfs.2019.119278.

Strategic planning for optimal development of aquaculture in coastal areas of Qeshm Island

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Received: October 2016 Accepted: August 2017

Abstract

The economic growth of aquaculture and the dependence of a large growing population on coastal resources have led to coastal degradation and reduced resources. In this paper while realizing the potential capacities of the island systems, the aquaculture activities of the island are specially discussed in the framework of Integrated Coastal Zone Management (ICZM). Therefore, in this study, firstly, the internal strategic factors (strengths and weaknesses) and external factors (opportunities and threats) of the environment were identified. Thereafter, Analytic Network Process (ANP) and Super Decision Software in SWOT matrix were used to evaluate and prioritize these factors, as well as to develop several proposed strategies. Using a designed network model, the proposed strategies were weighted and the main strategies of the evaluation matrix were ranked. In this study, the Qeshm Island as the largest island in the Persian Gulf was identified as the study area. The results showed that the most efficient strategies to optimal development of aquaculture use of coastal areas of Qeshm Island are using objectives, policies, and plans of aquaculture and aquatic hunting to build and strengthen sustainable aquaculture in the region, build and strengthen comprehensive aquaculture plans for conservation of natural marine resources in the framework of ICZM, create and develop infrastructure facilities and aquaculture infrastructure in order to create optimum use of the lands, allocate adequate funding to achieve conservation programs and user development of aquaculture and environmental protection involved in (ST) strategies.

Keywords: Aquaculture, Analytic network process, Strategic planning, SWOT model, Qeshm Island

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Introduction

Coastal Zones are considered sensitive and frail because of their geographical location and natural characteristics, biodiversity and associated ecosystems and constant influence of both land and sea; and they are very vulnerable to environmental changes and human activities (Sekhar, 2005; Hasanzadeh *et al*., 2013). However, ecological functions of coastal zones have led to the establishment of a wide range of human developments and exploitation in such zones while lack of attention to their structural stability and natural processes occurring in those zones will not guarantee sustainable development (FDA, 2012). Attempts to strike a balance between structural and ecological functions of coastal zones and development of human activities is a subject that has attracted attention in the field of environmental management of coastal zones within the framework of Integrated Coastal Zone Management (Mousavi *et al*., 2015). Therefore, in the Integrated Coastal Zone Management of Iran, objectives and strategies of environmental management are set and organized based on two approaches; protection-oriented and development-oriented approaches (Pak and Majd, 2011). In the protection-oriented approach, the main objectives of environmental management of coastal zones in Iran include; protecting the environment of coastal zones both on land and in sea, supporting biodiversity of coastal zones, reducing or preventing pollution of coastlines, exploiting the coastal resources concerning the potential of the territory while the development-oriented approach include paying attention to equal socioeconomic development of coastal areas and facilitating the process of acquisition of economic benefits (Lau, 2005; Pak and Farajzadeh, 2007). In the development-oriented approach, there are 6 main functions of coastal zones in Iran. These include environmental protection, agriculture, ecotourism, aquaculture, industries and mines and human settlements. Therefore, among the main functions of coastal zones in Iran, development of aquaculture as one of the main applications of development-oriented approach in Integrated Coastal Zone Management (ICZM) is remarkable (Zarei *et al*., 2016).

Factors that negatively affect the environment and sensitive ecological areas and as such threaten the resources of future generations are rapid population growth in coastal areas and uncontrolled exploitation of natural resources in these areas through the development of economic activities such as aquaculture and the dependence of a large segment of the population on these areas (Stancheva *et al*., 2016). The keys to success and survival of coastal ecosystems are sustainable dynamism, monitoring, and appropriate planning and management of the environment (Calado *et al*., 2016).

Qeshm has agriculture, aquaculture, industry, tourism uses, and it is a residential and population center. The residential part in coastal zones of Qeshm Island has formed the base settlement function, and aquaculture, fisheries, tourism and port activities are considered economic functions.

Since aquaculture use is one of the important coastal development approaches in Integrated Coastal Zone Management in Iran, the proposed model was based on ecological, social and economic criteria to develop appropriate strategies in coastal zones. At present, multi-criteria decision-making models are gaining wide popularity in increasing the accuracy of planning due to the fact that their qualitative and quantitative criteria can lead to selecting the best management option (Malczewski, 2002). Lots of instruments and quantitative techniques are used for strategic management. Since the main element in this field is making multiple considerations, the multi-criteria decision-making techniques (MCDM) have the highest usage (Moghimi *et al*., 2014). One of the main tools for decision support is SWOT matrix. This method examines the internal and external factors affecting organization performance to help decision makers formulate strategies on the basis of strengths to decrease weaknesses and use opportunities to reduce or avoid threats (Dayson, 2004). SWOT analysis alone cannot be used for the comprehensive evaluation of strategic decision-making processes (Chen and Yang, 2011). In most cases, the result of SWOT analysis is only a partial list of internal and external quality factors (Hasanzadeh *et al*., 2013). Although the SWOT can determine factors carefully and successfully, it fails to quantify the weights and the effects of strategic factors on choices. So, other decision support systems must be used to solve this problem (Lee and Kim, 2000). Therefore, the Analytic Network Process was introduced because the factors involved in SWOT analysis are not independent, but sometimes, there are some relations among them (Hasanzadeh *et al*., 2013). Therefore, by the introduction of the Analytic Network Process by "Thomas L. Saaty" a new approach emerged in the field of decision-making.

One of the pioneers in the world, conducting research in the realm of ANP was Saaty (1996). He conducted different scientific works, and many researchers worldwide make reference to his works on ANP. Some of the recent applications of SWOT and ANP are using the analytic network process (ANP) in a SWOT analysis – A case study for a textile firm (Yuksel and Dagdeviren, 2007), Analytic network process for criteria selection in sustainable coastal land use planning (Pourebrahim *et al*., 2010), A fuzzy ANP-based approach to evaluate region agricultural drought risk (Chen and Yang, 2011), Presentation of Coastal Environmental Management Plan using SWOT/ANP methods (Sharifipour and Mahmodi, 2012), Development of a fuzzy ANP based SWOT analysis for the airline industry in Turkey (Sevkli *et al*., 2012), Effectiveness of the Indian coastal regulation zones provisions for coastal zone management and its evaluation using SWOT analysis (Panigrahi and Mohanty, 2012), Evaluation of harvesting methods for Sustainable Forest Management (SFM) using the Analytical Network Process (Ghajar and Najafi, 2012), The application of Analytical Network Process to environmental prioritizing criteria for coastal oil jetties site selection in Persian Gulf coasts (Hasanzadeh *et al*., 2013), An ANP–SWOT approach for interdependency analysis and prioritizing the strategies of the steel scrap industry of Iran (Shahabi *et al*., 2014), Fuzzy analytic network process approach to evaluate land and sea criteria for land use planning in coastal areas (Najafinasab *et al*., 2015), The environmental management problem of Pohorje, Slovenia: A new group approach within ANP - SWOT framework (Groselj and Stirn, 2015), Selection of the optimal tourism site using the ANP and fuzzy TOPSIS (technique for order performance by similarity to ideal solution) in the framework of Integrated Coastal Zone Management (Zarei *et al*., 2016).

Different processes are proposed to conduct research using the combined SWOT and ANP method, but the method used in this paper is a combination of these different methods. Therefore, it is difficult to develop a strategic plan for environmental management and development of protected coastal areas in such an area which has faced critical problems due to coastal area development approaches. This problem can be solved through Multi-Criteria Decision Making (MCDM) techniques. The main objective of this study was to develop a model of strategic planning for the optimal development of aquaculture use in coastal areas of Qeshm Island. In this process, the ecological power of the mentioned coastal area can be identified, and using the SWOT-ANP combined model, some practical solutions and strategies have been formulated to extend the applicability of future aquaculture use.

Materials and methods

Case study

Qeshm Island is the largest island of the Persian Gulf (26° 50′ N 56°0′ E). It is located in southern Iran in the Hormozgan district. The population is estimated at about 120,846 people according to the 2011 census. The distance of Qeshm to Bandar Abbas is 20 km. It has an area of over 1295 km^2 and almost 100 kilometers long. The Qeshm Island has about 292 km of coastline (Statistical Center of Iran, 2011). Fig. 1 shows the geographical location of the study area.

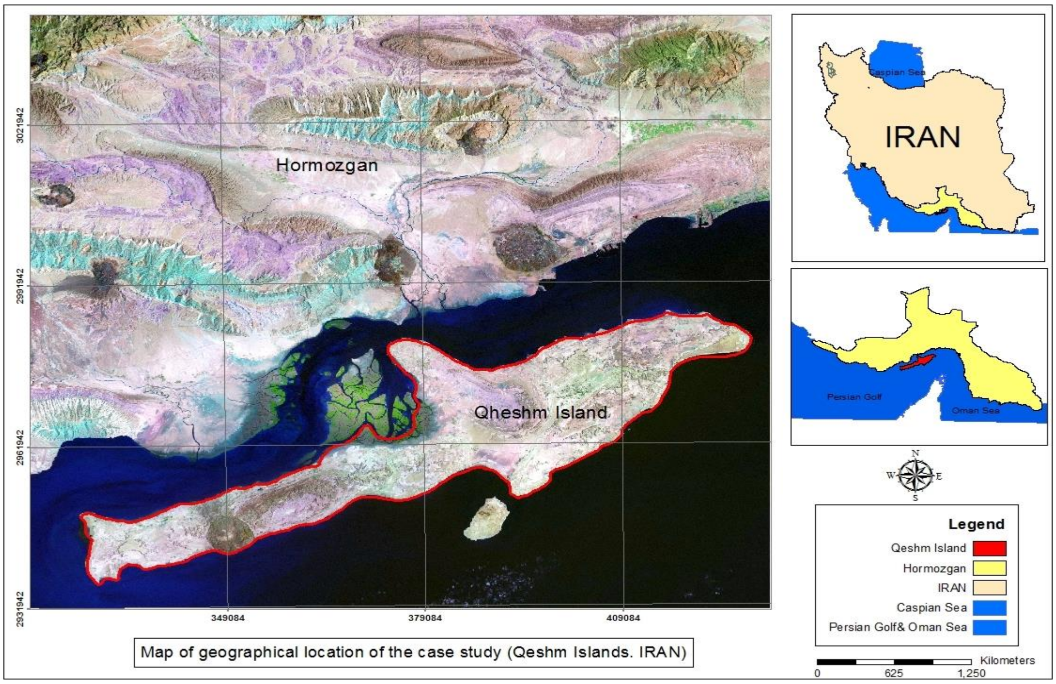

Figure 1: Map of geographical location of the Qeshm Islands.

Methodology

The present study is a practical one that used literature review and survey approaches, such as interview and questionnaire, to collect data. In this study, the SWOT analysis model and Analytic Network Process (ANP) were used to analyze the data (Sharifipour and Mahmodi, 2012). Given that the prerequisite for strategic planning is comprehensive knowledge about the region, the first step to implement SWOT for strategic management of optimal development of aquaculture use was done based on the comprehensive framework of strategy implementation. To this end, factors affecting the optimal development of aquaculture use in coastal areas of Qeshm Island were identified and analyzed. The internal and external factors were determined using the Delphi method, which involves the use of expert questionnaires. To obtain the opinions and views of managers, and experts in the region, 35 four-pointed questionnaires, which were prepared based on the Cochran formula of determining the sample size, were distributed among them. Subsequently, an initial list comprising internal and external factors affecting the development of aquaculture use strategies in coastal areas of Qeshm Island was prepared by these participants. To meet the aims of the present study, the main internal and external factors were matched using SWOT matrices to implement strategies in line with the purpose of the study and the main internal and external factors of the mentioned environment (Table 1). Finally, in order to devise decisions on different strategic choices in the previous stage, the compiled methods of SWOT and ANP were analyzed, matched and judged objectively, and optimal strategies were selected for the optimal development of aquaculture use in coastal areas of Qeshm Island.

The SWOT method

SWOT analytical study designed in the form of tables and stages are as follows:

- Providing a list of opportunities, threats, strengths and weaknesses
- Interpreting each of the opportunities, threats, strengths and weaknesses in terms of the conceptual model
- Using SWOT analytical model in analyzing data and determining strategies

The basic principle in strategic planning is to develop the strategy using external opportunities and preventing and mitigating the effects of external threats. On the other hand, the purpose of developing these strategies is determining applicable strategies rather than identifying the best strategy. Therefore, an organization can react defensively or offensively to external factors (Nikolaou and Evangelinos, 2010).

In this paper SWOT analysis is designed in the form of tables and stages as follows:

1. Preparing a list of opportunities, threats, strengths and weaknesses in the form of tables
2. Describing and interpreting each of the opportunities, threats, strengths in terms of analysis of spatial and regional planning
3. Identifying implementation strategies based on the analysis of internal and external strategic factors

The ANP method

The ANP model consists of three elements, (1) goal of selecting the best alternative, (2) criteria and sub criteria for the model, and (3) alternatives. The elements in the hierarchy of determinants are divided into dimensions and attribute enablers. Identification of dimensions and attribute enablers at each level and definition of inter relationships is necessary for the development of the decision model. The objective of hierarchy is ultimately to find out the alternatives (Najafinasab *et al*., 2015).

For proper pairwise comparison of matrices, the opinion of experts has been collected using a nine-point scale as listed (Table 1). The pair-wise comparisons are made in terms of, how element A is more important than element B. It uses a ratio scale for each level of criteria, sub criteria, and alternatives, which allows the construction of relative weight matrices (Sakthivel *et al*., 2015). For example, for a given criterion in the first row, if alternative A is “Very Strongly Preferred” over alternative B, then a weight of 7 is entered. If the alternative A is “Strongly Preferred” over alternative C, then a weight of 5 is entered. The judgment matrix A in which every element a_{ij} (i, $j = 1, 2, \dots, n$) is the quotient of weights of the criteria, as shown:

$$A = \begin{pmatrix} a_{11} & a_{12} \cdots & a_{1n} \\ a_{21} & a_{22} \cdots & a_{2n} \\ \vdots & \vdots \ddots & \vdots \\ a_{31} & a_{32} \cdots & a_{3n} \end{pmatrix}, a_{ii} = 1, a_{ii} = \frac{1}{a_{ij}}, a_{ij} \neq 0 \quad (1)$$

The decision matrix for the optimum blend selection is formulated by identified criteria and alternatives using Eq. (1).

In the last step, the mathematical process is commenced to normalize and find the relative weights of each matrix. The relative weights are given by the right Eigenvector (w) corresponding to the largest Eigen value (λ_{max}), as

$A_w = \lambda_{max} w$. (2)

If the pair wise comparisons are completely consistent, the matrix A has rank 1 and $\lambda_{max} = n$. In this case, weights can be obtained by normalizing any of the rows or columns of A (Wang and Yang, 2007).

It should be noted that the quality of output of ANP is strictly related to the consistency of the pair wise comparison judgments. The consistency is defined by the relation between the entries of A: $a_{ij} \times a_{jk} = a_{ik}$. The Consistency Index (CI) is

$CI = (\lambda_{max} - n)/(n - 1)$. (3)

The final consistency ratio (CR), usage of which let someone to conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the CI and the random index (RI), as indicated.

$CR = CI/RI$ (4)

where RI is the average index for randomly generated weights. The number 0.1 is the accepted upper limit for CR. If the final consistency ratio exceeds this value, the evaluation procedure has to be repeated to improve consistency. The measurement of consistency can be used to evaluate the consistency of decision makers as well as the consistency of overall hierarchy (Dagdeviren *et al*., 2009).

Table 1: Nine-point intensity of importance scale and its description.

Intensity of importance	Definition	Explanation
1	Equally important	Two activities contribute equally to the objective
3	Moderately more important	Experience and judgment slightly favor one over another
5	Strongly more important	Experience and judgment strongly favor one over another
7	Very strongly more important	Activity is strongly favored and its dominance is demonstrated in practice
9	Extremely more important	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent compromise between the priorities listed above

Proposed ANP algorithm for SWOT

The hierarchy and network model proposed in this study for SWOT analysis is composed of four levels. The goal (best strategy) is indicated in the first level, the criteria (SWOT factors) and sub-criteria (SWOT sub-factors) are found in the second and third levels respectively, and the last level is composed of the alternatives (alternative strategies). The super-matrix of a SWOT hierarchy with four levels is as follows:

$$W = \begin{array}{r} \text{goal} \\ \text{SWOT factors} \\ \text{SWOT sub-factors} \\ \text{Alternative} \end{array} \begin{bmatrix} 0 & 0 & 0 & 0 \\ W_{21} & 0 & 0 & 0 \\ 0 & W_{32} & 0 & 0 \\ 0 & 0 & W_{43} & I \end{bmatrix}$$

Where W_{21} is a vector which represents the impact of the goal on the criteria, W_{32} is a matrix that represents the impact of the criteria on each of the sub-criteria, W_{43} is a matrix that represents the impact of the sub-criteria on each of the alternatives, and I is the identity matrix.

To apply the ANP to matrix operations in order to determine the overall priorities of the alternative strategies identified with SWOT analysis, the proposed algorithm is as follows:

Step 1: Identify SWOT sub-factors and determine the alternative strategies according to SWOT sub-factors.

Step 2: Assume that there is no dependence among the SWOT factors; determine the importance degrees of the SWOT factors with a 1–9 scale (i.e. calculate W_1)

Step 3: Determine, with a 1–9 scale, the inner dependence matrix of each SWOT factor with respect to the other factors by using the schematic representation of inner dependence among the SWOT factors:(i.e. calculate W_2).

Step 4: Determine the interdependent priorities of the SWOT factors (i.e. calculate $w_{\text{factors}} = W_2 \times W_1$)

Step 5: Determine the local importance degrees of the SWOT sub-factors with a 1–9 scale (i.e. calculate $w_{\text{sub-factors (local)}}$)

Step 6: Determine the global importance degrees of the SWOT sub-factors (i.e. calculate $w_{\text{sub-factors (global)}} = w_{\text{factors}} \times w_{\text{sub-factors (local)}}$)

Step 7: Determine the importance degrees of the alternative strategies with respect to each SWOT sub-factor with a 1–9 scale (i.e. calculate W_4)

Step 8: Determine the overall priorities of the alternative strategies, reflecting the interrelationships within the SWOT factors (i.e. calculate $w_{\text{alternatives}} = W_4 \times w_{\text{sub-factors (global)}}$)

Application of the proposed ANP model

In this study, at first internal and external environment analysis is performed by a specific workshop. Based on these analyses, the strategically important sub-factors, i.e. the sub-factors which have very significant effects on the success of the organization, are determined. Using the SWOT sub-factors, the SWOT matrix and alternative strategies based on these sub-factors are developed (Table 2).

It can be seen from Table 2, that the organization has four alternative strategies. The strategy identified as SO involves making good use of opportunities by using the existing strengths of the organization. The WO strategy seeks to gain benefit from the opportunities presented by the external environmental factors by taking into account the weaknesses of the organization. Similarly, ST is the strategy associated with using the organization strengths to remove or reduce the effects of threats. The fourth and last strategy is WT, in which the organization tries to reduce the effects of its threats by taking its weaknesses into account. In this study, the aim of the SWOT analysis is to determine the priorities of the strategies developed and to determine the best strategy for the organization.

Table 2: Swot matrix

	Internal factors	
External factors	**Strengths (S)**	**Weaknesses (W)**
	S1: The variety of fishes and productive shrimp habitats in the coastal area S2: The long time presence of fishing in the region S3: The ability to develop processing - supplementary fisheries industry in the area and improve the economic situation of the residents of the region. S4: Available valuable fisheries resources in the region with high quality and reasonable price S5: The presence of proper conditions for shrimp reproduction and breeding in the littoral zone S6: The possibility of sea fishing and no need for production equipment	W1: Low income and low productivity in traditional fishing for local people W2: Reduction in aquatic stocks and the lack of investment for the protection and remaking of aquatic W3: Lack of adequate studies on other potential development methods of aquaculture such as cage farming W4: Lack of community involvement in policy making W5: High expenditure of aquaculture involves inputs, transportation and decreasing the added value W6: Illegal and indiscriminate hunting and fishing and non-compliance with fishing standards in the beaches
Opportunities (O)	**SO Strategies**	**WO Strategies**
O1: Efficient use of sea water in aquaculture and increase demand for fishery products O2: Increased attention of government to eliminate deprivation in rural and border areas as a national strategy O3: The possibility of using various communications for the transfer of aquatics to the other sectors and proximity to markets of Persian Gulf and Oman Sea O4: The presence of specialized human resources in the development of aquaculture at different levels in the region O5: The possibility of private sector participation and investment in aquaculture use and fisheries activities O6: plans for land use planning in coastal provinces and islands	SO1: Granting facilities to residents to farm aquaculture exports and its economic and social impact on their quality of life SO2: Using of new technologies and techniques to improve the quality of aquaculture without environmental hazards SO3: Integration of fisheries and aquaculture in order to enhance the level of income and livelihood of villagers in Qeshm Island SO4: Aquaculture development, seafood industry and export development in order to increase food security of residents of the region and other regions of the country	WO1: Codification of aquaculture comprehensive plan and coastal management in order to improve the quality of the environment WO2: Creating sustainable fisheries with the active participation of fishermen in the management of conservation, restoration and sustainable utilization of resources WO3: Greater Government attention to development and elimination of cultural and economic deprivation in coastal villages through increasing aquaculture and fisheries activities WO4: Increase the number of residents in villages and prevent their migration and create employment for the residents of villagers
Threats (T)	**ST Strategies**	**WT Strategies**

Table 2 continued:

T1: Lack of economic incentives to invest due to deprived and underdeveloped coasts	ST1: Allocating production subsidies and grants to the researchers who create innovative ideas in aquaculture development in the region	WT1: Special attention to education, promote and enhance the environmental awareness of decision-makers in the field of aquaculture
T2: Destruction and pollution of coastal sea water due to the entrance of wastewater and waste produced by aquaculture	ST2: Using the power of public participation in all stages of planning and implementing the optimum use of aquaculture and its positive effect on local communities	WT2: Development of aquaculture (shrimp) as a capacity in the villages of the region to improve quality of life of the residents
T3: Existence of competitive markets in other neighboring countries	ST3: Creating and developing infrastructure facilities and infrastructure aquaculture in order to create optimum use of the land	WT3: Using the potential of the region to maintain and develop aquaculture as a capacity in the region
T4: Illegal and trafficking jobs that have higher profitability than aquaculture	ST4: Allocating adequate funds for development in fisheries and aquaculture industries in coastal areas of Qeshm Island	WT4: Identifying and enjoying the region's potential and benefits of fishing and shrimp farming in order to compete with other fishing regions of the country
T5: Lack of comprehensive plans and management and systemic approach to the development of aquaculture and job creation		
T6: Lack of local community' access to the region and world markets due to political problems		

For this proposed model, 8 steps should be taken as described below:

Step 1: The problem is converted into a network structure in order to transform the sub-factors and alternative strategies into a state in which they can be measured by the ANP technique.

Step 2: Assuming that there is no dependence among the SWOT factors, pairwise comparison of the SWOT factors using a 1–9 scale is made with respect to the goal. The comparison results are shown in Table 3.

All pairwise comparisons in the application are performed by the expert team mentioned in the beginning of the study.

The pairwise comparison matrix, given in Table 3, is analyzed using Super Decision software, and the following eigenvector is obtained. In addition, the consistency ratio (CR) is provided in the last row of the matrix.

Table 3: Pairwise comparison of SWOT factors by assuming that there is no dependence among them.

SWOT factors	S	W	O	T	Relative importance
Strengths (S)	1	5	3	2	0.397
Weaknesses (W)		1	1/2	1/4	0.136
Opportunities (O)			1	1/2	0.209
Threats (T)				1	0.258
CR = 0.0٢					

$$W_1 = \begin{bmatrix} S \\ W \\ O \\ T \end{bmatrix} = \begin{bmatrix} 0.397 \\ 0.136 \\ 0.209 \\ 0.258 \end{bmatrix}$$

Step 3: Inner dependence among the SWOT factors is determined by analyzing the impact of each factor on every other factor using pairwise comparisons. Based on the inner dependencies among the SWOT factors, pairwise comparison matrices are formed for the factors (Table 4). The following question, *''what is the relative importance of strengths when compared with threats on controlling weaknesses?''* may arise in pair wise comparisons and lead to a value of 9 (absolute importance) as denoted in Matrix 2 of Table 3. The resulting eigenvectors are presented in the last column in Matrixes 1-4 of Table 4. Using the computed relative importance weights; the inner dependence matrix of the SWOT factors (W_2) is formed. Based on the interdependence between SWOT factors, the following results were obtained (Table 4).

Table 4: Pairwise comparison of SWOT factors by assuming that there is dependence among them.

Matrix 1- The inner dependence matrix of the SWOT factors with respect to ''Strengths''				
Strengths	**Weaknesses**	**Opportunities**	**Threats**	**Relative importance**
Weaknesses	1	1/5	1/3	0.175
Opportunities		1	2	0.489
Threats			1	0.336
CR = 0.02				
Matrix 2- The inner dependence matrix of the SWOT factors with respect to ''Weaknesses''				
Weaknesses	**strengths**	**Opportunities**	**Threats**	**Relative importance**
Strengths	1	5	3	0.601
Opportunities		1	1/2	0.125
Threats			1	0.274
CR = 0.01				
Matrix 3- The inner dependence matrix of the SWOT factors with respect to ''Opportunities''				
Opportunities	**strengths**	**Weaknesses**	**Threats**	**Relative importance**
Strengths	1	7	3	0.718
Weaknesses		1	1/5	0.089
Threats			1	0.213
CR = 0.01				
Matrix 4- The inner dependence matrix of the SWOT factors with respect to ''Threats''				
Threats	**strengths**	**Weaknesses**	**Opportunities**	**Relative importance**
Strengths	1	5	3	0.474
Weaknesses		1	1/5	0.119
Opportunities			1	0.407
CR = 0.02				

Finally the matrix of interdependence between SWOT factors is as follows:

$$W_2 = \begin{bmatrix} 1 & 0.601 & 0.718 & 0.474 \\ 0.175 & 1 & 0.089 & 0.119 \\ 0.489 & 0.125 & 1 & 0.407 \\ 0.336 & 0.274 & 0.213 & 1 \end{bmatrix}$$

Step 4: The interdependent priorities of the SWOT factors are calculated as follows:

$$W_{Factors} = W_2 \times W_1 = \begin{bmatrix} 1 & 0.601 & 0.718 & 0.474 \\ 0.175 & 1 & 0.089 & 0.119 \\ 0.489 & 0.125 & 1 & 0.407 \\ 0.336 & 0.274 & 0.213 & 1 \end{bmatrix} \times \begin{bmatrix} 0.397 \\ 0.136 \\ 0.209 \\ 0.258 \end{bmatrix} = \begin{bmatrix} 0.375 \\ 0.128 \\ 0.261 \\ 0.236 \end{bmatrix}$$

Significant differences are observed in the results obtained for the factor priorities (W_1, Table 3) when the interdependent priorities of the SWOT factors ($w_{factors}$) and dependencies are ignored. The results change from 0.397 to 0.375, 0.136 to 0.128, 0.209 to 0.261, and 0.258 to 0.236 for the priority values of factors S, W, O and T, respectively.

Step 5: Local priorities of the SWOT sub-factors are calculated using the pairwise comparison matrix. The pairwise comparisons matrices are detailed in Table 5. Priority vectors obtained by analyzing the pairwise comparison matrices provided in Table 5 are shown below.

$$W_{\text{Sub-factors(strengths)}} = \begin{bmatrix} 0.065 \\ 0.101 \\ 0.254 \\ 0.074 \\ 0.198 \\ 0.308 \end{bmatrix} \quad W_{\text{Sub-factors(weaknessess)}} = \begin{bmatrix} 0.093 \\ 0.313 \\ 0.045 \\ 0.259 \\ 0.215 \\ 0.075 \end{bmatrix} \quad W_{\text{Sub-factors(oppurtunities)}} = \begin{bmatrix} 0.349 \\ 0.096 \\ 0.124 \\ 0.040 \\ 0.146 \\ 0.245 \end{bmatrix} \quad W_{\text{Sub-factors(threats)}} = \begin{bmatrix} 0.057 \\ 0.231 \\ 0.112 \\ 0.075 \\ 0.213 \\ 0.312 \end{bmatrix}$$

Step 6: In this step, the overall priorities of the SWOT sub-factors are calculated by multiplying the interdependent priorities of SWOT factors found in Step 4 with the local priorities of SWOT sub-factors obtained in Step 5. The computations are provided in Table 6. The $w_{\text{sub-factors (global)}}$ vector, obtained by using the overall priority values of the sub-factors in the last column of Table 6, is provided below.

Table 5: Pairwise comparison matrices for SWOT sub-factors local priorities.

Matrix 1- Pairwise comparison matrices for strengths sub-factors							
Strengths	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**	**weights**
S_1	1	1/3	1/5	1/2	1/3	1/5	0.065
S_2		1	1/3	3	1/2	1/3	0.101
S_3			1	5	3	1/2	0.254
S_4				1	1/2	1/5	0.074
S_5					1	1/3	0.198
S_6						1	0.308
CR = 0.02							
Matrix 2- Pairwise comparison matrices for weaknesses sub-factors							
Weaknesses	**W_1**	**W_2**	**W_3**	**W_4**	**W_5**	**W_6**	**weights**
W_1	1	1/3	3	1/3	1/2	2	0.093
W_2		1	1/3	2	3	5	0.313
W_3			1	1/4	1/3	1/2	0.045
W_4				1	2	3	0.259
W_5					1	2	0.215
W_6						1	0.075
CR = 0.03							
Matrix 3- Pairwise comparison matrices for opportunities sub-factors							
Opportunities	O_1	O_2	O_3	O_4	O_5	O_6	weights
O_1	1	5	3	7	3	2	0.349
O_2		1	1/3	2	1/3	1/5	0.096
O_3			1	3	1/2	1/3	0.124
O_4				1	1/3	1/5	0.040
O_5					1	1/2	0.146
O_6						1	0.245
CR = 0.02							

Table 5 continued:

Matrix 4- Pairwise comparison matrices for threats sub-factors

Threats	T_1	T_2	T_3	T_4	T_5	T_6	weights
T_1	1	1/5	1/3	1/2	1/4	1/7	0.057
T_2		1	3	4	2	1/3	0.231
T_3			1	٢	1/2	1/5	0.112
T_4				1	1/3	1/6	0.075
T_5					1	1/3	0.213
T_6						1	0.312
CR = 0.03							

Table 6: Overall priority of the SWOT sub-factors.

SWOT Factors	Priority of the factors	SWOT sub-factors	Priority of the sub-factors	Overall priority of the sub-factors
		S_1	0.065	0.0243
		S_2	0.101	0.0379
Strengths	0.375	S_3	0.254	0.0952
		S_4	0.074	0.0278
		S_5	0.198	0.0742
		S_6	0.308	0.1155
		W_1	0.093	0.0120
		W_2	0.313	0.0401
Weaknesses	0.128	W_3	0.045	0.0058
		W_4	0.259	0.0332
		W_5	0.215	0.0276
		W_6	0.075	0.0096
		O_1	0.349	0.0911
		O_2	0.096	0.0251
Opportunities	0.261	O_3	0.124	0.0324
		O_4	0.040	0.0104
		O_5	0.146	0.0381
		O_6	0.245	0.0640
		T_1	0.057	0.0135
		T_2	0.231	0.0545
Threats	0.236	T_3	0.112	0.0264
		T_4	0.075	0.0177
		T_5	0.213	0.0503
		T_6	0.312	0.0736

Step 7: In this step we calculate the degree of importance of the alternative strategies with respect to each SWOT sub-factor. The details of the pair wise comparison matrices are provided in Appendix A. Using Super Decision software, the eigenvectors are computed by analyzing these matrices and the W_4 matrix:

$$W_4 = \begin{bmatrix} 0.188 & 0.128 & 0.088 & 0.441 & 0.148 & 0.154 & 0.564 & 0.152 & 0.536 & 0.546 & 0.472 & 0.484 & 0.157 & 0.166 & 0.347 & 0.093 & 0.442 & 0.194 & 0.385 & 0.312 & 0.412 & 0.547 & 0.501 & 0.484 \\ 0.092 & 0.082 & 0.139 & 0.176 & 0.331 & 0.523 & 0.243 & 0.534 & 0.141 & 0.253 & 0.169 & 0.274 & 0.085 & 0.254 & 0.261 & 0.361 & 0.186 & 0.096 & 0.171 & 0.142 & 0.314 & 0.137 & 0.173 & 0.137 \\ 0.273 & 0.278 & 0.318 & 0.312 & 0.419 & 0.241 & 0.136 & 0.236 & 0.242 & 0.139 & 0.456 & 0.151 & 0.494 & 0.492 & 0.131 & 0.479 & 0.273 & 0.258 & 0.353 & 0.465 & 0.178 & 0.232 & 0.237 & 0.294 \\ 0.447 & 0.512 & 0.455 & 0.071 & 0.102 & 0.062 & 0.057 & 0.056 & 0.081 & 0.062 & 0.109 & 0.091 & 0.264 & 0.088 & 0.261 & 0.067 & 0.119 & 0.452 & 0.091 & 0.081 & 0.096 & 0.084 & 0.089 & 0.085 \end{bmatrix}$$

Step 8: Finally, the overall priorities of the alternative strategies, reflecting the interrelationships within the SWOT factors, are calculated as follows:

$$W_{Alternative} = \begin{bmatrix} SO \\ WO \\ ST \\ WT \end{bmatrix} = W_4 \times W_{Sub\text{-}factors\ (global)} = \begin{bmatrix} 0.283 \\ 0.212 \\ 0.375 \\ 0.130 \end{bmatrix}$$

The results of ANP analysis indicate that ST is the best strategy with an overall priority value of 0.375.

Conclusion and suggestions

Marine-coastal environments play a pivotal role in the biosphere due to their close interaction with land and local waters. One of the important activities taking place in these areas that has an evident and indisputable social and economic effect is aquaculture and fisheries activities. Aquaculture and fisheries are important activities in development of Integrated Coastal Zone Management in the country. To this end, a model was proposed based on the coasts' ecological protection criteria also the environmental, social and economic criteria to develop appropriate strategies for these protections in coasts. With regards to devising and implementing managerial plans in coastal environment protection and development in line with ICZM, humans should control the environmental conditions in these areas through the preservation of environmental resources. In the long-term, this managerial plan requires strategic analysis. This study aimed to analyze the management of aquaculture use in coastal areas of Qeshm Island to provide the best strategies for aquaculture, in the framework of Integrated Coastal Zone Management, based on a combination of internal and external factors with the ANP-SWOT model in the Super Decision Software. In **t**his model, strategies were designed, weighted, calculated and processed in the form of one cluster (group) and 4 subgroups (group or nodes) in the ANP model and the results were displayed as multiple matrices. The results of ANP analysis showed that (ST) strategies were the best for aquaculture use development in the region. Selecting optimal strategies (ST) does not mean that other strategies cannot influence the strategic planning of aquaculture development in coastal areas, but instead indicates that the capabilities of the strategy of this Island under the present condition is more and need to be empowered. According to the results of this study, the coasts of this Island possess good potential in (ST) strategies for the optimal development of aquaculture use in coastal areas. This can be attributed to the fact that the relative weight rate is well distributed among the four groups of strategies and as such, these strategies have gained the highest points. These strategies include:

- Allocating production subsidies and grants to the researchers who create innovative ideas in aquaculture development in the region

- Using the power of public participation in all stages of planning and implementing the optimum use of aquaculture and its positive effect on local communities
- Creating and developing infrastructure facilities and infrastructure aquaculture in order to create optimum use of the lands
- Allocating adequate funds for development in fisheries and aquaculture industries in coastal areas of Qeshm Island

It is worthy of note that the solving of problems using a network that largely depends on modeling and network design does not follow a certain rule. Therefore, problem solving has its complexity, and it is not possible to generalize an overall rule or formula to solve problems. ANP can be a very useful framework for analyzing development issues, as it can be used to study internal and external relations, mutual relations of elements and variables, application of quantitative and qualitative criteria, adaptability in judgments, the possibility of paired comparison of variables in decision making, the possibility of final prioritization of proposed options, and overcome the problems of hierarchical relationships from top to bottom or from bottom to top by ignoring the concept of feedback. This process is a flexible way of helping decision makers to analyze complex issue whose elements are to be decided; altogether it is a comprehensive and powerful way to make accurate decisions. The ANP model can also be combined with other models; for example, the FANP model is a combination of ANP and fuzzy in which language estimations are converted into fuzzy numbers. The combination of Fuzzy approaches with the approach of this study in high uncertainty situations will lead to more accurate solutions. It is suggested that fuzzy numbers be used in case of input ambiguity. Moreover, the use of both FANP and modified TOPSIS techniques simultaneously reduces the number of paired comparisons and the level of complexity of the operation.

Acknowledgement

This article is the result of a PhD thesis in Science and Research Branch, Islamic Azad University, Tehran, Iran. The authors would like to acknowledge the specialized support of Qeshm Free Zone Organization and appreciate the experts for their useful comments to improve quality of the study.

Appendix A: Pair wise comparison matrices for the priorities of the alternative strategies based on the SWOT sub factors.

Table 1: Pair wise comparison matrices of the strategies based on the strengths sub factors

The possibility of creating a cache of natural biosphere (S1)	SO	WO	ST	WT	Relative importance
SO	1	4	2	5	0.484
WO		1	1/3	2	0.137
ST			1	4	0.294
WT				1	0.085

CR = 0.01

Table 1 continued:

Lack of land uses incompatible with environmental protection (S2)	SO	WO	ST	WT	Relative importance
SO	1	5	3	6	0.501
WO		1	1/4	5	0.173
ST			1	3	0.237
WT				1	0.089

CR = 0.01

Diversity of habitats and ecosystem and including ecological sensitivity (S3)	SO	WO	ST	WT	Relative importance
SO	1	4	3	7	0.547
WO		1	1/2	2	0.137
ST			1	3	0.232
WT				١	0.084

CR = 0.02

The presence of unique habitat of rare with world conservation value (S4)	SO	WO	ST	WT	Relative importance
SO	1	2	3	5	0.412
WO		1	2	3	0.314
ST			1	2	0.178
WT				1	0.096

CR = 0.01

Proper habitat for bird's hatch, sea turtles, mammal's reproduction (S5)	SO	WO	ST	WT	Relative importance
SO	1	2	1/3	3	0.312
WO		1	1/5	2	0.142
ST			1	7	0.465
WT				1	0.081

CR = 0.01

Ecological features and geographical location of region in Persian Gulf (S6)	SO	WO	ST	WT	Relative importance
SO	1	4	3	6	0.385
WO		1	1/2	3	0.171
ST			1	5	0.353
WT				1	0.091

CR = 0.02

Table 2: Pair wise comparison matrices of the strategies based on the weaknesses sub factors.

Pouring waste by tourists in the protected areas and sensitive coastal (W1)	SO	WO	ST	WT	Relative importance
SO	1	2	1/3	1/5	0.194
WO		1	1/5	1/6	0.096
ST			1	1/2	0.258
WT				1	0.452

CR = 0.01

Lack of appropriate plan related to the protection of coastal zone (W2)	SO	WO	ST	WT	Relative importance
SO	1	3	2	5	0.442
WO		1	1/2	2	0.186
ST			1	4	0.273
WT				1	0.119

CR = 0.04

The absence of coastal protection guard in the protected areas (W3)	SO	WO	ST	WT	Relative importance

Table 2 continued:

SO	1	1/5	1/7	2	0.093
WO		1	1/2	5	0.361
ST			1	6	0.479
WT				1	0.067
CR = 0.01					
Sensitivity and vulnerability of areas habitats to the ecological changes (W4)	SO	WO	ST	WT	Relative importance
SO	1	2	4	2	0.347
WO		1	2	1	0.261
ST			1	1/2	0.131
WT				1	0.261
CR = 0.02					
Destruction of many species due to the climate change and drought (W5)	SO	WO	ST	WT	Relative importance
SO	1	1/2	1/3	3	0.166
WO		1	1/2	2	0.254
ST			1	1/7	0.492
WT				1	0.088
CR = 0.03					
Lack of proper plan for protection of natural resources in protected area (W6)	SO	WO	ST	WT	Relative importance
SO	1	3	1/5	1/3	0.157
WO		1	1/7	1/5	0.085
ST			1	2	0.494
WT				1	0.264
CR = 0.02					

Table 3: Pair wise comparison matrices of the strategies based on the opportunities sub factors.

Presence of local communities in protected area with Motivation for participating (O1)	SO	WO	ST	WT	Relative importance
SO	1	4	3	5	0.484
WO		1	2	3	0.274
ST			1	2	0.151
WT				1	0.091
CR = 0.02					
The international importance of protected areas and attracting foreign investment (O2)	SO	WO	ST	WT	Relative importance
SO	1	3	2	5	0.472
WO		1	1/2	3	0.169
ST			1	4	0.456
WT				1	0.109
CR = 0.03					
Reputation of protected areas to attract public opinion and educational projects (O3)	SO	WO	ST	WT	Relative importance
SO	1	3	5	7	0.546
WO		1	2	5	0.253
ST			1	3	0.139
WT				1	0.062
CR = 0.01					
The use of new technologies in coastal protection in framework of sustainable development (O4)	SO	WO	ST	WT	Relative importance

Table 3 continued:

SO	1	4	3	5	0.536
WO		1	1/2	2	0.141
ST			1	4	0.242
WT				1	0.081

CR = 0.02

The official's attention to the sensitivity and vulnerability of protected areas (O5)	SO	WO	ST	WT	Relative importance
SO	1	1/3	1/2	3	0.152
WO		1	2	7	0.534
ST			1	5	0.236
WT				1	0.056

CR = 0.02

Codification of quantitative and qualitative protection standards of animal and plant species (O6)	SO	WO	ST	WT	Relative importance
SO	1	3	5	٧	0.564
WO		1	2	5	0.243
ST			1	3	0.136
WT				1	0.057

CR = 0.04

Table 4: Pair wise comparison matrices of the strategies based on the threats sub factors.

Non-establishment system of Integrated Coastal Zone Management (T1)	SO	WO	ST	WT	Relative importance
SO	1	1/3	1/2	3	0.154
WO		1	2	7	0.523
ST			1	5	0.241
WT				1	0.062

CR = 0.01

Insufficient knowledge of local societies from ecological benefits in protection areas (T2)	SO	WO	ST	WT	Relative importance
SO	1	1/3	1/5	2	0.148
WO		1	1/2	3	0.331
ST			1	5	0.419
WT				1	0.102

CR = 0.04

The development of industrial activities in the lands around the protected area (T3)	SO	WO	ST	WT	Relative importance
SO	1	3	2	5	0.441
WO		1	1/2	2	0.176
ST			1	3	0.312
WT				1	0.071

CR = 0.02

The exploitation of natural resources and Available reserves illegally in the region (T4)	SO	WO	ST	WT	Relative importance
SO	1	1/2	1/4	1/5	0.088
WO		1	1/2	1/3	0.139
ST			1	1/2	0.318
WT				1	0.455

CR = 0.03

Economic jobbery by institutions and organizations in order to develop their purposes (T5)	SO	WO	ST	WT	Relative importance

Table 4 continued:

SO	1	2	1/3	1/5	0.128
WO		1	1/2	1/7	0.082
ST			1	1/3	0.278
WT				1	0.512
CR = 0.04					
The direct role of rural societies and unprincipled exploitation of natural resources (T6)	SO	WO	ST	WT	Relative importance
SO	1	3	2	5	0.188
WO		1	1/2	2	0.092
ST			1	3	0.273
WT				1	0.447
CR = 0.03					

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