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Assessment of conservation status in Caspian Sea coastal area by the use of diversity indices

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Abstract

This research was conducted to investigate the plant species diversity in the protected and non-protected sites via comparison of biodiversity and similarity indices. The research area comprised a coastal system in the north of Guilan Province, Iran. Vegetation sampling was carried out along 16 shore perpendicular transects, approximately 500-m long. A total of 50 plot of 25 square meters were taken in transects. In each sampled plot, the cover percentage value of each species was estimated using Bran-Blanquet scales. Data analysis was carried out using diversity numerical indices of richness, diversity and evenness index. To assess the significance of numerical measures a student's t-test was used. The similarity index was selected for clarifying the species similarities between two sites. Graphs of Rainey parameterise diversity indices and species abundant model were plotted. The results showed species diversity in two compared area was very close together based on numerical indices. Data analysis by species abundant models was fitted to geometry model. Result showed conservation devices could not be effective and helpful tool for biological diversity maintenance and progress.

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Introduction

For many years, environmental variables and indices have been used to monitor pollution and the changes in biotic communities. Environmental indices include those that are based on physical and chemical, biological parameters and also perceived aesthetic qualities of the environment. The use of structural indices to measure fundamental community parameters associated with species abundance and community composition to assess changes in biological communities due to environmental stress has long been an important aspect of theoretical and applied ecological research (Pitkanen, 1998).

The Strategic Plan for Biodiversity 2011–2020 has been set as an objective of the restoration of 15% of the degraded ecosystems by 2020 (Naqinezhad, 2012). World conservation strategy has been objected to conserve ecological processes, vital systems and genetic diversity, and to sustainable use of the species and ecosystems (Sharifi and ghafori, 2008). In recent years, concern about the extinction of species and populations due to human activities has been stimulated a number of observational and experimental studies on the relationships between species richness and ecosystem functioning (Singh *et al.*, 2005).

Many studies have been carried out on species diversity in the world. Most of these studies used numerical indices and some of these applied parametric indices [rank-abundance plot (species-accumulation curves "SACs") and abundance distribution models (species-abundance distributions)"SADs"] beside numerical indicies for evaluation of species diversity. Based on abundance information and distribution of each species, species - accumulation curves (SACs)(Gotelli and Colwell, 2001; Ugland *et al.,* 2003), species-abundance distributions (SADs) and diversity indices have been usually calculated to compare species richness among communities or treatments (Untersher *et al.,* 2011). Many SAD models have been developed to understand the statistical structure of biological communities and to be able to predict unsampled parts of the communities. For example, geometric series have predicted extremely uneven abundances of organisms (May, 1975); broken-stick distributions have represented extremely even abundances (Mac Arthur, 1957) and log- normal (Preston, 1948) and log-series (Fisher *et al.,* 1943) models have predicted very low and very high proportions of rare species. Despite of the general interest of ecologists in SADs, lesser importance has been attached to the discrimination of exhaustiveness and insufficiency of sampling. A recent meta-analysis of plant and animal communities has revealed clear impacts of sampling intensity on the observed SAD (Ulrich *et al.*, 2010). Complete surveys typically followed by log-normal types of SADs, whereas incompletely sampled communities significantly deviated from log-normality, irrespective of spatiotemporal scales, geographic positions and species richness (Untersher *et al.*, 2011).

In this research, plant species diversity was compared in protected and non-protected sites in the south coastal area of the Caspian Sea for the first time. In order to achieve this, the vegetation of a nearly unaltered coastal sector in 16 site was described. This research sought to compare the plant species diversity of the Caspian coastal areas to determine the impact of governmental conservation policies and strategies on species differences.

Materials and methods

Study area

The research area comprised a coastal system in the northof Guilan Province, Iran, between 48° 52´ 44´´ - 50° 35´ 59´´ E and 36° 56´ 4´´-38° 26´ 55´´ N. The study area was delimited using a Landsat 7ETM satellite image (Path 166/ Row 34) (Fig. 1). The Caspian Sea constituted the southern region of the study area. The climate was humid and very humid with cool winter according to Eumberger climate classification (Abedi and Pourbabaei, 2010). Guilan has a humid subtropical climate by a large margin of the heaviest rainfall in Iran reaching as high as 1,900

mm in the southwestern coast and generally around 1, 400 mm. Rainfall is heaviest between September and December because the onshore winds from the Siberian High are strongest, but it occurs throughout the year though least abundantly from April to July. Humidity was very high because of the marshy character of the coastal plains and can reach 90 percent in summer for wet bulb temperatures of over 26 °C . Mean annual temperature was 15.8˚C and precipitation is 1506 mm. Maximum and minimum temperature was 27.8˚C in August and 4.1˚C in February, respectively(Zarekar *et al.*, 2012).

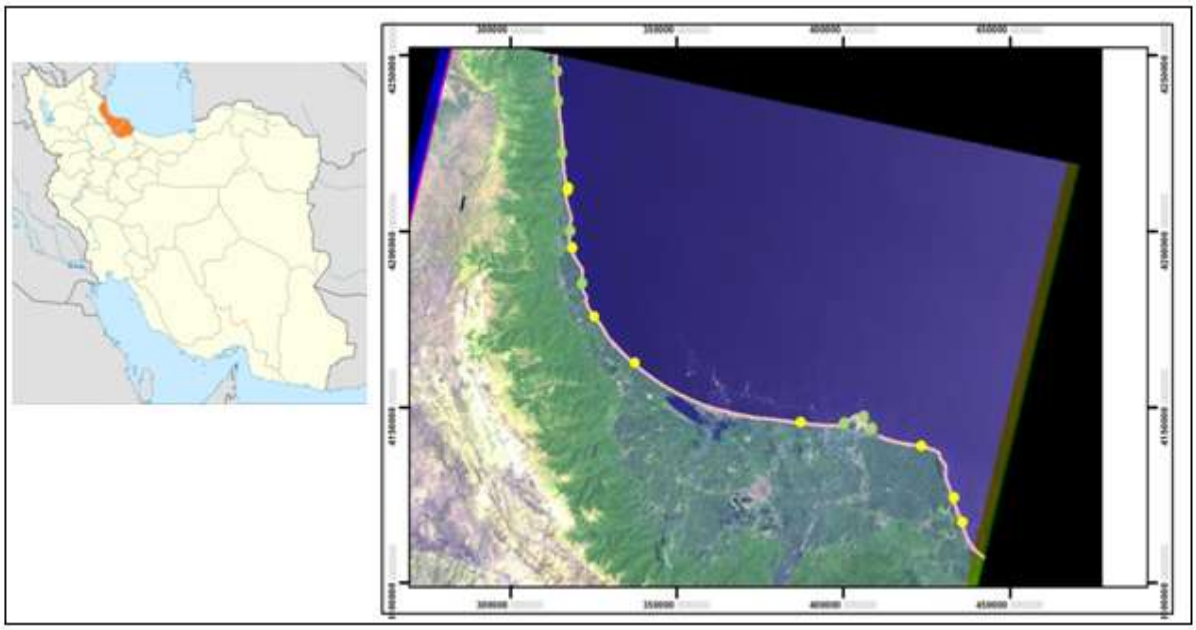

Fig. 1. Location of Guilan Province in Iran and vegetation sampling in coastal area.protected site definite with green point and Non-protected site site definite with yellow point.

Sampling methods

Prior to the commencement of fieldwork, a short reconnaissance survey was undertaken to get an overview of the area (Mashwani *et al.*, 2011). A total of 16 sites were selected and one transect was established in each site. For detailed data collection, line transect survey was selected which is a very popular vegetation survey technique (Kent and Coker, 1992). Vegetation sampling was carried out along 16 shore perpendicular transects between 100-500-m long (Table 1).

The length of transects was variable depended on the strip of the natural vegetation. Size of sampling plots was determined using nested plot sampling and species/area curve (Muller-dombois and Ellenberg, 1974). A total of 50 sampling areas were selected in stands of vegetation that were homogeneous to the eye in floristic composition and structure (Monestrat *et al.*, 2012). In each sampled plot, the cover percentage value of each species was estimated using Braun-Blanquet scale (Bran Blanquet, 1964).

Data analysis

Measuring plant diversity

To quantify the diversity of the plant species, Simpson index (1-D), Shannon-Wiene's (H'), Berger-parker (d) and Fishers alpha (S) diversity indices, Margalef (R) and Menhinick (D) richness indices, Sheldon(E) and Pielou (E_1) eveness indices were used. Indices were calculated by using PAST (Hammer *et al.*, 1999). The formulas are shown as table 2.

Jaccard similarity index (J) and Sorenson similarity index were selected for clarifying the similarity of the species between two areas (Ludwing and Reynolds, 1988; Tabari *et al.*, 2011; Singh *et al.* 2012;).

The formulas are as below:

$$J = \frac{a}{a + b + c} \qquad S_s = \frac{2a}{2a + b + c}$$

Where " a" is the common species in two areas, "b" is the only number of the species identified in the first area and c is the only number of the species identified in the second area. The means of biodiversity indices (diversity, evenness and richness) in two areas were compared using dependent samples t test. This analysis was performed using SPSS 16.0. To assess the models of diversity, the variability parameters of the plants has been used including geometric series log, normal log and broken stick. Species abundant models were plotted. Also Graphs of Rainey parameterize diversity index were plotted. The formula is shown in Table 3.

Results

Plant species richness and mean diversity indices in protected and Non-protected sites have been shown in table 4. Under the null hypothesis, plant species richness, diversity and evenness of the protected sites must be more than non-protected sites.

Table 1. Situation of transects in protected and non-protected sites.

Geographic Coordinate		Name of site	situation in protected/Non-protected site
x	y		
406140	4147563	Mohitbani sepidrood	Bujagh National Park
400212	4145483	Ziba kenar	Bujagh National Park
408582	4143873	Pool chobi kiashahr	Bujagh National Park
326855	4173470	Gissoum	Gissoum forest park
318664	4195469	Jokandan	Lisar protected area
318130	4200205	Ghale Bin	Lisar protected area
314185	4245608	Sibli	Lavandevil Wildlife refuge
314094	4250942	Abbas Abad	Lavandevil Wildlife refuge
324354	4177261	Khalif Abad	Non-protected site
387254	4145766	Chaparbord	Non-protected site
433317	4124368	Chaf	Non-protected site
449921	4101521	Reza Mahale	Non-protected site
321651	4185214	Tazeh Abad	Non-protected site
317496	4212363	Kheymesare Shafarood	Non-protected site
325160	4175905	Alalane Ghadim	Non-protected site
326336	4174369	Alisara	Non-protected site

Table 2. Numerical Biodiversity Indices.

Name of index	Formula	Index
Simpson	$1-D=\sum_{i=1}^{s} P_i^2 \qquad Pi=\frac{ni}{N}$	
Shannon-Wiener	$H'=-\sum_{i=1}^{s} Pi \ln Pi=-\sum_{i=1}^{s}(Pi)(\log pi)$	Diversity
Berger-parker	$d=\frac{N_{max}}{N}$	
Fishers alpha	$S = a\,Ln\,(1+n)\,/\,a$	
Menhinick	$D_{mg}=\frac{S}{\sqrt{N}}$	Richness
Margalef	$R=\frac{S-1}{Ln\,N}$	
Sheldon	$E=\frac{e^{H'}}{S}$	
Pielou	$E1=\frac{H'}{Ln(s)}=\frac{LnN_1)}{Ln(N_0)}$	Evennes

Review of the table 4 showed that the plant species richness in protected sites was lower than non-protected sites; also, among diversity indices, the value of Shannon and Berger were higher in protected sites. The values of the Simpson indices in two sites were the same and the value of Fisher index in protected sites was higher than that in non-protected sites. Comparing of richness indicators showed that the values of these indices in non-protected sites was higher than those in protected sites but evenness indices in protected sites were higher than non-protected sites. Also, table 4 depicts the Jaccard and Sorensen coefficient of the two studied areas. Jaccard's coefficient (J) was 0.661 and Sorensen coefficient (Ss) was 0.796. Table 5 Results of t- Test for comparing biodiversity indices in protected and non-protected sites. According to this table, the significant difference between the two sites by the numerical value of the indicator is not observed.

Table 3. Parametric formulas indicators (Ejtehadi *et al.*, 2009).

Index name	Geometric series	Log series	Normal log series	Broken stick series
Formula	$n_i = NC_k K(1-K)^{i-1}$	$S = \alpha \ln(1 + N/\alpha)$	$S(R) = S_O \exp(-a^2 R^2)$	$S(n) = \left[S(S-1)/N \right] (1 - n/N)^{S-2}$

In geometric series :
n_i =number in i species, N = total species ,C_k =a constant that number can be calculated from $C_k=[1-(1-K)^s]^{-1}$ and guarantees $\sum ni = N$,K = a constant number that can be calculated from $\frac{N\ min}{N}$
In log series :
S = Total number of species in the samples, N = total number of species in sample, α=Alpha diversity indices, Ln = Logarithm in base 10 .
In normal Log series :
S(R) = total number of octaves of R In left and right symmetrical curve ,$a=(2\sigma^2)^{1/2}$ =Inverse width of the distribution curve , S_0 = octave that has a number of species in mode .
In MacArthur broken stick series :
S (n) = Number of species with n individuals in abundance classes, S = total number of species, N = total number of individuals (Mahmoudi *et al.*, 2012).

Fig. 2. shows the variation of the number of taxa in 25 samples taken at two sites. According to this figure, the number of taxa are very close together. However, the number of species in protected sites are a little higher than those in non-protected sites. Also, total cover all species in the plots is shown in Fig. 3. Comparing of curves indicates no difference in species covering. Fig. 4 and 5 show species abundant models in the plots at two sites. According to these figures, geometric models are represented in both sites. Therefore, there are no differences between two studied areas based on this index. Fig. 6 shows the Rainey parametric index at two sites. Two plotted curves are overlapped with each other; therefore, these two sites are the same based on this index.

Table 4. Mean diversity indices in protected and Non-protected sites.

Diversity Index	Protect Site	non-protest Site
Species richness (S)	91	94
Shannon	3.769	3.735
Simpson	0.965	0.965
Fisher	19.58	20.62
Berger	0.094	0.086
Menhhinik	2.023	2.129
Margalef	11.82	12.28
Pilo	0.835	0.822
Sheldon	0.476	0.445
Jaccard's coefficient (J)	0.661	
Sorensen coefficient (S_s)	0.796	

Table 5. T- Test of biodiversity indices in protected and Non-protected sites.

	Diversity Index				Richness index		Evennes Index	
	Shannon	Simpson	Fisher	Berger	Menhhinik	Margalef	Pilo	Sheldon
F	0.89	1.389	0.66	0.850	3.338	0.111	1.502	3.449
P	0.858 N.S	0.660 N.S	0.950 N.S	0.977 N.S	0.580 N.S	0.929 N.S	0.907 N.S	0.652 N.S

Note: N.S: Not significance.

Disscussion

Richness of plant species was 91 and 94 in protected and non-protected site, respectively (table 2). A few floristic and ecological studies have been carried out on the southern coastal area of the Caspian Sea (Frey, 1974; Riazi, 1996; Asri and Eftekhari, 2002; Ejtehadi *et al*., 2003 & 2005; Akhani, 2003; Ghahreman *et al*., 2004; Asri and moradi, 2004 & 2006; Shokri *et al*., 2004; Sobh zahedi *et al*., 2005 & 2007; Asri *et al*., 2007; Sharifinia *et al*., 2007; Khodadadi *et al*., 2009; Naqinezhad *et al*., 2006; Naqinezhad, 2012).

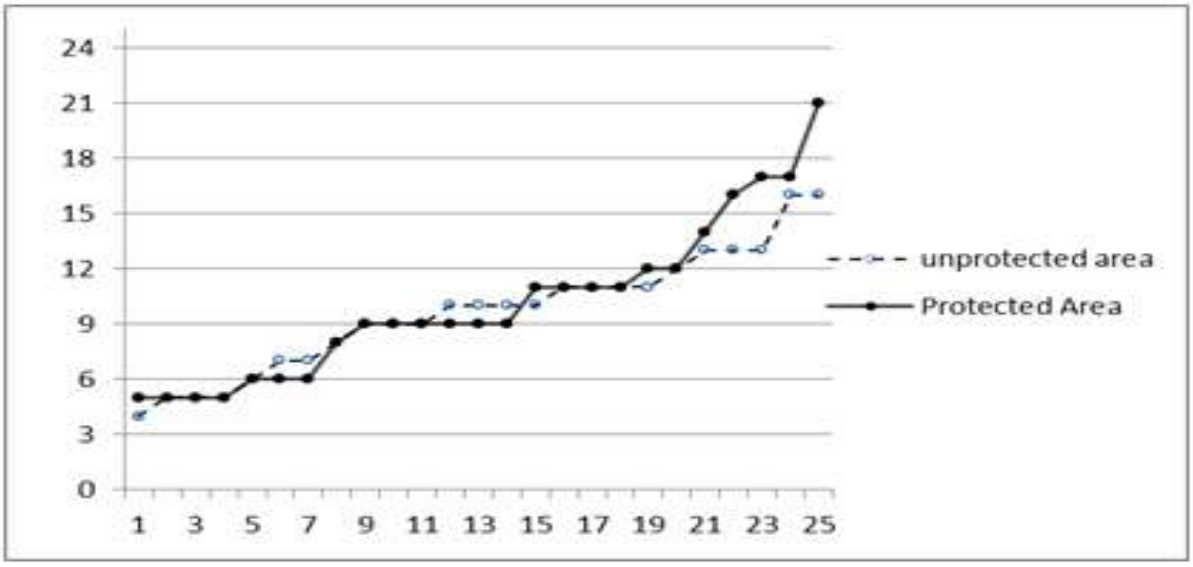

Fig. 2. Variation of the number of taxon in the plots.

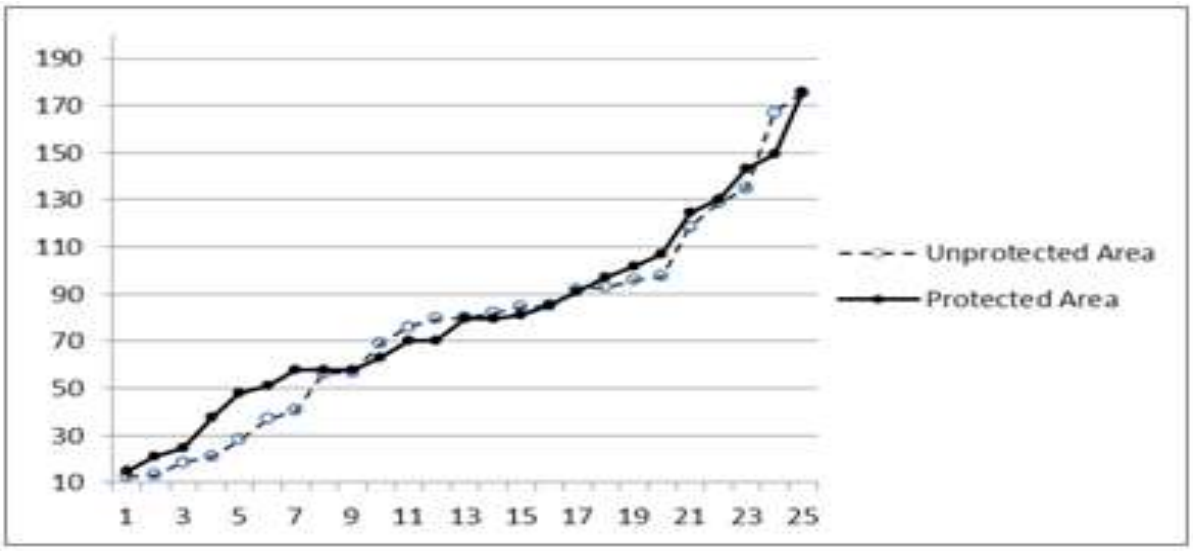

Fig. 3. Variation of the total cover of taxon in the plots.

These studies have presented Richness of 200-250 plant species in aquatic and terrestrial ecosystems in this region. Among these studies, Sobh zahedi *et al.* (2005) were identified 81 plant species in Guilan sandy beaches; also, Naqinezhad (2012) recognized three vegetation bands (zones) around the south Caspian coastline (Sand dune zone, Wet Sand dune zone and Wetland zone) and introduced 40 psammophytic plants belong to Sand dune zone of south Caspian coasts. Abbasi *et al.* (2009) examined the effect of conservation on biodiversity by calculating of the number of taxa, the number of individuals and cover species in the central zone, Peripheral (buffer) zone and non-protected region. Results showed that based on these parameters, the central zone and Peripheral zone had better situation than non-protected region, respectively.

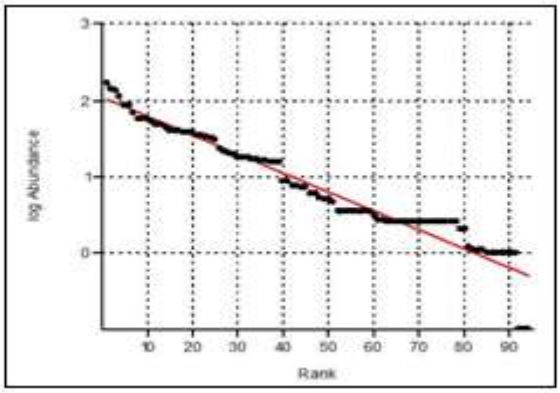

Fig. 4. Species abundant model in non-protected site.

They found that there was a close relationship between biological diversity and conservation level in the studied area. Checking of the numeric index of richness, diversity and evenness showed very low differences between the two sites. In many studies, such as Salami *et al.,* 2006; Terzioglu *et al.*, 2007; Mahmoodi *at al.,* 2009, 2012; Davari *et al.*, 2011; the t-test has been used to compare the diversity numerical indicators. Comparison of numerical indices by t-tests showed no significant difference between two sites.

Graphs of species abundant models and parametric index (Hill, Reyni,Patil and Taillie) were used to confirm the results of numerical indices. Using of these graphs can be finding in these reseaches: Ravanbakhsh *et al.,* 2007; Untersher, 2011; Mahmoodi, 2012; Pourbabaei *et al.*, 2012; Sohrabi, 2013. Based on these graphs, two studied areas fallowed by geometry abundance distribution model. Steep curves argue high dominance of community; logarithmic and geometric series models represented immature communities with low species diversity and these communities are fragile and unstable (Magurran, 2004). Geometric model represented homogeneous, under pressure and damaged area (Salami *et al.*, 2006; Akkafi *et al.*, 2007).

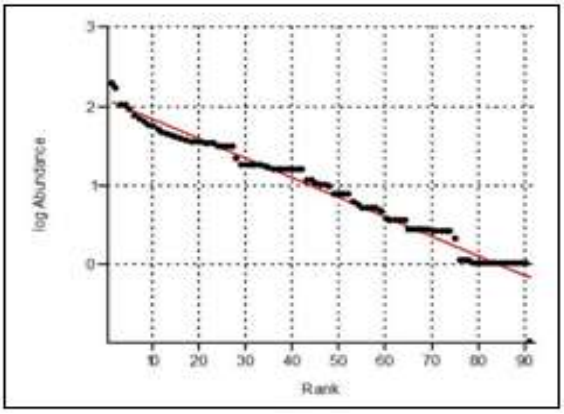

Fig. 5. Species abundant model in protected site.

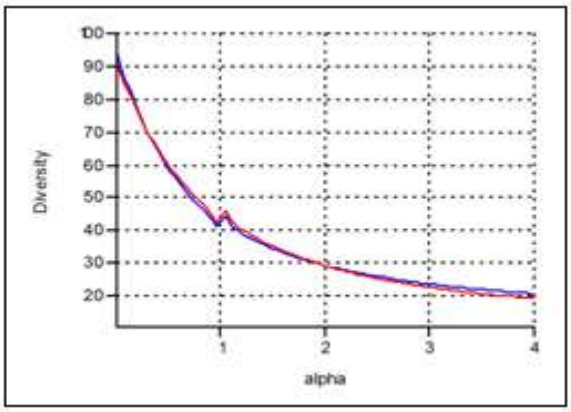

Fig. 6. The parameter index Rainey at two sites.

More or less, homogeneity is revealed by the higher value of similarity index; in contrast, the lower value indicates distinct heterogeneity (Singh, 2012). Similarity determined by Jaccard and Sorenson indices. According to these indices these sites had similarity about 60-70 %. Tabbari *et al.* (2011) used Jaccard similarity index for comparison of four stands in coastal forest in south Caspian coastline and

recognized stands with more similarity. Singh (2012) compared 3 sites by Sorenson index and determined more similarity sites relating to environmental characters.

Conclusion

The southern coastal area of the Caspian Sea represents a unique area with high conservation value. Southern Caspian coast in Guilan province consists of four protected area; Boujagh National Park, Lisar protected area, Lavandevil wildlife refuge and Gissoum forest park based on the supervision of Iranian Department of Environment (DoE) and Forests, Range and Watershed Management Organization (FRWO) Respectively. Therefore, last remaining coastal vegetation retained partially their natural characteristics can be observed in these sites. After introducing protected areas, the next step is implementation of management plans in accordance with the principles and rules defined in these sites. According to surveys, these sites do not have initial requirements for the implementation of the related laws (Implementing regulation of environmental improve and protection law).

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