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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 were, respectively, as follows: 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 to attract public attention and support.

Keywords: Analytic hierarchy process, Delphi survey, Extinction of Asiatic Cheetahs, Threatened species.

INTRODUCTION

Asiatic Cheetah is an endangered wildlife species in different countries around the world, including Iran (Nezami Balouchi, 2017). However, it is difficult to assess the current status of this mysterious species because of its extensive home range and low population density (Marker *et al.*, 2018). Asiatic Cheetah is a carnivorous species that is at the top of the food pyramid. Being under the threat of a carnivore and the lack of stability in its population is a sign of the shaky foundations of the food pyramid. In nature, all parts are related to each other. If the Asiatic Cheetah is protected, it basically means that other species and the habitat and ecosystem as a whole will be protected. According to the latest estimates, Cheetahs only exist in 6% of their former home range (Durant *et al.,* 2017). Historically, Asiatic Cheetahs were found in 16 countries in Southwest Asia and Central Asia, extending from Saudi Arabia to the Indian subcontinent (almost near the border of Bangladesh) through Iran and Afghanistan (Nowell and Jackson, 1996). In the early 1980's, Cheetahs disappeared from most of their home range, mainly due to habitat loss, land fragmentation, human-wildlife

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conflicts, and coursing (Pang *et al.,* 2018). With the exception of Iran, these animals went extinct in various Asian nations between 1940 and 1980 (Figure 1) (Nowell and Jackson, 1996), Similar to Cheetahs in North Africa, whose population is less than 250 and are also in danger of going extinct, predictions indicate that they will disappear from nearly all countries (Marker, 2002); at the moment, the Asiatic Cheetah subspecies only exists in Iran. According to statistics published by the Environmental Protection Agency (EPA), nearly 400 Asian Cheetahs were living in Iran almost 80 years ago. However, this number declined to 200 to 300 Cheetahs in a few years and, finally, 25 years ago, only 100 of them were found (Firouz, 1999). Since then, several estimates have been published, ranging from 40 to 140 Cheetahs. While there is no official estimate, the number of these animals has undoubtedly declined in Iran. Although evidence suggests that there are 60 to 100 Asian Cheetahs in Iran (Hunter *et al*., 2007), only 30 (Nezami Balouchi, 2019) or 40 (Farhadinia *et al*., 2016) of them are expected to exist. The total population of Cheetahs is estimated at 7000, with a total population of no more than 10,000 mature individuals (Durant *et al*., 2015). Therefore, Asiatic Cheetahs are listed as a Vulnerable (VU) species and included in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Human factors are the major reasons for the extinction of several animal species. For instance, reports have indicated the death of 28 Cheetahs due to human factors in Iran, 16 of which were caused by road accidents (Islamic Republic News Agency, 2019). The main Cheetah habitats are the central and southeast parts of Iran. Currently, there are protected areas in Yazd, Semnan, Isfahan, Kerman, North Khorasan, and South Khorasan Provinces in Iran. The most important of these habitats include Kavir National Parks, Siah Kuh, Turan Biosphere Reserve, Anjir Valley Wildlife Refuge, Miandasht, Abbas Abad, Darband, Naybandan, and the Protected Areas of

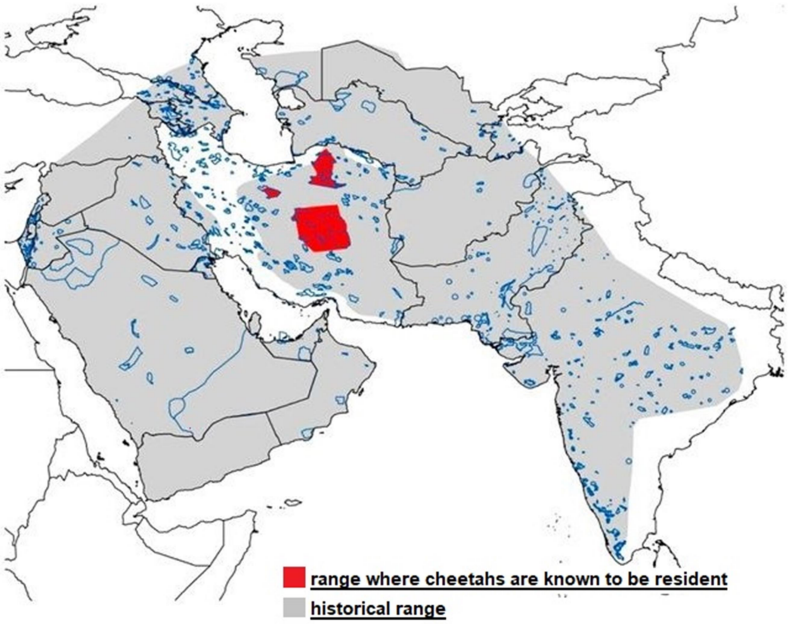

Figure 1. Cheetah's habitat resource (Durant *et al.,* 2015).

Mount Bafgh and Kalmand-Bahadoran (Islamic Republic News Agency. 2019).

Ecosystem functions are defined as the ability of natural processes and components to provide goods and services that meet the needs of organisms directly or indirectly (De Groot *et al*., 2002; Jax, 2016). Using this definition, ecosystem functions are considered as a subset of ecological processes and ecosystem structures. Each function (goods and services) is the result of the natural processes of the total ecological subsystems that form a sector (De Groot *et al*., 2002). Natural processes, one after another, are the result of complex interactions between vital (biotic organisms) and non-vital (chemical and physical) components of the ecosystems, among the world's material and energy forces. Ecosystem functions are considered as "ecosystem services and goods" when they are valuable to humans. In other words, it is the human presence that enables the transformation of ecological structures and processes into valuable phenomena (Costanza *et al*., 1997). In addition to providing a way to classify ecosystem services, the Common International Classification of Ecosystem Services (CICES) is also intended as a classification reference that allows interpretation between different ecosystem service classification systems [such as those used by the Millennium Ecosystem Assessment (MEA) and the Economics of Ecosystem and Biodiversity (TEEB)] (Haines-Young and Potschin-Young, 2018). The CICES classification, which is used to value all the functions and services of the ecosystem, includes three functions, namely, Provisioning, Regulation and Maintenance, and Culture for all members and organisms of the ecosystem (both biotic and abiotic, plants, animals, fungi, and algae ...). According to the classification of CICES (2018), the Provisioning function includes 25 services, the Regulation function 22 services, and the Cultural function 12 services for biotic organisms. This research aimed to prioritize the functions and services of Asiatic Cheetah in Iran based on CICES classification applying the opinions of professionals and experts.

According to our review of the literature on the ecosystem functions and services, previous studies have mostly focused on the functions and services for preserving plant species (Campagne *et al.,* 2015), forests (Brockerhoff *et al*., 2017), marine ecosystems (Martínez-López *et al*., 2019; Armoškaitė *et al*., 2020; Von Thenen *et al*., 2020), lagoons (Khomalli *et al*., 2020; Mustajoki *et al*., 2020), rivers (Vaughn, 2018; De Castro-Pardo *et al*., 2021), deep seas (Thurber, 2014), and animal microorganisms (McKenney *et al.,* 2018). The Common International Classification of Ecosystem Services (CICES) is the most commonly used classification (Campagne *et al.,* 2015; Brockerhoff *et al.,* 2017; Martínez-López *et al.,* 2019; Von Thenen *et al.,* 2020; Mustajoki *et al.,* 2020; Armoškaitė *et al.* 2020), followed by the Millennium Ecosystem Assessment (MEA) classification (McKenney *et al.,* 2018; Vaughn, 2018; Khomalli *et al.,* 2020; de Castro-Pardo *et al.,* 2021). Some studies have prioritized the identified ecosystem functions and services using multiple-criteria decision-making analysis (MCDA) (Mustajoki *et al.,* 2020; de Castro-Pardo *et al.,* 2021), expert scoring (Von Thenen *et al.,* 2020; Khomalli *et al.,* 2020) and analytic hierarchy process (AHP) (Khomalli, 2020). According to the literature review (Caro and Durant, 1991; Howarth and Farber, 2002; Walpole and Leader-Williams, 2002; Packer *et al.,* 2003; Chambers and Whitehead, 2003; Hebblewhite *et al.,* 2005; Sergio *et al.,* 2008; Richardson and Loomis, 2009; Terborgh and Freeley, 2010; Ijspeert, 2010; Naidoo *et al.,* 2011; Estes *et al.,* 2011; Wang *et al.,* 2012; Patel and Braae*.,* 2014; Ripple *et al.,* 2014; Li *et al.,* 2014; Komi, 2015; Sarasola *et al.,* 2016; Stier *et al.,* 2016; Verma *et al.,* 2017; Misachi, 2017; Klein *et al.,* 2018; Verma *et al.,* 2019; Borisov *et al.,* 2019; Marker, 2020; Sohrabinia and Hosseini Zavarei, 2010; Khalatbari, 2014; Farhadinia *et al.,* 2015; Nezami Balouchi, 2017; Nezami

Balouchi *et al.,* 2019; Farhadinia *et al.,* 2016; Khalatbari *et al.,* 2017; Yusefi *et al*., 2019) and the best of authors' knowledge, this study is the first study on the identification and prioritization of functions and services for Asiatic Cheetahs in the world, by using the CICES and expert opinions.

MATERIALS AND METHODS

First, all ecosystem functions and services for Asiatic Cheetahs were identified, based on the literature review and CICES criteria. Next, the Delphi method and AHP were used to identify and prioritize the most important services according to the experts' opinions. The Delphi method was used to arrive at a group opinion. While emphasizing the participants' anonymity, this method uses one or more questionnaires to arrive at an agreement (Keeney *et al.,* 2001).

The Delphi Method

The Delphi method is generally applied to congregate group opinions, achieve consensus in groups, and investigate a complex and multidisciplinary phenomenon. The requirements for this technique include inconsistent evidence, availability of experienced experts, unbalanced geographical distribution of experts, the necessity of data collection anonymity, lack of time limitations, and absence of a cost-effective method (Powell, 2003; Landeta; 2006). In this method, it is sometimes important to remove or select some items. In these cases, some criteria can be used by the group to reach an agreement on different items and select or remove them. Generally, the number of participants depends on several factors, including the homogeneity or heterogeneity of samples, goals of Delphi rounds or the extent of the problem, decision quality, research team's ability to manage the study, internal and external validity, time of data collection, available resources, scope of the problem, and response rate (Powell, 2003; Landeta, 2006; Chu and Hwang, 2008). The lowest and highest number of participants in previous studies is 10 and 1,685, respectively (Powell, 2003). However, if the participants are homogenous, the number of samples should range from 10 to 20 (Okoli and Pawlowski, 2004). The majority of Delphi studies include less than 50 participants (mostly 15 to 20). In this regard, Hsu and Sandford (2007) believed that the Delphi process should be continued until reaching consensus. Kendall's coefficient of concordance (W) is a commonly used criterion to evaluate consensus between observers (Webb and Williams, 1988). This scale aims to determine the degree of coordination and agreement between sets of ranks for n objects or individuals. In other words, it can determine the rank correlations between k sets of ranks. This scale is highly useful for evaluating inter-judge reliability. Overall, Kendall's coefficient of concordance represents the similarity of criteria used by the participants to rank one or more items (Siegel and Castellan, 1988). It can be calculated based on the following formula (Williams and Web, 1994):

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

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 of ranks of an item; K is the number of sets of ranks (number of referees); N is the number of ranked items; and $\frac{1}{12}K^2(N^3 - N)$ is the maximal sum of squared deviations (attainable only in the case of full consensus among raters). This indicator shows deviation of the observed homogeneity from full homogeneity of the findings, ranging from zero (lack of consensus) to one (full consensus) (Williams and Web, 1994). It includes both qualitative and quantitative criteria (Shahnoshi Foroushani, 2007) and consists of goals, criteria, sub-criteria, and strategic options at

the lowest level, which are evaluated and prioritized for ranking. Kendall's coefficient of concordance is a more comprehensive and analytical criterion for evaluating the validity of a Delphi survey because it shows whether experts are using essentially the same criteria when ranking the study's objectives (Profillidis and Botzoris, 2018). It is known that a Cronbach's Alpha higher than 70% indicates acceptable reliability. Considering the high number of the participants (n> 50), homogeneity above 51% represents consensus (Habibi, 2012).

The AHP Method

The main hypothesis in AHP method is the independence of higher levels from lower levels and other criteria and factors at each level (factors in each level only depend on those at higher levels). In other words, the coefficient of importance at each level is necessarily determined by higher-level factors (Ghodsipour, 2006). The AHP includes the following three main stages (Saaty, 1996; Saaty, 2005):

1) **Hierarchical Structure Creation**: The problem should be clearly defined in a reasonable hierarchical system. This stage involves determining the decision-making criteria and identifying possible options. The link between objectives, criteria, and alternatives is linear and one-sided. The items do not affect the criteria, and the criteria are independent of each other (Budi et al., 2020).

2) **Pairwise Comparison and Weighting**: This stage aims to determine the relative importance of each criterion and the effective factors. A pairwise comparison is conducted if there is an internal link. Reciprocal values are considered for reverse comparisons ($a_{ij}=1/a_{ji}$, where a_{ij} denotes the importance of element i for element j), which is in accordance with the methodology proposed by Saaty (1996). AHP uses a matrix for pairwise comparisons, and the local priority (W) is measured to determine the relative importance of each element:

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

Where, A is the matrix for a pairwise comparison, w denotes the weight vector, and λ_{max} is the largest weight vector of matrix A. The priority matrix is used for all pairwise comparisons.

3) **Calculation of Consistency Ratio (CR)**: To determine the compatibility of comparisons, the CR must be calculated for each of the matrices. If CR is ≤0.1, comparisons are consistent (Azar and Rajabzadeh, 2012); otherwise, the decision should be revised. The CR is calculated as follows:

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

Where, RI is the consistency ratio, and CI is the degree of deviation from consistency. The CI formula is as follows:

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

Where, λ_{max} corresponds to the largest specific value, and n is the length of the pairwise comparison matrix. RI is generally a random consistency index or an index of randomly generated weights. Its value is determined based on the pairwise comparison matrix $(n \times n)$ from Table 1 (Saaty, 1980). All the above-mentioned steps were performed in the Expert Choice Comparison® AHP Software (Ghodsipour, 2006). Group consensus is necessary when making pairwise comparisons to prevent any potential bias.

RESULTS

Data Collection

To prioritize the functions and services for Asiatic Cheetahs in Iran, particular attention must be paid to their habitats, physical and

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

behavioral characteristics, and their 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 the top predators, including Asiatic and African Cheetahs, different functions and services were determined. The CICES classification was useful for determining all the ecosystem functions and services. CICES 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, since 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 including aesthetic, entertainment, cultural, symbolic, scientific, educational, existence value, and bequest value are 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.

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

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

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.

In this study, 81% of the participants were male and 18% female. 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

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

Functions	Services	Processes and components of Asiatic Cheetah	SECIC	Goods and services	Source
Regulation and 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.	(Verma et al., 2017; Verma et al., 2019; Murali et al., 2017; Ejtehadi et al., 2010)
	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	(Badola et al., 2010; Verma et al., 2017)
	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	(Verma et al., 2019)
	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	(Murali et al., 2017; Verma et al., 2019; Antonella et al., 2020)
	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	(Verma et al., 2017;Verma et al., 2019)
	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	(Murali et al., 2017)
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	(Murali et al., 2017)
	Entertainment	Cheetah's role for entertainment and recreational opportunities	Entertainment Elements of living systems used for entertainment or representation	Ecotourism and tourism; Safari	(Department of Environment, 2019)
	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	(Allsen, 2006; Nezami, 2017; Murali et al., 2017; Farhadinia et al., 2012)
	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.	(-Sohrabinia and Hosseini Zavarei, 2010; United Nations Development Program (UNDP), 2016)

Table 2 continued…

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

Functions	Services	Processes and components of Asiatic Cheetah	SECIC	Goods and services	Source
Cultural	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.	(Li et al., 2014; Apps et al., 2014)
	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	(AkbariFaizabadi and Jalalpour, 2012; Khalatbari, 2014; Khalatbari et al., 2017)
	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.	(UNDP andthe World Conservation Union (IUCN))
	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.	(Khalatbari et al., 2017; Farhadinia et al., 2017; Yousefi et al .,2019)

sub-criterion (Table 4). Figure 4 displays 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 the first and second Delphi rounds are 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. Figure 6 demonstrates the comparison of the mean scores of Regulation and Maintenance and Cultural functions in the first and second Delphi rounds. Overall, in the Delphi method, criteria with scores less than 3.5 should be removed (Ghodsipour, 2006). Therefore, gas regulation, water regulation, soil regulation, and pollination and seed dispersal were removed in the second round of Delphi method.

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

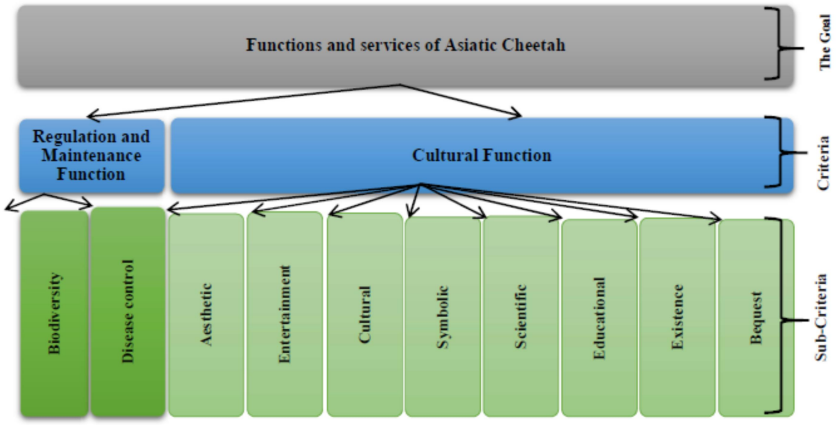

Figure 2. The AHP method and services and functions identified in the first stage.

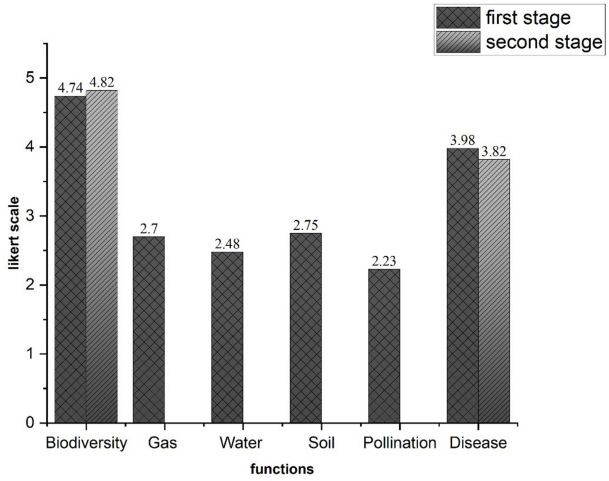

Figure 3. The mean scores of services related to Regulation and Maintenance functions in the first and second Delphi rounds.

were prioritized over Regulation and Maintenance functions.

In the second stage, the Regulation and Maintenance functions included biodiversity and disease control. Besides, the Cultural functions included aesthetic, entertainment, cultural, symbolic, scientific, and educational, existence value, and bequest value (Figure 3). To prioritize the functions and services for Asiatic Cheetahs in the second round via AHP, prioritization was considered as the study objective, while Regulation and Maintenance and Cultural functions were considered as the criteria. According to the findings, the mean scores of biodiversity and disease control were 4.82 and 3.82, respectively (Figure 4). Regarding the Cultural dimension, the mean scores of aesthetic, entertainment, cultural, symbolic, scientific, educational, existence value, and bequest value were 4.47, 4.44, 3.55, 4.40, 3.67, 4.58, 4.93, and 4.95, respectively (Figure 5). Also, the mean scores of Regulation and Maintenance and Cultural functions were 4.32 and 4.37, respectively (Figure 6). As for all dimensions, the mean score was higher than 3.5, and no dimension was excluded. The AHP was used to

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

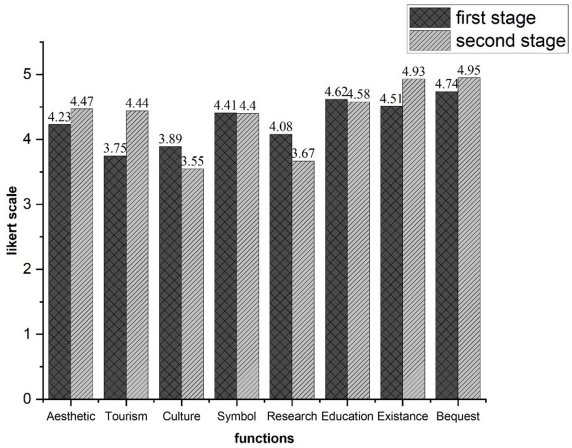

Figure 4. The mean scores of services related to Cultural functions in the first and second Delphi rounds.

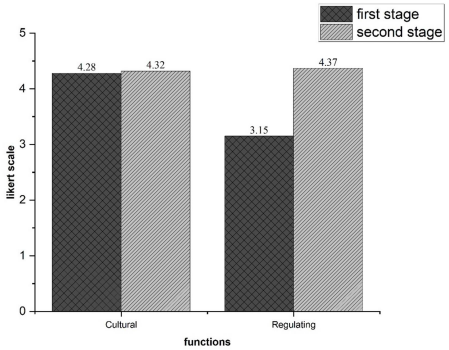

Figure 5. Comparison of the mean scores of Regulation and Maintenance and Cultural functions.

Table 4. Comparison of the mean scores of services and functions in the first and second Delphi 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	-		-
Cultural	Disease control	0.228	4.28	3.98	0.494	4.37	3.82
	Aesthetic	0.699		4.23	0.709		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

prioritize biodiversity and disease control services; the former had the highest priority. Regarding Cultural functions and based on the participants' opinions, AHP indicated bequest value and cultural and aesthetic values as the main criteria with the highest and lowest priorities, respectively, followed by existence value and education.

DISCUSSION

Richer biodiversity means more stable nature. Man depends on nature. The protection of the Asiatic Cheetah is in line with the protection of biodiversity on the planet. Lack of protection for the Asiatic Cheetah will have a variety of negative effects and threats on a local, national, regional, and international scale. An innovative strategy for the preservation and sustainable management of existing ecosystems can result from understanding and evaluating the functions of the living animal species. The role of every biotic organism will be clearer by understanding and identifying its ecosystem functions and services that leads to conserving it more specifically and effectively. Therefore, the CICES classification was used to investigate and identify the ecosystem services and functions provided by Asiatic Cheetah. Due to the lack of research in previous studies, identifying the Functions and Services of the Cheetah among the 25 provisioning services, 22 regulatory services, and 12 cultural services that were introduced by CICES 2018 for biotic organisms was challenging and difficult. As a result, in this study, 6 regulatory services and 8 cultural services were considered for the Cheetah to be determined by experts. Finally, 2 Regulation and Maintenance Services and 8 Cultural Services were chosen by the participating experts.

Asiatic cheetahs can be protected from extinction using different techniques at all levels of society, but some of these tactics should be implemented by the people and others by the government. Some of the

recommended strategies for preserving Asiatic Cheetah are as follows:

- Creating alternative and sustainable livelihoods in order to avoid the exploitation of cheetah habitats and to restore plant and animal richness in order to restore ecosystems with Asian cheetah species
- Training local communities, especially shepherds and cattlemen living near the habitats of Cheetahs, holding conferences and workshops (national and international) for familiarization with this unique species, and performing scientific research.
- Fencing and securing the roads of the Asiatic cheetah habitat, increasing the necessary equipment and facilities for the protection of the Asiatic cheetah, increasing the number of rangers in the area. Building wildlife corridors (e.g., bridges or subways) in the vicinity of Cheetah habitats to reduce traffic accidents, similar to Sweden, the United States, Australia, Netherlands, Finland, Canada, Kenya, and Singapore.
- Promoting public and NGO participation in the sustainable management of Cheetah habitats (i.e., planning, implementation, monitoring, and evaluation) and increasing the awareness of local communities about environmental and ecological values using promotional and educational programs.
- Identification of full research capacity on Cheetahs, developing research priorities related to Cheetahs and their habitats, and sharing the information with all related research centers and researchers.
- Designing Cheetah coins and attracting public support to protect endangered animals, particularly Asiatic Cheetahs. For instance, Turkmenistan designed Turkmenian eyelid gecko coins (*Eublepharis turcmenicus*). Besides, Kenya, Iceland, and the European Union countries designed similar coins to protect endangered species.

CONCLUSIONS

This research aimed to study the functions and services of Asiatic Cheetahs in Iran's ecosystem, Based on CICES 2018 classification, focusing on bequest, existence, biodiversity, educational, aesthetic, entertainment, symbolic, disease control, scientific, and cultural functions. The Regulation and Maintenance function was prioritized. The study also revealed that all services related to the Cultural function are important for the Asiatic Cheetah and its economic value can be estimated. The research proposes measures to protect Asiatic cheetahs, including preventing habitat loss, promoting biodiversity, and protecting species in their food chain. Future studies should prioritize these functions and explore their economic value.

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کارکرد ها و خدمات اکوسیستمی یوز آسیایی

م. تسلیمی، ح. امیرنژاد، ب. نظامی بلوچی، و ک. عطایی سلوط

چکیده

یوز یکی از گونه‌های حیات وحش در معرض خطر انقراض در کشورهای مختلف جهان، از جمله ایران است و نیز در لیست قرمز اتحادیه بین‌المللی حفاظت از طبیعت قرار گرفته است. امروزه ایران تنها جایی است که یوز آسیایی در آن یافت می‌شود و آخرین برآوردها نشان می‌دهد که تنها ۳۰ تا ٤۰ قلاده یوز آسیایی باقی مانده است. پژوهش حاضر با هدف اولویت‌بندی عملکرد و خدمات اکوسیستمی یوز آسیایی در ایران از دیدگاه متخصصان و متخصصان انجام شد. پس از بررسی ادبیات، بر اساس طبقه‌بندی مشترک بین‌المللی خدمات اکوسیستمی (CICES) در سال ۲۰۱۸، از میان کارکردهای تأمینی، فرهنگی، تنظیمی و حمایتی، کارکردهای فرهنگی و تنظیمی و ١٤ خدمت برای یوز آسیایی در ایران استخراج شد. سپس با استفاده از فرآیند تحلیل سلسله مراتبی (AHP) و روش دلفی، اولویت توابع و خدمات در دو مرحله بررسی شد. نتایج نشان داد که مهمترین کارکردها و خدمات شناسایی شده به ترتیب به شرح زیر است: کارکردهای فرهنگی (٤.۳۷)، تنظیمی(٤.۳۲) و خدمات مربوط به ارزش میراثی (٤.۹٥) یوز آسیایی، ارزش وجودی (٤.۹۳)؛ آموزشی (٤.٥۸)؛ زیبایی‌شناختی (٤.٤۷)؛ سرگرمی (تفریح و اکوتوریسم) (٤.٤٤)؛ نمادسازی (٤.٤۰)؛ علمی (۳.٦۷)، فرهنگی (۳.٥٥)، تنوع زیستی (٤.۸۲)؛ و کنترل بیماری (۳.۸۲). از جمله اقدامات لازم برای جلوگیری از انقراض یوز که می‌توان به احداث کریدور حیات وحش در زیستگاه‌های یوز، ترویج مشارکت جوامع و سازمان های مردم نهاد در مدیریت پایدار زیستگاه های یوز و طراحی سکه با طرح یوز برای جلب توجه و حمایت عمومی آن ها، اشاره کرد.