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An Study of Effective Species Plant and Ecological Niche Analytical Approach of Environmental Factor for Assessing the Proper Levels of Fauna and Flora in the Northeastern Part of Shiraz

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Abstract

The present was mainly intended to figure out how much suitable Bamoo National Park as an important habitat for Persian gazelle's were via an Ecological Niche Factor Analytic (ENFA) approach to evaluating the geographical distribution of the species on a large scale through presence-only data. The rationale behind this research endeavor was related to the negative influence human interference can exert on habitat fragmentation and species segregation. As a multivariate approach, ENFA has been widely applied in many fields including wildlife management, habitat assessment and prediction. Throughout the current study, bio-mapper was utilized in such a way that the presence points constituted the dependent variable, whereas predator, vegetation, altitude, distance from the trough, topography, aspect, slope and soil were considered as the independent variables of the study. The results gained from the study revealed that the Persian gazelle's prefer 1700-200 elevation zones and 2-5% slope dominated by such shrub species as *Astaragalus* and *Artemisia sieberi*. In addition, the global marginality turned out to be above 1 indicating that the requirements for the habitats of the study differed from the average conditions. That the global specialization coefficient was above 1 showed that the Persian gazelle's considered as specialized species in the area occupied a narrow niche. Regarding the variables, trough, altitude, and vegetation were the most effective ones, but Predator was demonstrated to be a major threat to the habitat. According to the map, the areas were classified into three categories, namely suitable, intermediate, and unsuitable habitats, and the continuous Boyce index gained from the harmonic mean distance algorithm was indicative of the most important areas of unsuitable habitats, the highest amount of robustness, and the predictive power of the HS model.

1. Introduction

Currently some models that can predict the spatial distribution of species [1; 2; 3; 4] are gaining interest. They are sometimes called resource selection function or habitat suitability models. As they often help both in understanding species niche requirements and predicting species potential distribution, their use has been especially promoted to tackle conservation issues, such as managing species distribution [5; 6]. Suitable habitat mapping is very important for wildlife conservation and ecosystem management, and the actual geographical distribution of species shown on HS maps is the result of the analysis of species–environment relationships [7]. Species distribution lies well within the optimal range of environmental factors [8]. It is, therefore, useful for ecological modelers to design a methodological algorithm to compute HS by incorporating most of the environmental factors using presence–absence data or presence-only data to develop a more precise estimate. Also, the 'ecological niche' is an important concept in HS modelling. It has been developed on the basis of the relationship between a species and its environment [9]. The ecological niche concept was first introduced by [10] who argued that every species has its own physiological, morphological and behavioral profile, which makes it suitable to occupy particular spaces offered by nature. [11], on the other hand, developed the concept of niche as the sum of all environmental factors acting on the organism; the niche is thus defined as a region of a *n*-dimensional hyper volume [12].

The models statistically relate field observations to a set of environmental variables, presumably reflecting some key factors of the niche, like topography, geology or land-cover. They produce spatial predictions indicating the suitability of locations for a target species, community or biodiversity. Different types of modeling techniques are used to fit different types of biological information recorded at each sample site: (1) *presence-only*: occurrences of the target species are recorded; (2) *presence/absence*: each sample site is carefully monitored so as to assert with sufficient certainty whether the species is present or absent [13], The reliability of absences depends on the species' characteristics (e.g. biology, behavior, history) [14]. Methods that predict species distribution from presence-only data search for an environmental 'envelope' characterizing the areas in which the species is present and extrapolate to the remaining areas under study [2]. An example of these alternative techniques, often called envelope method [4], is Ecological Niche Factor Analysis (ENFA) [15]. Iran is confirmed to host three species of gazelles [16]. The most widespread Persian gazelle's species in Iran is the goitered gazelle (*Gazella subgutturosa*) that exists throughout most of the country, except the northern and some southern parts of the country [17; 18]. Beyond the Iranian borders, it is a species aboriginal to the central Asian steppes from Turkey [19], Iraq [20] and Arabian Peninsula to the Gobi desert [21]. It is currently categorized as Vulnerable (VU), and if conservation efforts are not made for this species in the near future, this could change to the Extinction (EX) category [22].

There is a dearth of knowledge on the species' distribution, invasion trend, and effects across the globe, especially in Iran. Habitat Suitability (HS) has become an increasingly important component of species/ecosystem management. HS assessment is usually based on presence/absence data related to environmental variables. An exception is Ecological Niche Factor Analysis (ENFA), which uses presence-only data and which does not require absence data. [9] identified the suitable habitat of Sambar deer existing in Thailand by using ecological niche analysis and four features, namely geographical features (elevation and slope, landform, geomorphology), consumable features (vegetation types such as food resources, cover area, and water resources) human-factor features (ranger units, villages, roads, and area of government offices), and species–human interaction features (effect of perturbations by other species, human activities/visitations, and human-induced events on SD) The results gained from their study show that the HS map with only geographical features has the highest coefficient value (0.516). To manage the Persian gazelle's species, the distributions of this species and also the environmental parameters that control its distribution were to be determined.

Therefore, the aims of this study were manifold. They included (1) locating the Persian gazelle's habitats, (2) estimating the suitability of the habitats at some pre-determined points, and (3) investigating the environmental factors that constrain the current distribution of the Persian gazelle's in the national parks in Bamboo.

2. Material and Methods

2.1. Study Area

Bamoo National Park (eastern longitudes = 52° 29′ and 52° 56′, northern latitudes = 29° 39′ and 29° 50′) is located in the northeastern part of Shiraz from Fars province, Iran. The area covers about 46,913 hectares (See Figure 1 below). The park's highest and lowest point is 2700 and 1700 m above sea level. The climate is cold and semi-arid. The average annual precipitation and temperature are 392.9 mm and 17.9 ° C, respectively, in the reagent stations in Shiraz. This area is also characterized by the northwest and west wind.

2.2. Species Presentation

In 1962, Bamoo National Park was nationally known to be an exclusion zone (100,000 hectares), but a decrease in its coverage area has recently taken place. In 1967 the name was changed into a protected area, but it was called a National park after it was named a Wildlife park in 1970. Bamoo Wildlife National Park includes 32 mammal species five of which including *Vuples cana,* Panthera pardus saxicolor, Hyaena hyaned, Felis chus, Gazella subgutturosa, Capra aegagrus, and Ovis orientalis are known as indicator species. Besides, two species including *Panthera pardus saxicolor* (leopard) and *Hyaena hyaena* (Striped hyaena) are recognized as جredator species. Persian gazelle's (*Gazella subgutturosa*) is the largest grass-fed steppe plain in Iran. Also, it has abundantly been scattered in most areas of the plain in the past. The population of this species has rapidly declined over the recent years. The category "nearly threatened" dating back to 2003 was replaced by the category Vulnerable (VU) dating back to 2008. Persian gazelle's is already present in 15 protected areas in Iran. Bamoo National Park is a mountainous region, so it is not a suitable habitat for *Gazella subgutturosa.* However, there is a huge population of the species on the plains owing to various environmental landscapes. The main habitat for *Gazella subgutturosa* is Chah- mahakei Tang region.

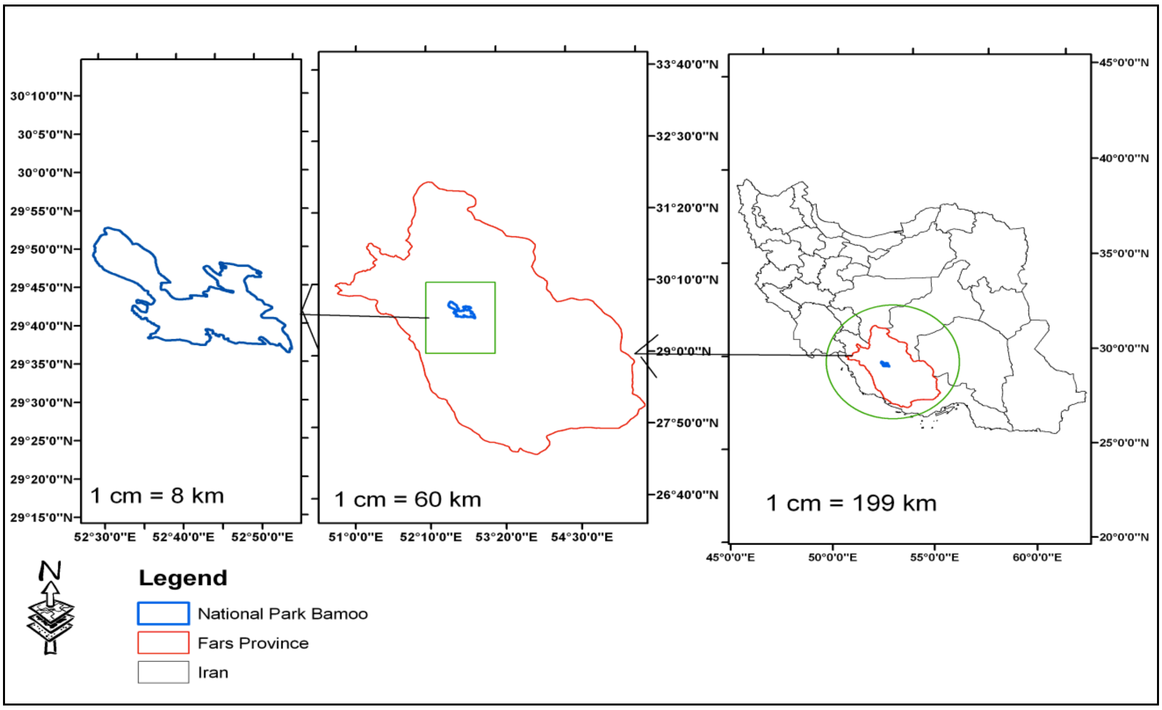


Figure 1. Bamoo National Park Map

2.3. Methods

In this study, the ecological niche factor analysis was used to achieve the goals of the study. In addition, to provide a HS model and create layers, Biomapper software [23] and the Idrisi 3.2 software were utilized, respectively. Layers required to run the model in the Biomapper software are classified into two layer sets including Eco-geographical Map and Work Map. These layers were initially prepared within the Idrisi software and were then imported into the Biomapper software. The Work map indicating the presence of *Gazella subgutturosa* was used in the point (vector) format. This map was converted to a network (Raster) format for its entry into the software. As for the eco-geographical map, it includes the independent environmental variables and other factors affecting the presence of species including:

Slope classes (See Figure. 2 below).

- Elevation classes (See Figure. 3 below).

The two maps above were obtained from the Digital Elevation Model (DEM).

- Aspect classes (See Figure. 4 below).

- Vegetation (See Figure 5 below).

2.3.1. Data Preparation

Prior to the Bio-mapper-assisted analysis, it was required that the network maps be analyzed to be prepared for future use.

Therefore, the following steps were taken. Firstly, the normality of the data was investigated in that the ecological niche factor analysis was sensitive to the normality of the primary data. Once this principle was left unobserved, it could lead to deviation from proper calculations and production of unreliable outputs. Secondly, some environmental, independent variables were normalized using the BOX-COX method which is a useful tool for data normalization. Since ecological niche factor analysis is largely insensitive to the initially normal data, of normal and failure to observe this principle leads to deviation from the correct calculation and output will be invalid, one of the best methods proposed to normalize the data in Biomapper is Box-Cox method. The transformation of the data in this way is done by equation 1:

$$T(X) = \frac{(XY-1)}{Y} \qquad (1)$$

X: The main variable

T(X): The amount of transformed

Y: The correlation coefficient between the data (if the value is zero the log data is used instead of the above formula [24].

2.4. Survey of data correlation rate:

After normalization of data, correlation matrix for environmental variables and other effective factors on the attendance of species was calculated and the correlation rate was obtained. In ENFA method emphasizes on the condition that if two variables have the correlation rate higher than %85, one of the two variables can be eliminated from the analysis based on the opinion of researcher. In this study the correlation between variables was less than the critical level to remove one of them. Therefore remaining variables were used to analyze ENFA (Table 1).

Boolean is preliminary stage for preparation of data prior their entry to analysis within a circular (Circular) and the direct distance (Distance). During this analysis, species preserves a certain distance from a source (Circular) or get away from a certain distance from the source (Distance). In habitat suitability prediction, in order to assess the accuracy and precision of the estimated model, the amount of (RS) spearman correlation coefficient was calculated. The correlation is between the distributions of the species attendance points in each habitat suitability class and habitat suitability categories. Final map of habitat suitability is a map consists of continuous values from 0 to 100 in which the closer the value to 100, the higher the suitability is. Classes with higher values have higher suitability. If the amount of this coefficient for model is more than 80%, it is indicated that the estimated model have acceptable accuracy and precision [23]. Finally, suitability map obtained could show suitable habitat for *Gazella subgutturosa* in 3 different classes in the National Park Bamboo.

ENFA calculates factors from eco-geographical variables (EGVs, e.g., slope, Altitud, Aspect, vegetation and distances to Trough). These EGVs describe the ecological niche of a species or population. The first of the extracted factors maximizes the marginality of the species, which is defined as the ecological distance between the species optimum and the mean habitat within the reference area. Therefore, a high marginality (values close to 1) occurs if the species lives in a very particular subset of habitat type(s) relative to the reference area. The other factors describe the specialization of the species, defined as the ratio of the standard deviation of the global distribution of values of a specific ecological variable to that of the focal species. The global tolerance of the species(the inverse of the global specialization) indicates how specialized a species is, with values close to one for euryoecious (broad niche) and values close to zero for stenoecious (narrow niche) species [25].

Table 1: the correlation matrix of environmental variables

Oil Lines	Slope	Soil	Prey eater	Vegetation	Elevation	Trough	Variables
0.225	0.154	0.322	0.382	-0.432	0.487	1	Trough
-0.237	0.021	0.054	-0.026	-0.045	1	0.229	Elevation
0.362	-0.312	-0.237	0.321	1	-0.024	0.023	Vegetation
0.231	0.212	-0.128	1	-0.029	0.112	-0.328	Prey eater
-0.146	1	0.121	-0.216	0.012	-0.221	0.123	Slope
1	0.19	-0.243	0.012	0.109	-0.034	0.165	Oil Lines

2.5. Model validation

After the drawing the habitat suitability map, the model validation was assessed by Cross-validation tests and continuous Boyce index. To comparison between the variables and set of dependent and independent factors be performed easily. As well as dependence of habitat suitability was determined by quantitative and qualitative variables.

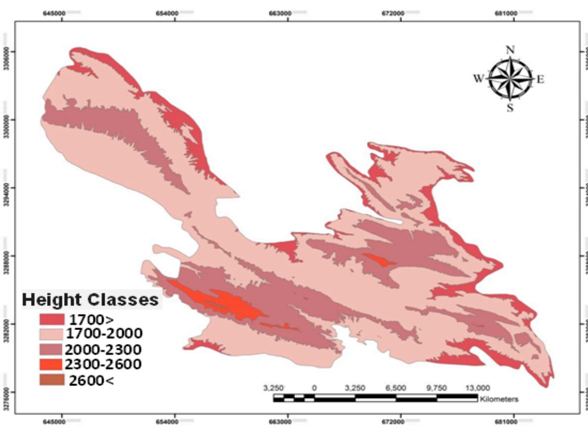
3. Results and discussion

3.1 Geographical features (Slope, Elevation and Aspect)

According to altitude, slope and aspect maps (Figures 2, 3 and 4) most of area was located in classes of 2-5% slope, elevation of 1700-2000m and plain aspect. So plains covered a considerable area of national park Bamboo. These maps were compared with Persian gazelle's distribution map (Figure 6) and vegetation (Fig. 5) and thus the most of suitable habitat for the Persian gazelle's located in plain areas, Therefore the Persian gazelle's in this park caused by characteristics of the plain.

3.2 consumable features (vegetation types as food resources)

Bamoo National Park is an area the steppe and semi-steppe. Shrubs species such as Astaragalus Spp and other species the pasture as Stipa Barbata, Artemisia sieberi, Annual Grasses and Achillea Spp were Formed the main vegetation in this area. Map of the distribution of Persian gazelle's (Figure 6) was consistent with vegetation (Fig. 5) of annual grasses also abundant species of Astragalus. Therefore this species are the Main feed Persian gazelle's.



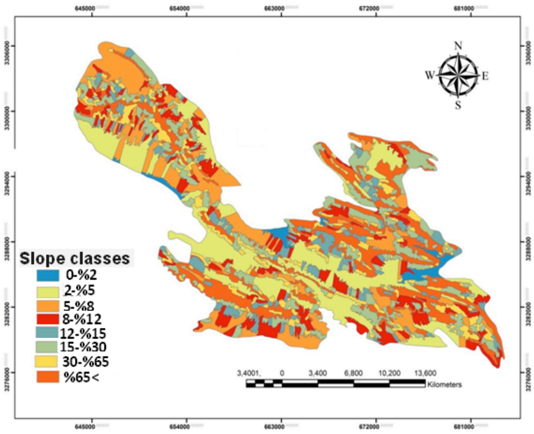


Figure 2: Map of Elevation the National Park Bamoo Figure 3: Map of Slop the National Park Bamoo

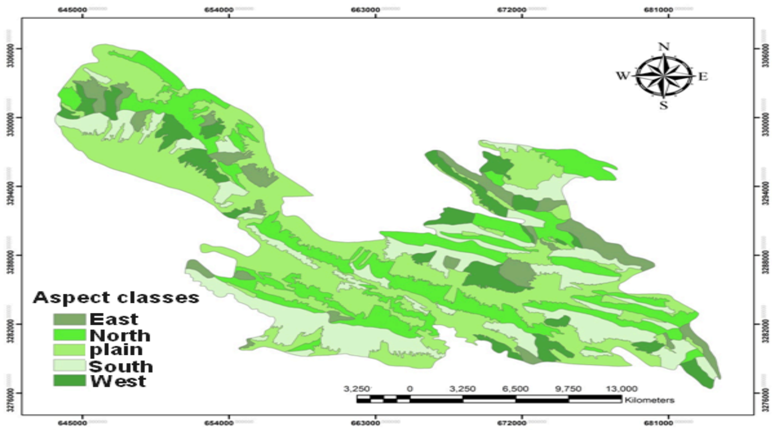


Figure 4: Map of Aspect the National Park Bamoo

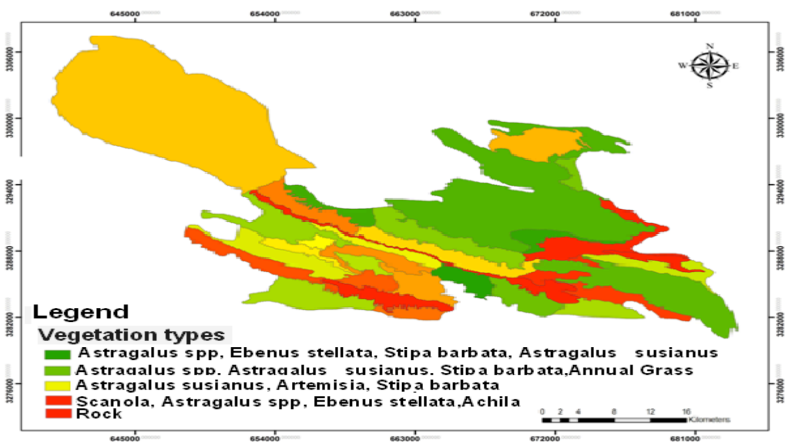


Figure 5: Map of vegetation types the National Park Bamoo

3.3. Layer of species presence

Map of species present (Figure 6) showed the points the distribution Persian gazelle's, that in recent years due to lack of protective measures and migration to other areas the population this unique species declined in Iran. This was the reason that Persian gazelle's were limited their ecological niche.

3.4. Ecological Niche Factor Analysis

Two factors of global Marginality and Specialization were obtained by ENFA (Table 2). The global Specialization for this species was 1.86. Based on these results, Persian gazelle's are a Specialization species which has a narrow spread of ecological. It often tends to live in a narrow range of environmental conditions and in relation to all of the dependent variables of ecological acts specialty. Global marginality the Persian gazelle's was 1.35. This showed uneven distribution of Persian gazelle's in National Park Bamboo (If the Marginality is close to zero, uniformly distributed). As well as Persian gazelle's tend to live in high-level environmental variables and the specific conditions.

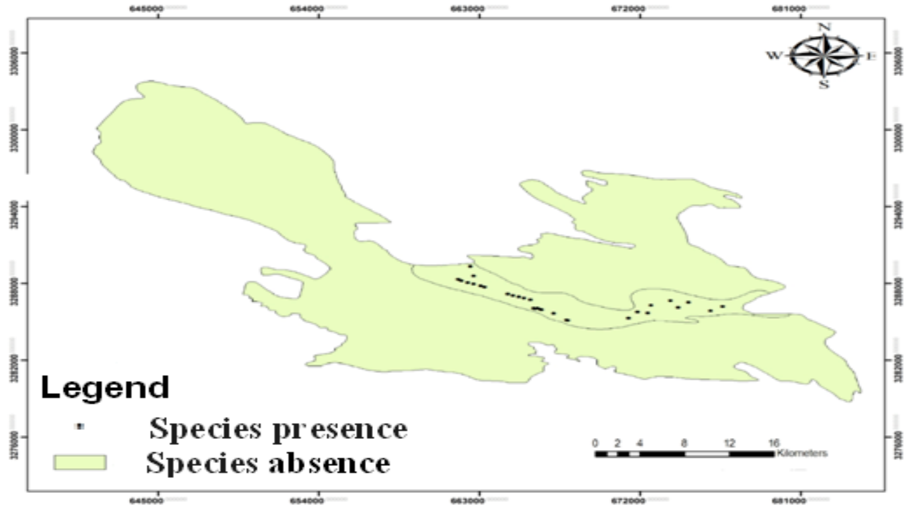


Figure 6. Map points (GPS) of the distribution Persian gazelle's in Bamoo National Park

Ecological niche factor analysis was obtained the score matrix. The contribution of each variable in the distribution of species will be determined by it. The first column of the score matrix (Table 3) showed 100% of the marginality and 75% of the specialization. Other columns showed the 11%, 5%, 4% and 3% of specialization respectively. Overall, High and positive values in the column of the marginality showed tendency of species to live in greater amounts than the average it factors in the environment. The habitat variables in the first column of the table 3 factors are arranged in order of importance in model building, with the variables in the upper rows being the most important. The three habitat variables affecting Gazalles distribution in order of importance included trough and then Altitude and Vegetation at the National Park Bamoo. Preyeating variable showed negative impact on the habitat suitable Persian gazelle's.

Accuracy and precision of the predicted habitat suitability models for the estimation were evaluated using the RS (Spearman correlation coefficient). The accuracy and precision of estimating the models is acceptable if the value of this coefficient for the model was over 80%. Correlation coefficients were obtained 80% for Persian gazelle's habitat suitability model at the National Park Bamoo.

Table 2: Environmental scoring matrix of independent variables

(1%) S5	(4.34%) S4	(9.18%) S3	(14.3%) S2	(%100)Marginality 71.18%)S1	Variables
0.185	0.105	0.316	0.354	0.637	Trough
-0.108	0.024	0.249	0.367	0.598	Elevation
0.067	0.043	-0.123	0.345	0.476	Vegetation
0.059	0.041	0.031	-0.248	-0.372	Prey eater
0.196	0.063	-0.128	-0.223	0.326	Soil
0.276	-0.045	0.026	0.162	0.241	Slope
-0.063	0.043	-0.141	0.126	0.243	Oil Lines

3. 5 Habitat suitability maps

Ecological niche factor analysis was performed and habitat suitability maps were obtained by the four algorithms, distance geometric mean, harmonic mean distance, the minimum distance and the median distance. In order to better display and analysis capability, the maps were classified into classes, suitable habitat, intermediate habitat and unsuitable habitat (Figure 7). Adaptation layers of Eco-geographic and habitat suitability map (Map obtained by the ecological niche factor analysis) showed that the Persian gazelle's were observed mostly in areas with vegetation types include annual grasses,Astaragalus Spp, Artemisia sieberi, and other pasture species that have provided suitable habitat for this species feeding. Also different algorithms used to determine the areas of suitable habitat showed that the highest area of suitable habitat was obtained of algorithms the harmonic mean distance (Table 3).

3. 6 model (ENFA) validation

Authenticity indicators was obtained of maps generated by algorithms the geometric mean distance, the minimum distance, the harmonic mean and the median distance (Table 4). The highest Authenticity was obtained by the harmonic mean distance and then the maps produced with the mean minimum distance algorithm, harmonic distance and the median distance respectively. In total, the authenticity of each of the four habitat suitability maps were confirmed by indicators obtained.

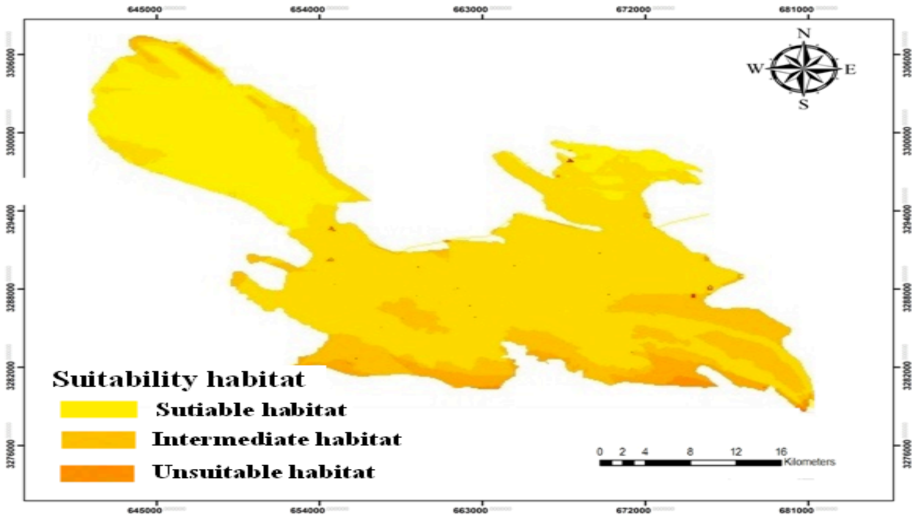


Figure 7: Map of Persian gazelle's habitat suitability by Ecological-Niche Factor Analysis (ENFA)

Table 3: Comparison of Boyce index by different statistical algorithms

Algoritm	Boyce Index+SD	Row
0.861±0. 431	Median	1
0.945± 0.25	Harmonic	2
0.913±0.022	Geometric	3
0.710±0.215	Minimal distance	4

4. Discussion

In this study, The ecological niche factor analysis (ENFA), trough, elevation and vegetation regarded as the most important variables for the Persian gazelle's habitat selection in National Park Bamoo(Table 2). This species was mostly consistent with the environmental conditions at a mean elevation between 1700 to 2000 meters above sea level (Fig. 2), slope 0 -2% (Fig 3) with classes of Aspect the plain and Northern (Fig. 4) and plant types such as annual grasses, Artemisia sieberi and other pasture species as Astragalus Spp were food sources suitable for this species. Adaptation of eco-geographical layers the vegetation map (Fig 5) and habitat suitability map (Figure 7) confirmed that the most distribution of Persian gazelle's occurred in the plant communitie of Astaragalus Spp, Astaragalus susianus,Stipa barba, annual grass and Astaragalus susianus, Artemisia, Stipa barba. Global marginality and Specialization was up to 1.35 and 1.86 for Persian gazelle's in National Park Bamoo. Also indicated by the specialization factor, the occurrence of the *G.s. subgutturosa* is positively associated with the trough, Elevation and vegetation but negatively with Prey-eating (Table2). Larger values of marginality indicate that the species is not equally distributed in the environment and that the habitats utilized strongly differ from the average conditions in the study area [15; 26]. Alternatively small values of specialization represent less restricted niches on some particular environmental variable [26] and high values of specialization means the species do not tolerate variation in that dimension [27]. So severe dependence the Ghazal to trough was a reason the lack different water resources. As well as the troughs distributed by protective measures in plain areas. Since the Prey-eating species of leopards and hyenas are located in the mountainous areas and elevated, the occurrence of the *G.s. subgutturosa* is negatively associated with Prey- eating. This means that the Persian gazelle's avoid Prey-eating parts of the habitat and tend to parts of the habitat that is the flat and covered with shrubs. [28] found that availability of vegetation as food; topography and distance to water were the main factors determining habitat suitability for wild sheep in Mooteh Wildlife Refuge. Also [29] showed that of the three plant communities including *Artemisia sieberi,* Artemisia ausheri and Astaragalus spp cover an area of more the suitable habitat of sheep and rams in Kolahghazy National Park, near water sources were also more suitable habitat for the species. In another study, it was found that Persian gazelle's preferred vegetation types which were dominated by shrubs, such as the *Artemisia herba*-alba [30]. [31] Mongolian gazelles show a preference for grasslands in the intermediate ranges of vegetation productivity. It is likely that the highest regions of vegetation productivity require too great an energy cost to seek out and that Mongolian Persian gazelle's are taking an energy maximizing approach and accepting the tradeoff of foraging in habitat with higher biomass but lower nutritional value and higher fiber.

[32] reported that Persian gazelle'stypical habitat in Iran is shrub lands and particularly Artemisia lands of the semi-arid areas. [33] showed a high correlation between the presence of gazelle (Gazella dorcas) and shrubs density. [34] reported that due to the low quality of desert plants gazelle (Gazella dorcas) had to use a variety of plant communities. [35] examined five variables affecting for Gazalle species for the Wildlife Habitat Suitability Qomishlo including vegetation, slope, elevation, distance to water sources and the distance to the road. The results Anabasis apylla- Artemisia siebri, Astragalus Spp. Perennial grasses and Artemisia Sieberi-Scariola Orientalis have the highest degree of desirability (75%) but area the plant types Artemisia Sieberi – Astragalus Spp was degree of desirability (25%) and lowest area. Most of the species presence (41%) was located at an altitude of 1900-1700 meters. Four habitat suitability maps were derived by layers of variables and point's presence of species and finally the area is classified into three classes, suitable habitat, intermediate habitat and unsuitable habitat. The map adapted with eco-geographical layers so that suitable habitats are located in plant types include annual grasses,Astaragalus Spp, Artemisia sieberi. Different algorithms were used that according to the highest Boyce Index, the harmonic mean distance algorithm was best to draw a habitat suitability map, in other words, the extent of unsuitable habitat was more of the harmonic mean than four other algorithms (Table 3). [36] reported the best algorithm to draw a habitat map of goitered gazelle (Gazella subgutturosa subgutturosa) is the median algorithm. The species of Persian gazelle's is present on the plain between the mountain ranges in National Park Bamoo, so the result achieved by the harmonic mean is correct.

Conclusion

The Persian gazelle's in Iran are worthy of strong research and conservation efforts as they are currently endangered. If conservation efforts are not implemented for this species in the near future, its status could be changed to the Extinct (EX) category. In Bamoo National Park, the presence of species restricted to patches of habitat. Ecological Niche Factor Analysis (ENFA) was able to identify the classes of habitat for species of Persian gazelle's, so that map of habitat classes included the unsuitable, suitable and intermediate suitable habitats and most distribution of Persian gazelle's located in intermediate suitable that the Eco-geographical variables (EGV) such as Altitude, Vegetation and Trough are suitable and Predator such as *Panthera pardus saxicolor* (leopard) and *Hyaena hyaena* (Striped hyaena) are not present. So besides that Persian gazelle's have been more exposed to risk from human activities, the Eco-geographical variables showed an important role in habitat suitability for this species. Ecological Niche Factor Analysis (ENFA) results, the occurrence of the G. s. subgutturosa was negatively affected by predator but due to the relief of the area, the topographic factors and vegetation do not seem to deter the dispersal of the Persian gazelle's in the study area.

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