

## **Functions and Ecosystem Services of Asiatic Cheetah**

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### **Abstract**

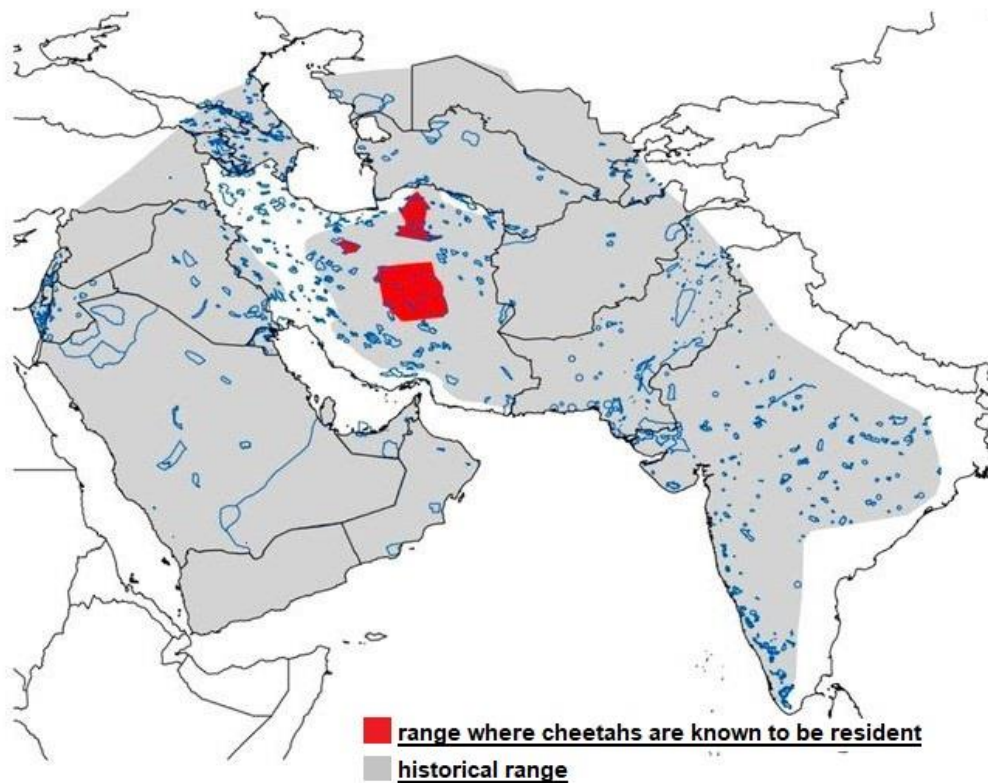
Cheetah is one of the endangered wildlife species in different countries around the world, including Iran, and has been included in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Today, Iran is the only place where Asiatic Cheetahs can be found, and the latest estimates indicate that only 30 to 40 Asiatic Cheetahs remain. The present study aimed to prioritize the ecosystem functions and services for Asiatic Cheetahs in Iran from the perspectives of experts and professionals. After a literature review, based on the 2018 Common International Classification of Ecosystem Services (CICES), among Provisioning, Cultural, and Regulation and Maintenance functions, the Cultural and Regulation and Maintenance functions and 14 services were extracted for Asiatic Cheetahs in Iran. Next, by using the Analytic Hierarchy Process (AHP) and the Delphi method, the priority of functions and services was investigated in two stages. The results showed that the most important functions and services identified were as follows, respectively: Cultural (4.37), Regulation and Maintenance (4.32) functions, and services related to the Bequest value (4.95) of Asiatic Cheetahs; Existence value (4.93); Educational (4.58); Aesthetic (4.47); Entertainment (recreation and ecotourism) (4.44); Symbolic (4.40); Scientific (3.67), Cultural (3.55), Biodiversity (4.82); and Disease control (3.82). The necessary measures for preventing the extinction of Asiatic Cheetahs include the construction of wildlife corridors in habitats of Cheetahs; promoting participation of communities and non-governmental organizations in the sustainable management of Cheetah habitats, and designing coins with Cheetah designs to attract public attention and support.

**Keywords:** Analytic hierarchy process; Asiatic cheetahs; Ecosystem functions and services.

## 37 INTRODUCTION

38 Asiatic Cheetah is an endangered wildlife species in different countries around the world,  
39 including Iran (49). However, it is difficult to assess the current status of this mysterious species  
40 because of its extensive home range and low population density (41). Asiatic Cheetah is a  
41 carnivorous species and Carnivores are at the top of the food pyramid. Being under the threat  
42 of a carnivore and the lack of stability in its population is a sign of the shaky foundations of the  
43 food pyramid. In nature, all parts are related to each other. If the Asiatic Cheetah is protected,  
44 it basically means that other species and the habitat and ecosystem as a whole will be protected.  
45 According to the latest estimates, Cheetahs only exist in 6% of their former home range (16).  
46 Historically, Asiatic Cheetahs were found in 16 countries in Southwest Asia and Central Asia,  
47 extending from Saudi Arabia to the Indian subcontinent (almost near the border of Bangladesh)  
48 through Iran and Afghanistan (50). In the early 1980's, Cheetahs disappeared from most of their  
49 home range, mainly due to habitat loss, land fragmentation, human-wildlife conflicts, and  
50 coursing (53). With the exception of Iran, these animals went extinct in various Asian nations  
51 between 1940 and 1980 (Figure 1) (50), Similar to Cheetahs in North Africa, whose population  
52 is less than 250 and are also in danger of going extinct, predictions indicate that they will  
53 disappear from nearly all countries (40); at the moment, the Asiatic Cheetah subspecies only  
54 exists in Iran. According to statistics published by the Environmental Protection Agency (EPA),  
55 nearly 400 Asian Cheetahs were living in Iran almost 80 years ago. However, this number  
56 declined to 200 to 300 Cheetahs in a few years, and finally, 25 years ago, only 100 of them  
57 were found (22). Since then, several estimates have been published, ranging from 40 to 140  
58 Cheetahs. While there is no official estimate, the number of these animals has undoubtedly  
59 declined in Iran. Although evidence suggests that there are 60 to 100 Asian Cheetahs in Iran  
60 (29), only 30 (48) or 40 (20) of them are expected to exist. The total population of Cheetahs is  
61 estimated at 7,000, with a total population of no more than 10,000 mature individuals (17).  
62 Therefore, Asiatic Cheetahs are listed as a vulnerable (VU) species and included in the  
63 International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Human  
64 factors are major reasons for the extinction of several animal species. For instance, reports have  
65 indicated the death of 28 Cheetahs due to human factors in Iran, 16 of which were caused by  
66 road accidents (31). The main Cheetah habitats are the central and southeast parts of Iran.  
67 Currently, there are protected areas in Yazd, Semnan, Isfahan, Kerman, North Khorasan, and  
68 South Khorasan provinces in Iran. The most important of these habitats include Kavir National  
69 Parks, Siah Kuh, Turan Biosphere Reserve, Anjir Valley Wildlife Refuge, Miandasht, Abbas

70 Abad, Darband, Naybandan, and the protected areas of Mount Bafgh and Kalmand-Bahadoran  
71 (31).



73 **Fig 1. Cheetahs Habitat Resource: Durant et al. (16).**

74 Ecosystem functions are defined as the ability of natural processes and components to provide  
75 goods and services that meet the needs of organisms directly or indirectly (14; 32). Using this  
76 definition, ecosystem functions are considered as a subset of ecological processes and  
77 ecosystem structures. Each function (goods and services) is the result of the natural processes  
78 of the total ecological subsystems that form a sector (14). Natural processes, one after another,  
79 are the result of complex interactions between vital (biotic organisms) and non-vital (chemical  
80 and physical) components of ecosystems, among the world's material and energy forces.  
81 Ecosystem functions are considered as "ecosystem services and goods" when they are valuable  
82 to humans. In other words, it is the human presence that enables the transformation of ecological  
83 structures and processes into valuable phenomena (12). In addition to providing a way to  
84 classify ecosystem services, the Common International Classification of Ecosystem Services  
85 (CICES) is also intended as a classification reference that allows interpretation between  
86 different ecosystem service classification systems (such as those used by the Millennium  
87 Ecosystem Assessment (MEA), the Economics of Ecosystem and Biodiversity (TEEB) is used)  
88 (25). The CICES classification, which is used to value all the functions and services of the

89 ecosystem, includes three functions Provisioning, Regulation and Maintenance, and Culture for  
90 all members and organisms of the ecosystem (both biotic and abiotic, plants, animals, fungi,  
91 and algae ...) is defined. According to the classification of CICES (2018), the Provisioning  
92 function includes 25 services, the Regulation function 22 services, and the Cultural function 12  
93 services for biotic organisms. **This research aimed to prioritize the functions and services of**  
94 **Asiatic Cheetah in Iran based on CICES classification applying the opinions of professionals**  
95 **and experts.**

## 96 97 **Literature Review**

98 According to our review of the literature on the ecosystem functions and services, previous  
99 studies have mostly focused on the functions and services for preserving plant species (7),  
100 forests (5), marine ecosystems (42; 2; 74), lagoons (36; 46), rivers (71; 13), deep seas (69), and  
101 animal microorganisms (43). The Common International Classification of Ecosystem Services  
102 (CICES) is the most commonly used classification (7; 5; 42; 74; 46; 2), followed by the  
103 Millennium Ecosystem Assessment (MEA) classification (43; 71; 36; 13). Some studies have  
104 prioritized the identified ecosystem functions and services using multiple-criteria decision-  
105 making analysis (MCDA) (46;13), expert scoring (74; 36) and analytic hierarchy process (AHP)  
106 (36). **According to the literature review (8; 27; 75; 52; 9; 26; 63; 57; 68; 30; 66; 47; 18; 76; 54;**  
107 **58; 39; 34; 19; 38; 20; 62; 67; 72; 44; 49; 35; 37; 73; 4; 49; 79; 10)** and best of author's  
108 knowledge, this study is the first study on the identification and prioritization of functions and  
109 services for Asiatic **Cheetahs in the world,** by using the CICES and expert opinions.

## 110 111 **MATERIALS AND METHODS**

112 First, all ecosystem functions and services for Asiatic Cheetahs were identified, based on the  
113 literature review and CICES criteria. Next, the Delphi method and AHP were used to identify  
114 and prioritize the most important services according to the experts' opinions. The Delphi  
115 method was used to arrive at a group opinion. While emphasizing the participants' anonymity,  
116 this method uses one or more questionnaires to arrive at an agreement (33).

### 117 118 **The Delphi Method**

119 The Delphi method is generally applied to congregate group opinions, achieve consensus in  
120 groups, and investigate a complex and multidisciplinary phenomenon. The requirements for  
121 this technique include inconsistent evidence, availability of experienced experts, unbalanced  
122 geographical distribution of experts, the necessity of data collection anonymity, lack of time  
123 limitations, and absence of a cost-effective method (55). In this method, it is sometimes

124 important to remove or select some items. In these cases, some criteria can be used by the group  
 125 to reach an agreement on different items and select or remove them. Generally, the number of  
 126 participants depends on several factors, including the homogeneity or heterogeneity of samples,  
 127 goals of Delphi rounds or the extent of the problem, decision quality, research team's ability to  
 128 manage the study, internal and external validity, time of data collection, available resources,  
 129 scope of the problem, and response rate (55; 11). The lowest and highest number of participants  
 130 in previous studies is 10 and 1,685, respectively (55). However, if the participants are  
 131 homogenous, the number of samples should range from 10 to 20 (51). The majority of Delphi  
 132 studies include less than 50 participants (mostly 15 to 20). In this regard, Hsu and Sandford  
 133 (28) believed that the Delphi process should be continued until reaching consensus. Kendall's  
 134 coefficient of concordance (W) is a commonly used criterion to evaluate consensus between  
 135 observers (77). This scale aims to determine the degree of coordination and agreement between  
 136 sets of ranks for n objects or individuals. In other words, it can determine the rank correlations  
 137 between k sets of ranks. This scale is highly useful for evaluating inter-judge reliability. Overall,  
 138 Kendall's coefficient of concordance represents the similarity of criteria used by the participants  
 139 to rank one or more items (65). It can be calculated based on the following formula (78):

$$W = \frac{S}{\frac{1}{12}K^2(N^3 - N)} \quad (1)$$

140 where  $S = \sum(R_j - \frac{\sum R_j}{N})^2$  is the sum of squared deviations of  $R_j$  from the mean  $R_j$ ;  $R_j$  is the sum  
 141 of ranks of an item;  $K$  is the number of sets of ranks (number of referees);  $N$  is the number of  
 142 ranked items; and  $\frac{1}{12}K^2(N^3 - N)$  is the maximal sum of squared deviations (attainable only in  
 143 the case of full consensus among raters). This indicator shows deviation of observed  
 144 homogeneity from full homogeneity of the findings, ranging from zero (lack of consensus) to  
 145 one (full consensus) (78). It includes both qualitative and quantitative criteria (64) and consists  
 146 of goals, criteria, sub-criteria, and strategic options at the lowest level, which are evaluated and  
 147 prioritized for ranking. Kendall's coefficient of concordance is a more comprehensive and  
 148 analytical criterion for evaluating the validity of a Delphi survey because it shows whether  
 149 experts are using essentially the same criteria when ranking the study's objectives (56). It is  
 150 known that a Cronbach's alpha higher than 70% indicates acceptable reliability. Considering  
 151 the high number of the participants ( $n > 50$ ), homogeneity above 51% represents consensus (24).

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## 155 **The AHP method**

156 The main hypothesis **in AHP method** is the independence of higher levels from lower levels  
157 and other criteria and factors at each level (factors in each level only depend on those at higher  
158 levels). In other words, the coefficient of importance at each level is necessarily determined by  
159 higher-level factors (23). The AHP includes three main stages (59; 61):

160 1) Hierarchical structure creation: The problem should be clearly defined in a reasonable  
161 hierarchical system. This stage involves determining the decision-making criteria and  
162 identifying possible options. The link between objectives, criteria, and alternatives is linear and  
163 one-sided. The items do not affect the criteria, and the criteria are independent of each other  
164 (6).

165 2) Pairwise comparison and weighting: This stage aims to determine the relative importance of  
166 each criterion and effective factors. A pairwise comparison is conducted if there is an internal  
167 link. Reciprocal values are considered for reverse comparisons ( $a_{ij}=1/a_{ji}$ , where  $a_{ij}$  denotes  
168 the importance of element  $i$  for element  $j$ ), which is in accordance with the methodology  
169 proposed by Saaty (60). AHP uses a matrix for pairwise comparisons, and the local priority ( $W$ )  
170 is measured to determine the relative importance of each element:

$$171 \quad AW = \lambda_{max}W \quad (2)$$

172 where  $A$  is the matrix for a pairwise comparison,  $w$  denotes the weight vector, and  $\lambda_{max}$  is the  
173 largest weight vector of matrix  $A$ . The priority matrix is used for all pairwise comparisons.

174 3) Calculation of consistency ratio (CR): To determine the compatibility of comparisons, the  
175 CR must be calculated for each of the matrices. If CR is  $\leq 0.1$ , comparisons are consistent (59);  
176 otherwise, the decision should be revised. The CR is calculated as follows:

$$177 \quad CR = \frac{CI}{RI} \quad (3)$$

178 where  $RI$  is the consistency ratio, and  $CI$  is the degree of deviation from consistency. The  $CI$   
179 formula is as follows:

$$180 \quad CI = \frac{\lambda_{max} - n}{n - 1} \quad (4)$$

181 where  $\lambda_{max}$  corresponds to the largest specific value, and  $n$  is the length of the pairwise  
182 comparison matrix.  $RI$  is generally a random consistency index or an index of randomly  
183 generated weights. Its value is determined based on the pairwise comparison matrix ( $n \times n$ )  
184 **from Table 1** (59). All the above-mentioned steps were performed in the Expert Choice  
185 Comparison<sup>®</sup> AHP Software (23). Group consensus is necessary when making pairwise  
186 comparisons to prevent any potential bias.

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**Table 1.** The random consistency index.

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

## RESULTS

### Data collection

To prioritize the functions and services for Asiatic Cheetahs in Iran, particular attention must be paid to their habitats, physical and behavioral characteristics, and effects on the environment and other animals. For this purpose, a comprehensive literature review of both national and international studies was carried out. Next, based on the CICES classification and studies on top predators, including Asiatic and African Cheetahs, different functions and services were determined. The CICES classification is useful for determining all the ecosystem functions and services. It is comprised of three Provisioning, Regulation and Maintenance, and Cultural functions for all members and organisms in the ecosystem (i.e., biotic and abiotic organisms, plants, animals, fungi, and algae). According to the CICES classification, because Cheetah is an endangered predator, only regulating and cultural functions were considered. In other words, the provisioning function (i.e., supply of food and leather) was removed, depending on the context of Iran. Generally, the Regulation and Maintenance function includes biodiversity, gas regulation, water regulation, soil regulation, pollination and seed dispersal, and disease control. Moreover, Cultural functions include aesthetic, entertainment, cultural, symbolic, scientific, educational, existence value, and bequest value has mentioned in the Table 2.

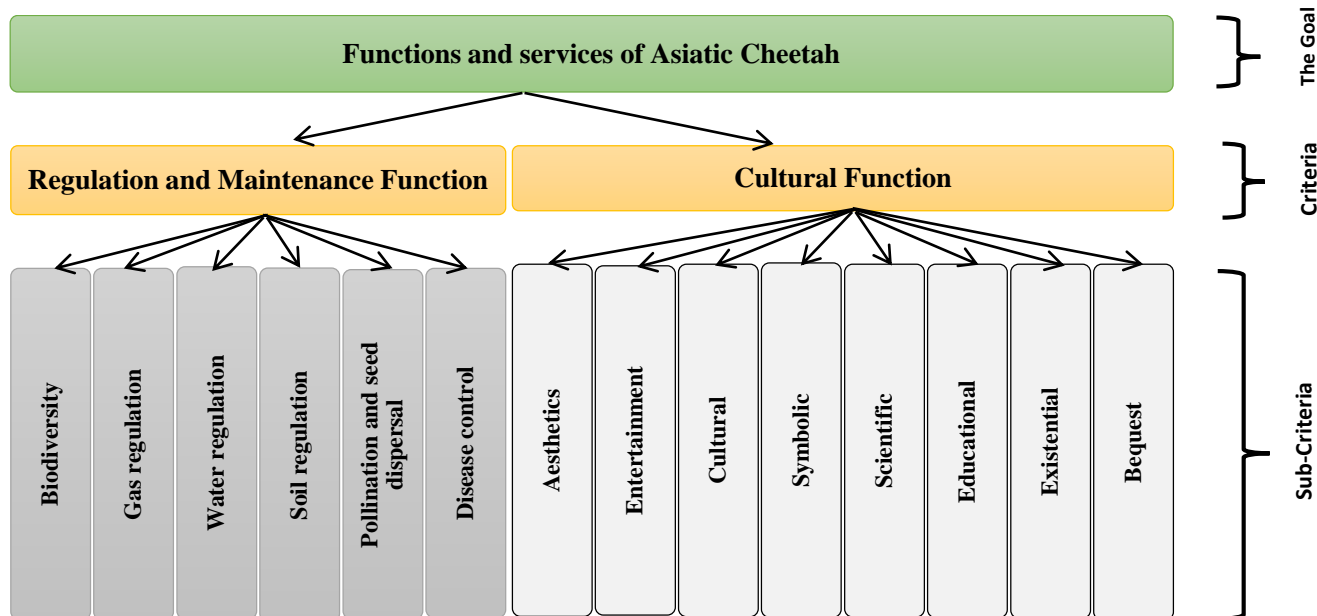
After the identification of functions and services, a questionnaire was designed, which included items to score the identified functions (six items for Regulation and Maintenance functions and eight items for cultural functions). Scoring was based on a five-point Likert scale, ranging from Very important (5), important (4), moderately important (3), and slightly important (2) to the unimportant (1). The Cronbach's alpha (87.9%) and Kendall's coefficient of concordance (51.2%) were used to evaluate reliability and validity, respectively. The questionnaire was finalized in the second round since the Kendall's coefficient of concordance did not change and the number of participants was large.

**Table 2: Summary of Functions and Services of Asiatic Cheetah.**

Functions	Services	Processes and components of Asiatic Cheetah	SECIC	Goods and services	Source
Regulation & Maintenance	Biodiversity	The Asiatic Cheetah is an important indicator species and is an umbrella species for protecting fragile ecosystems, as it is sensitive to population, abundance of prey, habitat destruction, and human presence.	Maintaining nursery populations and habitats (including gene pool protection)	Protection of genetic diversity increases species uniformity and biodiversity.	(72; 73; 45)
	Gas regulation	Cheetahs protect plant species by preventing overgrazing.	Regulation of chemical composition of atmosphere. Global climate regulation by reduction of greenhouse gas	Improving air quality through the control of fine dust	(3; 72)
	Water regulation	Cheetahs are essential for restoring vegetation and regulating water flow.	Buffering and attenuation of mass flows	Increasing the level of underground water tables and absorption of surface water	(73)
	Soil regulation	Cheetah species promote vegetation restoration and preservation of soil nutrients and food chain.	Decomposition and fixing processes and their effect on soil quality	Soil formation Improving soil fertility Prevent soil erosion	(1; 45; 73)
	Pollination and seed dispersal	Cheetah promotes pollination and seed dispersal to improve vegetation.	Pollination (or 'gamete' dispersal in a marine context), Pollination and seed dispersal	Pollination	(72; 73)
	Disease control	Disease control through hunting of weak, slow and diseased species.	Disease control	Disease control by hunting weak, slow and sick individuals in herds	(45)
Cultural	Aesthetic	Rare species are seen as a reflection of creation.	Spiritual, symbolic and other interactions with natural environment.	Uniqueness of moles on the body and face of Cheetah is like fingerprints in humans	(45)
	Entertainment	Cheetah's role for entertainment and recreational opportunities	Entertainment Elements of living systems used for entertainment or representation	Ecotourism and tourism; Safari	(15)
	Cultural	Cheetah is a source of inspiration for creative activities.	Characteristics of living systems that are resonant in terms of culture or heritage	Photography, verse literature, books, films, paintings, and sculptures	(21; 45; 49)
	Symbolic	Creating a national symbol to raise awareness of Cheetah.	Spiritual, symbolic and other interactions with natural environment. Symbolic, Elements of living systems that have symbolic meaning	Cheetah has been used as a symbol in poetry, sculptures, and reliefs, and as the symbol of cities.	(70; 31; 66)
	Scientific	Cheetah species inspire research in morphology, physiology, habitat identification, and species valuation.	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	Scientific research Modeling ostrich limbs for robot and car suspension design.	(39)
	Educational	Modeling the Asiatic Cheetah species in formal and informal education	Characteristics of living systems that enable education and training	Educating local communities to protect the species	(31; 34; 35)
	Existence value	Society is willing to pay for the protection of the Asiatic Cheetah, a rare species.	Characteristics or features of living systems that have an existence value	Funds allocated to protect Asiatic Cheetah species by UNDP, GEF, and IUCN.	(70)
	Inheritance value	Willingness to pay society to protect the species for the benefit of future generations	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting. Other biotic characteristics that have non-use value. Bequest	Preservation of species for future generations.	(35; 20; 79)



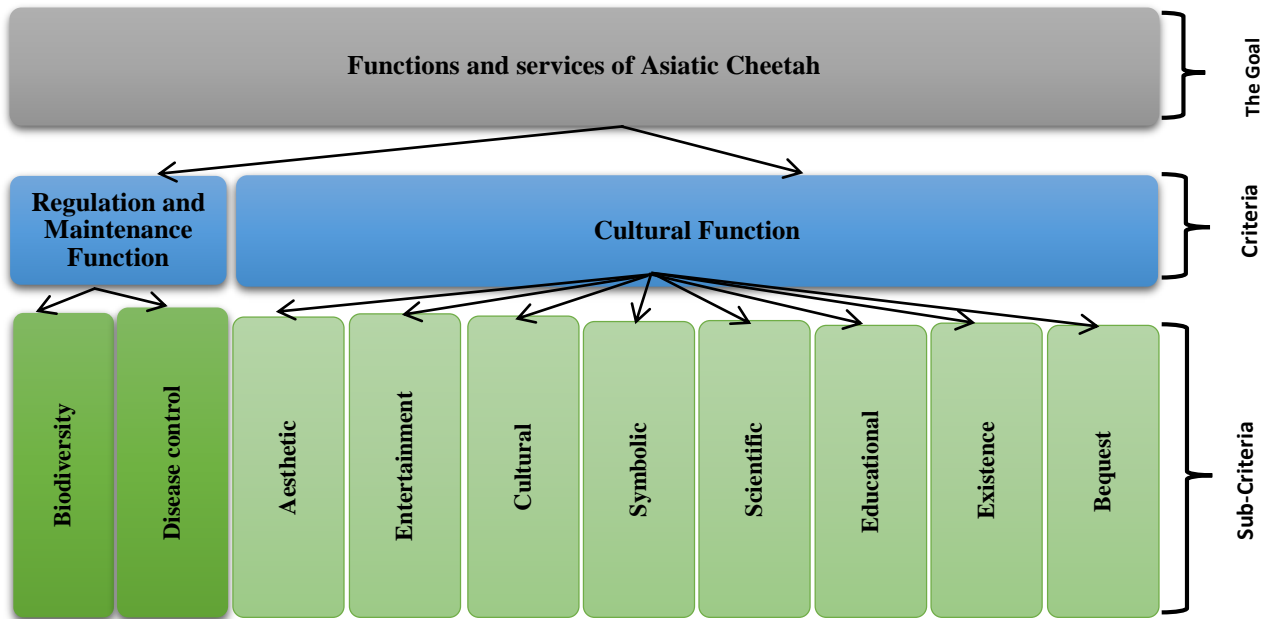
222 A total of 64 experts from different fields were asked to complete the questionnaire. The experts  
 223 were from various fields, including park rangers, veterinarians, experts of the EPA and the  
 224 General Directorate of Environmental Protection, professionals and retirees, Iranian researchers  
 225 (in Iran or outside Iran), Cheetah-related non-governmental organizations (NGOs), faculty  
 226 members of Iranian universities, and media activists focusing on Cheetahs (e.g., writers,  
 227 journalists, reporters, and documentary filmmakers). The link of the questionnaire, either the  
 228 mobile or desktop version, was sent to the participants through email and social media while  
 229 informing them through phone calls. The first stage of data collection continued for one month.  
 230 After removing partially completed questionnaires, a total of 55 questionnaires were found  
 231 eligible. Figure 2 shows the AHP and services and functions that were identified in the first  
 232 stage. In the first stage, the inconsistency ratio was zero, indicating consensus among experts.



233 **Fig 2. The AHP method and services and functions identified in the first stage.**

234  
 235 The questionnaire was redesigned after obtaining the experts' opinions in the first stage, which  
 236 resulted in the removal of water, gas, and soil regulation and Pollination and seed dispersal.  
 237 The link to the revised questionnaire was sent to all experts via email and social media; finally,  
 238 the data of 55 questionnaires were analyzed. The second stage continued for 15 days. The  
 239 identified functions and services during the second stage are presented in Figure 3. The  
 240 inconsistency ratio in the second stage was 0.0072, that indicating a high level of consistency.

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**Fig 3.** The AHP method and the identified functions and services in the second stage.

The AHP was used to prioritize the mentioned functions and services. To prioritize the functions and services, the sub-criteria for each criterion and then the criteria were prioritized. The socioeconomic characteristics of the participants are presented in Table 3.

**Table 3.** The socioeconomic characteristics of the participants.

	Variables	Frequency (N)	Frequency (%)
Sex	Female	10	18
	Male	45	81
Education level	Diploma	1	1.08
	Bachelor's degree	9	16
	MSc	24	46
	PhD	19	24
	Postdoc degree	2	3
Field	Researcher	10	18
	Faculty member	6	10.9
	Park rangers and experts of EPA	28	50
	NGOs	5	9.9
	Social media activists	6	10.9

In this study, 81% and 18% of the participants were male and female, respectively. Overall, the education level of 83% of the participants was MSc or higher (i.e., MSc, PhD, and postdoc degrees). The Delphi method was applied to calculate the mean score of each sub-criterion (Table 4). Figure 4 displayed the mean scores related to Regulation and Maintenance functions services in first and second Delphi rounds. Also, the mean scores related to Cultural functions services in first and second Delphi rounds were presented in the figure 5. Moreover, the mean score of each criterion was calculated, which was 3.15 for the Regulation and Maintenance function and 4.28 for the cultural function. The figure 6 demonstrated the comparison of the mean scores of Regulation and Maintenance and Cultural functions in first and second Delphi

261 rounds. Overall, in the Delphi method, criteria with scores less than 3.5 should be removed (24).  
 262 Therefore, gas regulation, water regulation, soil regulation, and Pollination and seed dispersal  
 263 were removed in the second round of the Delphi method.

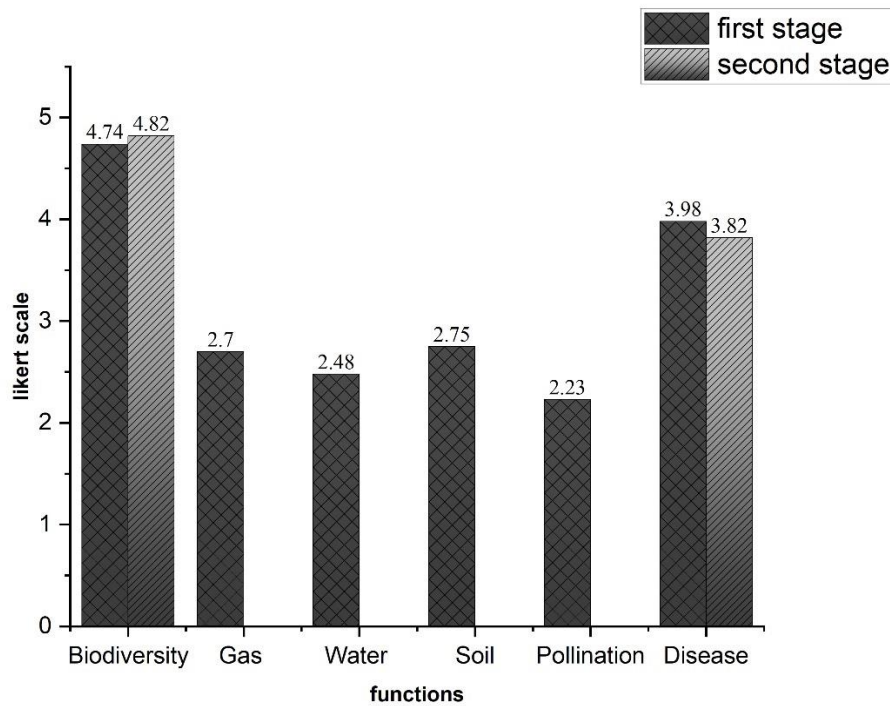
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 265 **Table 4.** Comparison of the mean scores of services and functions in the first and second Delphi  
 266 rounds.

Functions	Services	Normalized Priority Round one	Mean of functions Round one	Mean of services Round one	Normalized Priority Round two	Mean of functions Round two	Mean of services Round two
Regulation and Maintenance	Biodiversity	1.00	3.15	4.74	0.865	4.32	4.82
	Gas regulation	0.422		2.70	-		
	Water regulation	0.402		2.48	-		
	Soil regulation	0.388		2.75	-		
	Pollination and seed dispersal	0.338		2.23	-		
	Disease control	0.228		3.98	3.82		
Cultural	Aesthetic	0.699	4.28	4.23	0.709	4.37	4.47
	Entertainment	0.918		3.75	0.690		4.44
	Cultural	0.519		3.89	0.380		3.55
	Symbolic	0.777		4.41	0.672		4.40
	Scientific	0.584		4.08	0.411		3.67
	Educational	0.918		4.62	0.770		4.58
	Existence	0.841		4.51	0.987		4.93
Bequest	1.00	4.74	1.00	4.95			

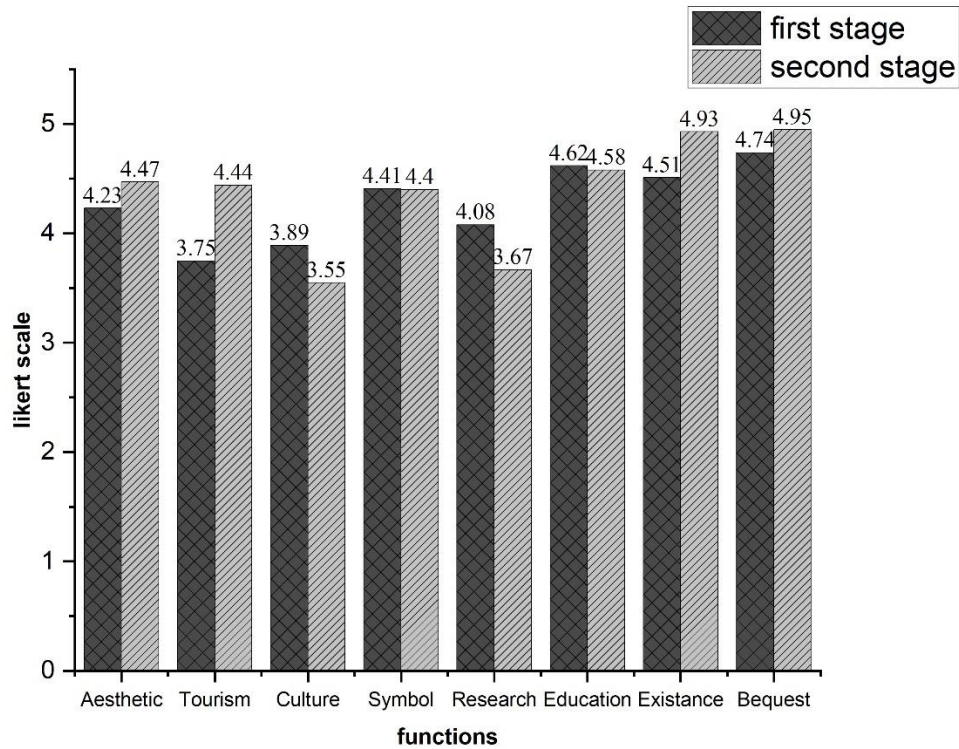
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 268 After calculating the sub-criteria and criteria, the AHP method was used to prioritize Regulation  
 269 and Maintenance and Cultural functions and services. According to the findings, the highest  
 270 and lowest scores in Regulation and maintenance were attributed to biodiversity and disease  
 271 control, respectively. The bequest value obtained the highest score, followed by Educational,  
 272 existence value, symbolic, aesthetic, scientific, cultural, and Entertainment in Cultural  
 273 Function. After determining the priority of services related to Regulation and Maintenance and  
 274 Cultural functions, the functions were prioritized. According to the findings, Cultural functions  
 275 were prioritized over Regulation and Maintenance functions.

276 In the second stage, the Regulation and Maintenance functions included biodiversity and  
 277 disease control. Besides, the Cultural functions included aesthetic, entertainment, cultural,  
 278 symbolic, scientific, and educational, existence value, and bequest value (Figure 3). To  
 279 prioritize the functions and services for Asiatic Cheetahs in the second round via AHP,  
 280 prioritization was considered as the study objective, while Regulation and Maintenance and  
 281 Cultural functions were considered as the criteria. According to the findings, the mean scores  
 282 of biodiversity and disease control were 4.82 and 3.82, respectively (Figure 4). Regarding the  
 283 Cultural dimension, the mean scores of aesthetic, entertainment, cultural, symbolic, scientific,  
 284 educational, existence value, and bequest value were 4.47, 4.44, 3.55, 4.40, 3.67, 4.58, 4.93,

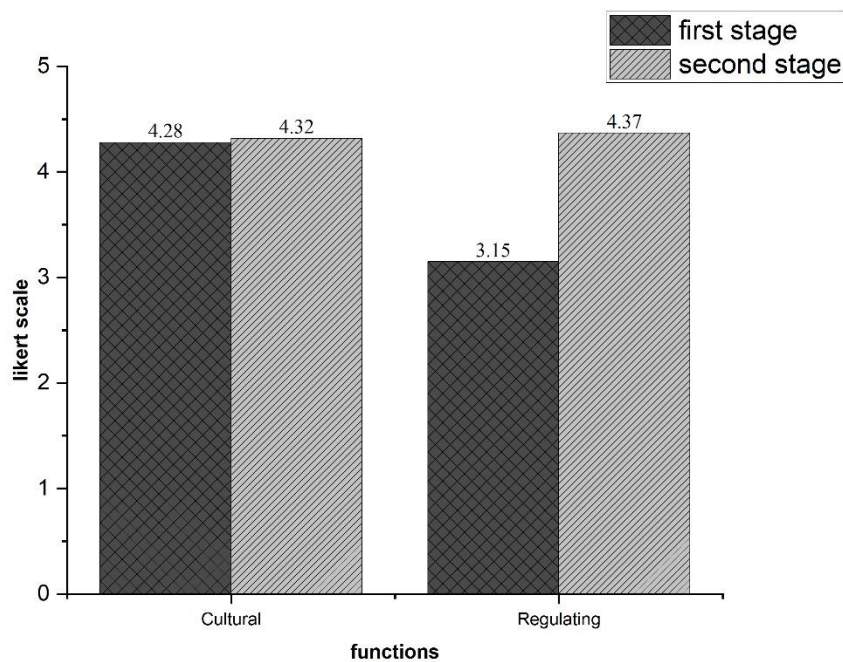
285 and 4.95, respectively (Figure 5). Also, the mean scores of Regulation and Maintenance and  
286 Cultural functions were 4.32 and 4.37, respectively (Figure 6). As for all dimensions, the mean  
287 score was higher than 3.5, and no dimension was excluded. The AHP was used to prioritize  
288 biodiversity and disease control services; the former had the highest priority. Regarding  
289 Cultural functions, AHP indicated bequest value and cultural and aesthetic values as the main  
290 criteria with the highest and lowest priorities, respectively, based on the participants' opinions,  
291 followed by existence value and education.



292 **Figure 4.** The mean scores of services related to Regulation and Maintenance functions in the  
293 first and second Delphi rounds.  
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 296 **Figure 5.** The mean scores of services related to Cultural functions in the first and second  
 297 Delphi rounds.



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 299 **Figure 6.** Comparison of the mean scores of Regulation and Maintenance and Cultural  
 300 functions.  
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302 **DISCUSSION**

303 Richer biodiversity means more stable nature. Man depends on his nature. The protection of  
 304 the Asiatic Cheetah is in line with the protection of biodiversity on the planet. Lack of protection

305 for the Asiatic Cheetah will have a variety of negative effects and threats on a local, national,  
306 regional, and international scale. An innovative strategy for the preservation and sustainable  
307 management of existing ecosystems can result from understanding and evaluating the functions  
308 of living animal species. The role of every biotic organism will be clearer by understanding and  
309 identifying its ecosystem functions and Services which leads to conserving it more specifically  
310 and effectively. Therefore, the CICES classification was used to investigate and identify the  
311 ecosystem services and functions provided by Asiatic Cheetah. Due to a lack of research in  
312 previous studies, identifying the Functions and Services of the Cheetah among the 25  
313 provisioning services, 22 regulatory services, and 12 cultural services that were for biotic  
314 organisms introduced by CICES 2018 was challenging and difficult. As a result, in this study,  
315 6 regulatory services and 8 cultural services were considered for the Cheetah to be determined  
316 by Experts. Finally, 2 Regulation and Maintenance Services and 8 Cultural Services were  
317 chosen by Experts.

318 There are different strategies for preserving Asiatic Cheetahs from endangered, but they should  
319 use at different levels of Society. Some of these Strategies should apply by the government, and  
320 Some by the people. Some of the recommended strategies for preserving Asiatic Cheetah are;  
321 **Creating alternative and sustainable livelihoods in order to avoid the exploitation of cheetah**  
322 **habitats and to restore plant and animal richness in order to restore ecosystems with Asian**  
323 **cheetah species;** Training local communities, especially shepherds and cattlemen living near  
324 the habitats of Cheetahs, holding conferences and workshops (national and international) for  
325 familiarization with this unique species, and performing scientific research. **Fencing and**  
326 **securing the roads of the Asiatic cheetah habitat, increasing the necessary equipment and**  
327 **facilities for the protection of the Asiatic cheetah, increasing the number of rangers in the area.**  
328 Building wildlife corridors (e.g., bridges or subways) in the vicinity of Cheetah habitats to  
329 reduce traffic accidents, similar to Sweden, the United States, Australia, Netherlands, Finland,  
330 Canada, Kenya, and Singapore. Promoting public and NGO participation in the sustainable  
331 management of Cheetah habitats (i.e., planning, implementation, monitoring, and evaluation)  
332 and increasing the awareness of local communities about environmental and ecological values  
333 using promotional and educational programs. Identification of full research capacity on  
334 Cheetahs, developing research priorities related to Cheetahs and their habitats, and sharing the  
335 information with all related research centers and researchers. Designing Cheetah coins and  
336 attracting public support to protect endangered animals, particularly Asiatic Cheetahs. For  
337 instance, Turkmenistan designed Turkmenian eyelid gecko coins (*Eublepharis turkmenicus*).

338 Besides, Kenya, Iceland, and the European Union countries designed similar coins to protect  
339 endangered species.

## 340 341 **Conclusions**

342 In this research, an attempt has been made to study the functions and services of the Cheetah in  
343 the ecosystem and its role in nature, to help achieve this as much as possible. Accordingly, due  
344 to the lack of a similar study, first studies on the functions and ecosystem services of animal  
345 species were reviewed, and then, based on the classification of CICES and existing definitions,  
346 two functions and 14 services of cheetahs were determined. The AHP and Delphi method  
347 indicated biodiversity, disease control, aesthetic, entertainment, cultural, symbolic, scientific,  
348 and educational, existence, and bequest as the most important services and functions for Asiatic  
349 Cheetahs in Iran. After the first round of Delphi method, Gas regulation, Water regulation, Soil  
350 regulation and Pollination and seed dispersal services were removed based on the expert's  
351 opinions. Finally, after the second round, biodiversity and disease control services from  
352 Regulation and Maintenance Function and disease control, aesthetic, entertainment, symbolic,  
353 scientific, educational, existence and bequest services from Cultural Function remained. In other  
354 words, this study identified 2 functions and 10 services based on CICES 2018 for Cheetah. The  
355 role of every biotic organism will be clearer by understanding and identifying its ecosystem  
356 functions and services which leads to conserving it more specifically and effectively. Based on  
357 the findings, experts have prioritized Asiatic Cheetah services in the following order of  
358 importance: bequest, existence, biodiversity, educational, aesthetic, entertainment, symbolic,  
359 disease control, scientific, and cultural; additionally, the Cultural function and services have  
360 been prioritized over the Asiatic Cheetah's Regulation and Maintenance function and services.  
361 As a result, only biodiversity services and disease control have been prioritized from the  
362 Regulation and Maintenance function; thus, these two services should be valued from the  
363 Regulation and Maintenance function in future studies to estimate the economic value of Asiatic  
364 Cheetah ecosystem services. But in the current situation, due to the danger of extinction of the  
365 Asiatic Cheetah and its very small population in nature, this unique species does not have a  
366 Provisioning function and cannot have a significant impact on nature; unless this species is  
367 rapidly revitalized; Therefore, in this case, it's possible to hope that in the future the Regulation  
368 and Maintenance function will have a higher priority than the Cultural function. Furthermore,  
369 the findings of this study have revealed that all services related to Cultural function are  
370 important for the Asiatic Cheetah and its economic value can be estimated. If the government  
371 seeks to draw more attention to the Asiatic Cheetah in the society, it should focus on the services

372 related to the Cultural function, which include bequest, existence, educational, aesthetic,  
373 entertainment, symbolic, scientific and cultural. Overall, the following measures are proposed  
374 to protect Asiatic Cheetahs: Preventing habitat loss using productive and sustainable methods,  
375 while emphasizing biodiversity, participatory management of natural resources (e.g.,  
376 engagement of local communities), and protecting species in the food chain of Asiatic Cheetahs.  
377 The results of this research in the field of functions and services of Cheetah, Asiatic Cheetah  
378 functions and services and prioritization of Asiatic Cheetah functions and services in future  
379 studies can be useful and will helpful to planners and policy makers in this field. This research  
380 may also be beneficial for researchers interested in economic valuation of the Asiatic Cheetah.  
381 Furthermore, for future studies, it is recommended to compare different classifications for  
382 Cheetahs, especially Asiatic Cheetahs and to investigate more about this unique apex predator.

383

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