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Sustainable Management of the Herpetofauna of the Iranian Plateau and Coastal Iran

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Abstract: The global initiative toward sustainability includes the long term protection of biodiversity. Northern and western Iran are part of the Irano-Anatolian biodiversity hot spot that has many centers of endemism as a biogeographical center for the origin of many amphibian and reptile taxa. A high diversity of habitat types coupled with climatologically diverse environments result in the 13 different physiographic regions that support this biodiversity. The known herpetofauna of Iran comprises approximately 232 reptile and 22 amphibian species belonging to about 100 genera, 31 families, five orders and three suborders. The Squamata with 199 species in 78 genera and 18 families is the most specious reptilian order in Iran and account for approximately 85 percent of the herpetofauna. Fifty five endemic species in 11 families and 22 genera are considered here. At present, numerous factors, including habitat destruction through increased agriculture, as well as vegetation burning and climate change along with increasing risks of desertification have made a major impact on various ecosystems. Further, threats come from exotic species, the use of reptile products in traditional medicine and food, and pollution. There are ten Vulnerable, four Endangered, and seven Critically Endangered herpetofaunal elements in Iran. The establishment of protected areas, participation of non-governmental organizations (NGOs) in herpetological conservation, and more research of taxonomy, species range and habitats, threats and their mitigation are required for the sustainable management of Iranian herpetofauna. A concerted Iranian and international program for the sustainable management of Iranian herpetofauna is required because of Iran's biogeographic status, its high level of herpetological diversity and endemicity, and its importance as a global biodiversity hot spot.

Key words. Iranian Plateau, Sustainable management, Conservation, Amphibians, Reptiles, Threatened species.

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Introduction. The sustainable management of natural resources is required to provide the needs of humanity for both the present and in the future. Sustainable management includes the maintenance of environmental assets, including natural habitats and associated biodiversity (Browne 2014, Bradley et al. 2012). However, many natural resources, including biodiversity in general, are being over exploited (Bradley et al. 2012, Butchart et al. 2010). Herpetological biodiversity is often not prominent in discussions of sustainable management of natural resources. However, both reptiles and amphibians (herpetofaunas) fulfill a vital link in the food chain and the stability of both freshwater and terrestrial ecosystems (Duellman and Trueb 1994). Herpetofaunas are also important in the culture of many societies, where in the global society frogs and salamanders have become major icons for environmental health and protection (Mobaraki et al. 2014). Unfortunately, many species of herpetofauna are highly threatened and populations are generally declining (Collins 2010, Böhme 2013). In this review we discuss the herpetological biodiversity of the Iranian Plateau and adjacent coastal regions and measures for its sustainable management. According to the Article 6 of the Convention on Biological Diversity: "*Each Contracting Party shall, in accordance with its particular conditions and capabilities:* (a) *Develop national strategies, plans or programs for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programs which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned; and* (b) *Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programs and policies*" (Gaston and Spicer 2004).

According to the Convention the exploitation of biodiversity as a renewable resource is sustainable if it can be continued for the foreseeable future. Wildlife resource use that is not sustainable will lead to depletion of populations, degradation of habitats or ecosystems, loss of ecosystem services, and potentially extinction (Butchart et al. 2010). Many herpetofaunas have highly specific needs for thermoregulation, topography, types of soil and water resources, connectivity of habitat patches, and diverse vegetation structure (Edgar et al. 2010). The sustainable management of Iranian herpetofauna requires understanding species autecology, and extends to the biogeographical differences and similarities between the 13 physiographic regions in Iran. The Iranian Plateau, with its wide range of geographical conditions coupled with a diversity of climates, is home to centers for the origin of numerous species and also provides an impressive herpetofaunal biodiversity. Iran mostly lies in the Palearctic zoogeographical realm bordering the Oriental and African zoogeographical realm that is of global significance as a herpetofaunal transition zone, and northern and western Iran are a part of the Irano-Anatolian biodiversity hot spot (Fig. 1, Gholamifard and Rastegar-Pouyani 2012).

Iran has a coastline extending almost 1800 km on the northern Persian Gulf and the Sea of Oman. Four provinces border the sea area: Khuzestan, Bushehr, Hormozgan, and Sistan and Baluchestan. Additionally, about 30 small and large islands with a total coastline of about 600 km are located in the Persian Gulf. Many of these islands provide habitat for the reproduction of threatened sea turtles. The herpetofaunas of the Iranian Plateau has declined, primarily due to habitat loss, degradation, and fragmentation, and even in protected areas some threats are apparent and declines have occurred. We present the sustainable management of Iranian herpetofauna with an emphasis on endemics, and provide some urgent requirements for its sustainable management.

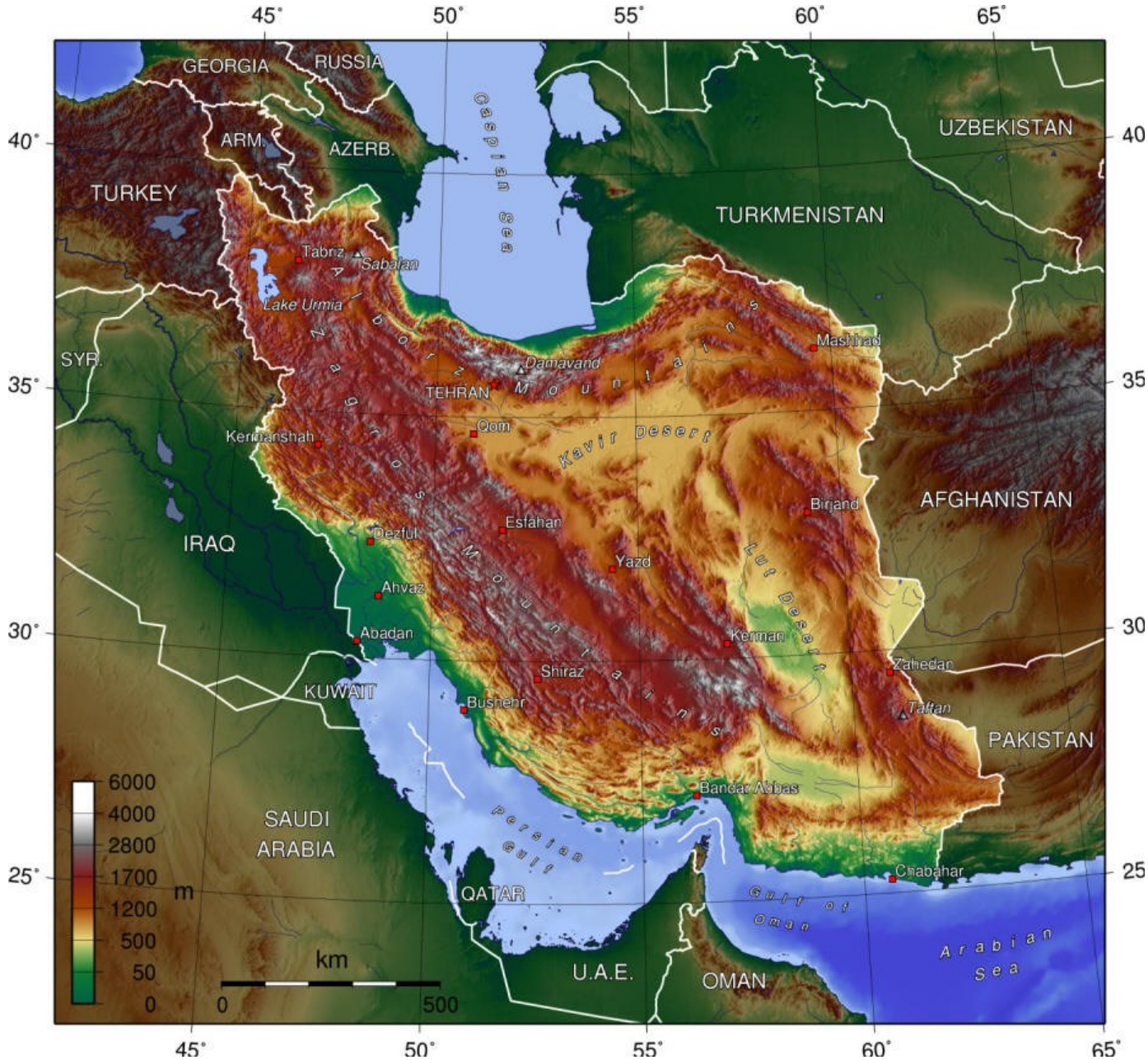

Figure 1. Topographic map of Iran shows various physiographic regions (source: www.worldofmaps.net).

Herpetofaunal biodiversity. The herpetofauna of Iran is comprised of about 232 reptile and 22 amphibian species belonging to about 100 genera, 31 families, five orders and three suborders found in 13 different physiographic regions (Anderson 1999, Rastegar-Pouyani et al. 2008, Ahmadzadeh et al. 2013, Kamali 2013, Uetz and Hošek 2014). The Squamata with 199 species in 78 genera and 18 families is the most specious reptilian order in Iran encompassing about 85 percent of the species of herpetofauna (Fig. 2,3). Iran also hosts five species of sea turtles in five genera and two families Cheloniidae and Dermochelyidae), some under specific conservation measures (Fig. 4), three species of terrapins in three genera and three families (Emydidae, Geoemydidae, and Trionychidae), two species of tortoises (Testudinidae), as well as one species of Amphisbaenia, *Diplometopon zarudnyi*, and one species of crocodilian, *Crocodylus palustris*.

Endemics. Endemic species are an important part of the natural heritage of a country and of global significance. Therefore, areas with significant populations of endemics and/or genetically significant endemics are prime candidates for species conservation and the protection of habitats of special conservation or scientific value (Code 2006). Fifty five endemic species in 11 families and 22 genera (Rastegar-Pouyani et al. 2008, Gholamifard 2011, Ahmadzadeh et al. 2013, Kamali 2013, Uetz and Hošek 2014) are considered in detail in this review (Fig. 3, Table 1). As research and conservation efforts intensify, new species of herpetofauna are being discovered in Iran, with eight species described in the past two years (Fathinia et al. 2011, Nazarov et al. 2012, Rajabizadeh et al. 2012, Ahmadzadeh et al. 2013, Heidari et al. 2013, Krause et al. 2013). Other species are being resurrected from synonymy or being categorized as synonyms. The most endemic and species diverse family is the Gekkonidae, followed by the Lacertidae (Fig. 3; Table 1). These two families collectively dominate endemic herpetofauna with 31 species of the total.

Iranian endemics of particular conservation significance include a viper, *Pseudocerastes urarachnoides* (Fig. 5), a worm snake *Xerotyphlops wilsoni*, and two salamanders, *Neurergus kaiseri* and *N. microspilotus*). The spider-tailed horned viper, *P. urarachnoides*, has the most elaborate morphological caudal ornamentation yet reported in a snake, with the possible exception of the rattlesnakes, *Crotalus* and *Sistrurus* (Bostanchi et al. 2006). *Xerotyphlops wilsoni* is the only endemic species of Iran with a single recorded specimen (Gholamifard 2011). The Critically Endangered Lorestan newt, *N. kaiseri,* is the flagship species of amphibian conservation in Iran and is protected under Appendix I of CITES (Convention on International Trade in Endangered Species), which bans export/import of this (CITES: CoP15 Prop. 14. 2010). The Kurdistan newt, *N. microspilotus*, is also Critically Endangered, with populations of both *Neurergus* species relying on aquatic habitats threatened by land use practices and climate change (Mobaraki et al. 2014).

Among the physiographic regions the Zagros Mountains contain the highest number of endemics, followed by the central Iranian Plateau, and the western foothills of the Zagros Mountains and Elburz Mountains. The Zagros Mountains, with an area of 530,000 km^2, isolate populations and therefore drive the evolution of some Iranian lizard and salamander species. The Zagros Mountain chain forms both a barrier between the Central Plateau and the Mesopotamian lowlands, and a corridor for the southward distribution of northern faunal elements. The Zagros Mountains have played a major role in the speciation of *Asaccus*, *Microgecko*, and *Neurergus*, and a global hot-spot for these genera (Torki et al. 2008).

Endemic species in Iran are distributed in highly localized, single physiographic regions, and multi-physiographic regions (Gholamifard 2011). One species of the leaf-toed geckos, *Asaccus kermanshahensis* (Fig. 5) is known only from a small cave in the Zagros Mountains (Rastegar-Pouyani 1996). Some other taxa are known only from a single locality, even though there are no known biogeographical reasons for them not being more widespread.

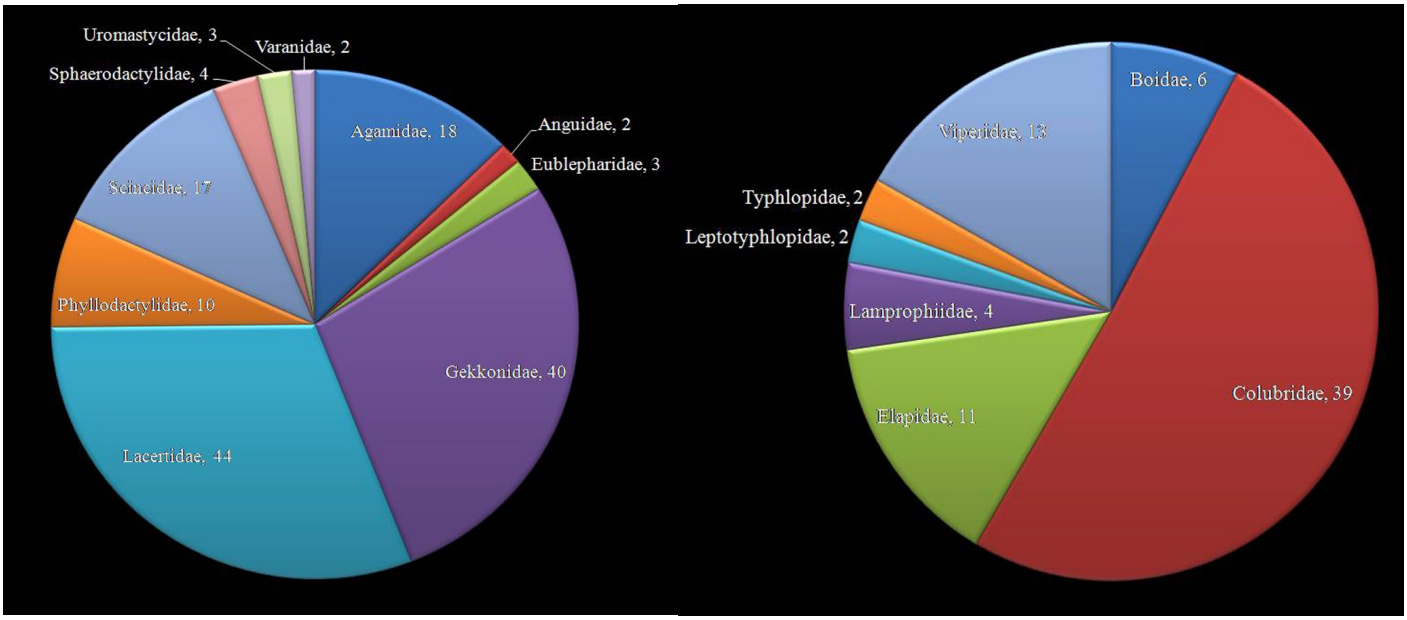

Figure 2. Species richness of the Sauria (left) and Ophidia (right) in Iran.

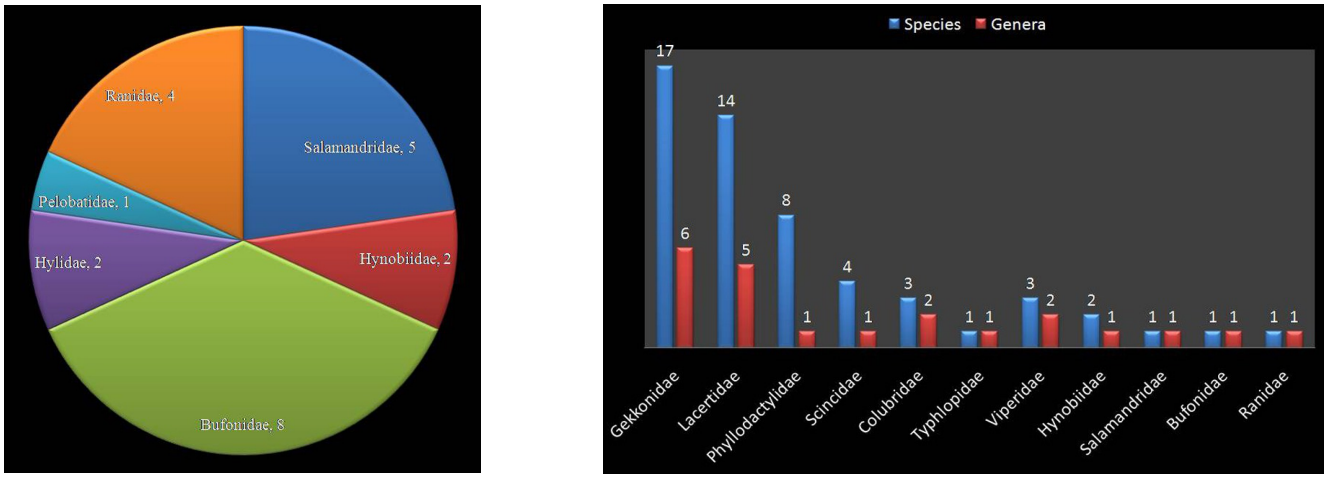

Figure 3. Species diversity of amphibians (left) and number of endemic species (right) in each family of amphibians and reptiles of Iran according to genera.

Table 1. List of endemic species of each family of Iran's amphibians and reptiles.

Bufonidae. *Pseudepidalea luristanica*

Ranidae. *Rana pseudodalmatina*

Hynobiidae. *Paradactylodon gorganensis, P. persicus*

Salamandridae. *Neurergus kaiseri*

Gekkonidae. *Bunopus crassicauda, Cyrtopodion brevipes, C. gastrophole, C. golubevi, C. hormozganum, C. kiabii, C. kimanense, C. persepolense, C. sistanensis, Hemidactylus romeshkanicus, Mediodactylus aspratilis, M. ilamensis, M. sagittifer, M. stevenandersoni, Microgecko helenae, M. latifi, Tropiocolotes naybandensis*

Lacertidae. *Acanthodactylus khamirensis A. nilsoni, Apathya yassujica, Darevskia caspica, D. kami, D. kopetdaghica, D. schaekeli, D. steineri, Eremias andersoni, E. kavirensis, E. lalezharica, E. montanus, E. papenfussi, Iranolacerta zagrosica*

Phyllodactylidae. *Asaccus andersoni, A. granularis, A. iranicus, A. kermanshahensis, A. kurdistanensis, A. nasrullahi, A. tangestanensis, A. zagrosicus*

Scincidae. *Ophiomorus maranjabensis; O. nuchalis; O. persicus; O. streeti*

Colubridae. *Eirenis kermanensis, E. rechingeri, Hierophis andreanus*

Typhlopidae. *Typhlops wilsoni*

Viperidae. *Montivipera kuhrangica, M. latifii, Pseudocerastes urarachnoides*

Threats. There are ten Vulnerable, four Endangered, and seven Critically Endangered herpetofaunal elements in Iran (IUCN 2014, Table 2). Iranian reptiles and amphibians have declined rapidly in both numbers and range in recent years due to major factors, including habitat loss and fragmentation, pollution, direct killing, indirect killing, persecution, illegal collection for trade, and exotic species and translocation of native species (Rastegar-Pouyani et al. 2011, Gholamifard and Rastegar-Pouyani 2012, Sharifi et al. 2013).

Habitat loss. Herpetofauna have relatively limited dispersal abilities and are particularly susceptible to the effects of habitat fragmentation as they generally cannot cross large expanses of unsuitable terrain to move from one patch of suitable habitat to another suitable habitat (Edgar et al. 2010). Habitat fragmentation is among the most serious causes of population decline for the herpetofaunas of Iran, with the threat of habitat fragmentation also extending to most other Iranian faunas. Habitat modification, fragmentation, or loss through dams and roads, intensive agriculture, infrastructure development, urbanization, grazing, shifting agriculture, deforestation, and mining, have damaged many ecosystems (Fig. 6a,b,c,d; 7a,b,c,d). There are now far fewer suitable habitats available for many species, and what populations remain are often found in small and isolated patches of habitat. These populations are threatened by fitness loss through inbreeding (Edgar et al. 2010), and perhaps almost total habitat loss through fires, or population loss during extended droughts. These fragmented populations require greater efforts for their conservation than when their habitat is connected.

Freshwater ecosystems globally are among the most threatened globally (Strayer and Dudgeon 2010). In Iran they face significant reductions in biodiversity, which can be linked to overexploitation through human population growth, water pollution, flow modification, drought, destruction or degradation of habitat, and invasion by exotic or regionally translocated species (Coad 1980, Esmaeili et al. 2010). Historically, the Iranian Plateau had numerous freshwater recourses, including wetlands, rivers, lakes, and streams that provided suitable habitats for many species and high populations of herpetofauna, especially for some native and endemic species such as salamanders along the Zagros and Elburz Mountains (Fig. 1, Sharifi et al. 2008a, Coad 2014).

These freshwater species, and especially those with limited distribution, are threatened by increasing droughts over recent decades and increased utilization of water resources for agricultural and industrial purposes. In addition, the increased construction of dams has destroyed habitat and isolated the remaining populations. Some of these species are also subject to illegal harvest, and unless mitigated, the combination of these threatening factors will eventually lead to the extinction of most, if not all, of the populations of these species.

Figure 4. One of the allocated sites for the protection of displaced eggs of Hawksbill sea turtle (*Eretmochelys imbricata*) from human and natural predators along the shore of Shib-Deraz village in the Qeshm Island, a apart of the conservation project for this Critically Endangered species by the Department of the Environment and NGOs. *Image Asghar Mabaraki.*

Figure 5. Left, the spider-tailed horned viper, *Pseudocerastes urarachnoides*, and right, the Kermanshah leaf-toad cave gecko, *Asaccus kermanshahensis.*

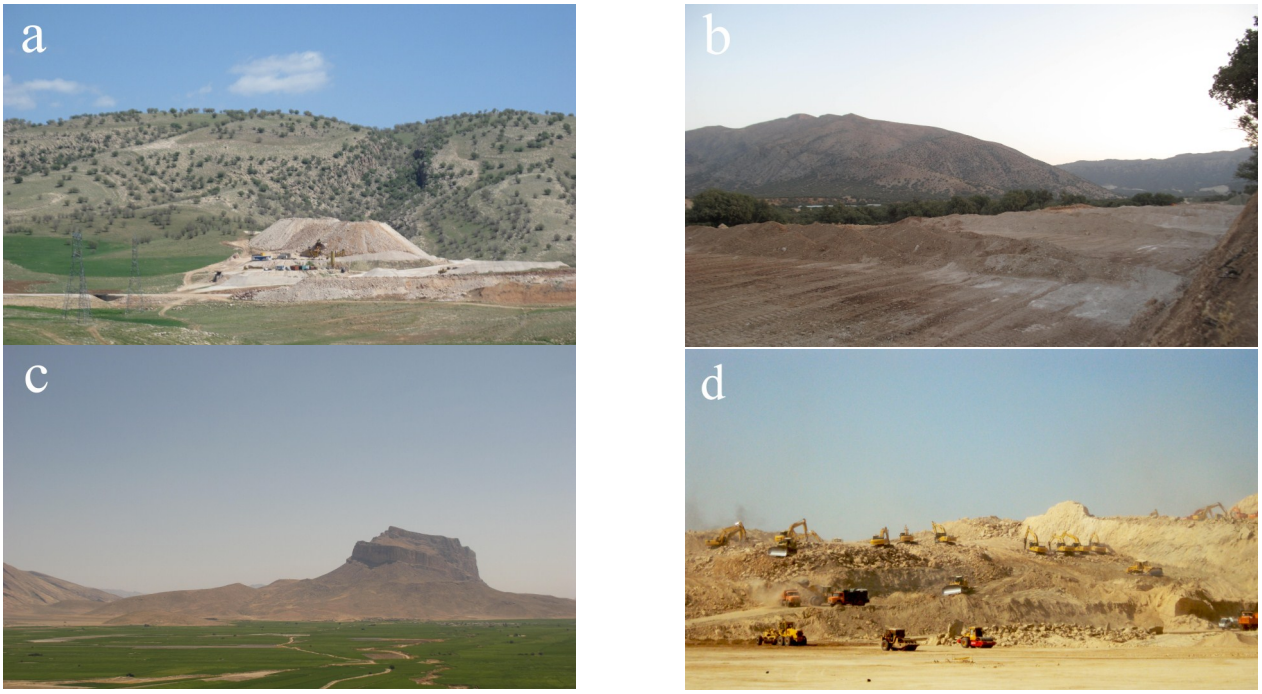

Figure 6. Habitat loss through destruction and degradation. (a) mining in Kermanshah Province 2014; (b) fragmentation of habitat by construction of highway in north of Fars Province 2013; (c) intensive agriculture in north of Fars Province 2013; (d) infrastructure development for the South Pars Gas Fields in the port of Asaluyeh, Bushehr Province. *Images Ali Gholamifard and Hiwa Faizi*.

Herpetofauna species are also dependent on specific features of their terrestrial or aquatic habitat and may move between habitats on a seasonal basis. Fragmentation of habitats and microhabitats through factors including agriculture, burning vegetation, forestry, mining, and highways (Fig. 6a,b,c,d) can isolate populations and result in reduced genetic diversity, increased mortality, increased predation pressure, increased edge habitat, reduced habitat quality, and invasive species colonization (Al-Sheikhly et al. 2013, Mifsud 2014). Therefore, habitat connectivity is essential for the long-term variability of much herpetofauna. Amphibians in Iran are particularly threatened by aquatic pollution and in some regions by increasing light pollution. Some populations of amphibians, and especially salamanders, may already be affected by recent extended periods of drought (Rastegar-Pouyani et al. 2011, 2013, 2014). A growing demand for some herpetofauna in the pet trade, and habitat loss as a result of firewood collection for small-scale subsistence use, are also major threats.

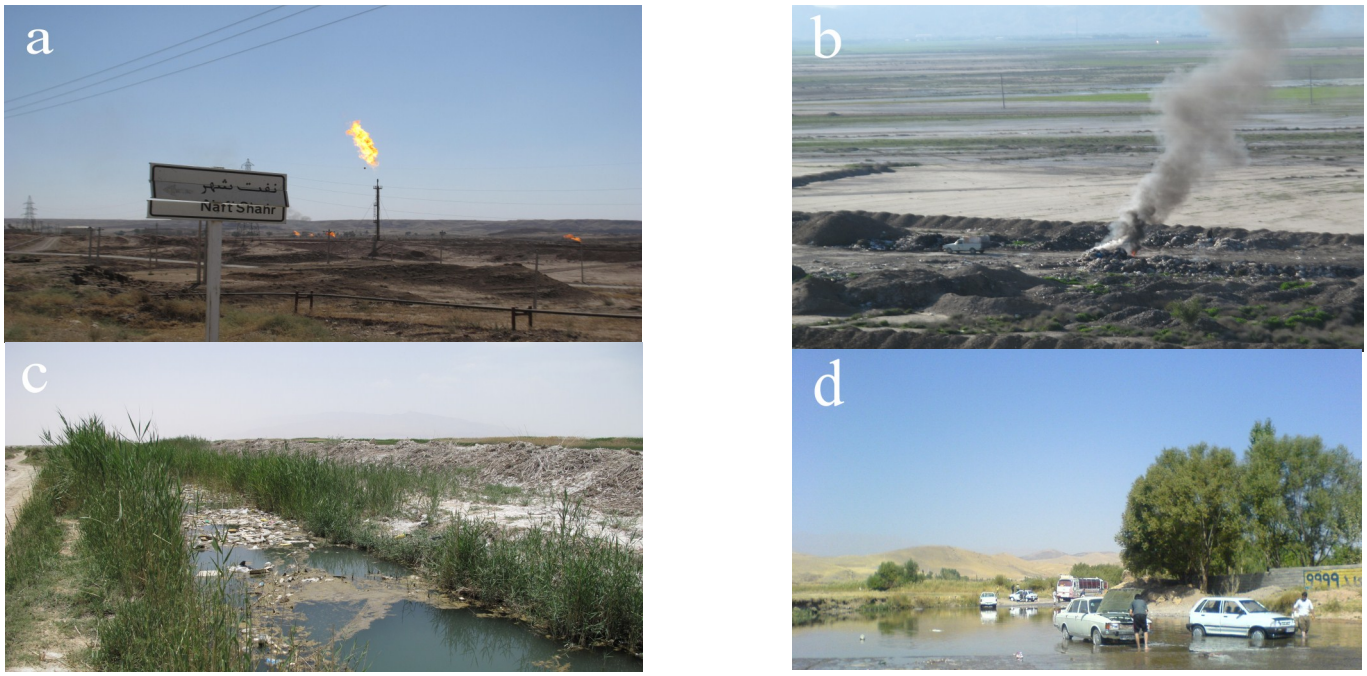

Figure 7. Chemical and biological pollution in natural habitats of amphibians and reptiles: (a) Oil refinery pollution in Kermanshah Province 2013; (b) non-normative waste disposal in southwest of Fars Province 2014; (c) biological and chemical pollution of habitat in the Maharlu Lake basin in Fars Province 2010; (d) car wash in the river, Kermanshah Province 2007. *Images Ali Gholamifard*.

Table 2. List of threatened species of amphibians and reptiles in Iran according to criteria of the IUCN Red List (the International Union for Conservation of Nature) and CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora). CR: Critically endangered; EN: Endangered; VU: Vulnerable. *: Endemic; I: Appendix I; II: Appendix II.

Family	Species	IUCN	CITES
Agamidae	*Phrynocephalus persicus*	VU	
Lacertidae	*Eremias pleskei*	CR	
Uromastycidae	*Saara asmussi*		II
	Saara loricata		II
	Uromastyx aegyptia	VU	II
Varanidae	*Varanus bengalensis*		I
	Varanus griseus		I
Boidae	*Eryx elegans*		II
	Eryx jaculus		II
	Eryx jayakari		II
	Eryx johnii		II
	Eryx miliaris		II
	Eryx tataricus		II
Elapidae	*Naja oxiana*		II
Viperidae	**Montivipera latifi*	EN	
	Montivipera wagneri	CR	II
	Vipera ebneri	VU	I
	Vipera eriwanensis	VU	
Cheloniidae	*Caretta caretta*	EN	I
	Chelonia mydas	EN	I
	Eretmochelys imbricata	CR	I
	Lepidochelys olivacea	VU	I
Dermochelyidae	*Dermochelys coriacea*	CR	I
Trionychidae	*Rafetus euphraticus*	EN	
Testudinidae	*Testudo graeca*	VU	
	Testudo horsfieldii	VU	
Crocodylidae	*Crocodylus palustris*	VU	I
Hynobiidae	**Paradactylodon gorganensis*	CR	
Salamandridae	*Neurergus crocatus*	VU	
	**Neurergus kaiseri*	CR	I
	Neurergus microspilotus	CR	
Bufonidae	*Bufo eichwaldi*	VU	

Direct killing. Humans directly kill Iranian snakes and lizards because of fear and superstitions, or with turtles, large snakes, and lizards to satisfy increasing demand for use in traditional medicine or as food. As human populations increase the sustainable harvesting of herpetofauna requires greater regulation combined with targeted research.

Indirect killing. Roads are a significant cause of mortality for some herpetofauna, and can therefore threaten the herpetological diversity through direct impacts on localised populations including fragmentation (Mifsud 2014). Herpetofaunas are often killed as they attempt to access seasonal habitat, nest in warm and dry soil on the shoulder of a road, bask on the road surface, or access to food on the road (Fig. 9a,b,). The effect of roadkill on populations can be extreme when the road is near critical reptile habitats such as snake hibernacula (Mifsud 2014). Prescribed fire maintains or increases habitat for some herpetofauna, however, uncontrolled burning can threaten some species (Mifsud 2014). For example, fire in caves by nomads and mountaineers has a significant negative effect on the survival and conservation of leaf-toed geckos of the genus *Asaccus* (Karamiani, pers. comm.).

Pollution. Amphibians and some reptiles have highly permeable skin and typically have extensive contact with water or soils

Figure 8. A giant viper, *Macrovipera lebetina* killed by a local person in southwest of Fars Province. *Image Ali Gholamifard*.

(Mifsud 2014). Declines in the populations of herpetofauna in Iran have been linked to increased pollution. However, relatively little work has been done to document the response of herpetofauna to various types of pollution including chemical pollution created by human through factories, and pesticides and herbicides used in agriculture (Rastegar-Pouyani et al. 2013, Figure 7a,b,c,d).

Persecution. The snakes and lizards of Iran are the most persecuted herpetological group, as many people have social, religious, or cultural beliefs that snakes and lizards will harm them and or their livestock. According to these people snakes and lizards are evil in addition to being venomous and aggressive. Larger snakes whether poisonous or nonpoisonous, and especially snakes with warning sounds such as vipers (Fig. 8) and the diadem snake *Spalerosophis diadema*), and are more feared and therefore suffer greater persecution than other snakes. Generally, habitat destruction combined with their outright killing by humans are the greatest threats that Iranian snakes face.

Varanids are the largest lizards in Iran with two species, *Varanus bengalensis* and *V. griseus*. *V. bengalensis* is assessed in the IUCN Red List of Threatened Species (IUCN 2014) as Least Concern.

Figure 9. Road fatalities of amphibians and reptiles are common during nocturnal foraging, spring emergence, and fall migration: (a) the endangered Desert Monitor (*Varanus griseus*) from southwest of Fars Province; (b) subadult Western Leopard Gecko (*Eublepharis angramainyu*) from north of Fars Province. *Images Ali Gholamifard*.

Varanus bengalensis has a wide range across south central and Southeast Asia and occupies a variety of habitats (Anderson 1999).

In other countries, *V. bengalensis* is hunted for food and for fat in medicine, and for its skins which are sold (Koch et al. 2013). These threats caused listing of *V. bengalensis* on Appendix I of CITES (CITES Trade Database 2013). Fortunately in Iran, none of the above harvesting threats exist for monitors.

The only threatening factor for Varinids in Iran is mistakenly considering them to be dangerous. Due to fear about its large body size and a hissing alert and movement of its long tongue, and because of cultural beliefs, another member of the monitors in Iran, *V. griseus* (Fig. 9a), is killed, especially by sheepherders and ranchers. In southern Iran, a superstitious belief about *V. griseus* is that it sticks to milk glands of goats, causes goats to stop producing milk and can even result in death. In Iran some populations of *V. griseus* are endangered.

The legless lizards (family Anguidae) are also sometimes killed as they are mistaken for snakes. There are numerous other examples of superstitions about reptiles and amphibians affecting the populations survival in different parts of Iran. Taking into account the IUCN criteria on Vulnerable species, 10% probability of extinction within 100 years, we consider that some of the Iranian scincid lizards with limited distribution should be considered as Vulnerable including *Chalcides ocellatus* and *Scincus scincus conirostris*. There are no known extinct species among scincid lizards in Iran.

Illegal collection. In Iran the illegal collection of herpetofaunas for the national and international trade as pets, or for their natural parts and products, as food, traditional medicine, and decorative crafts has reduced the viable populations for some species (Sharifi et al. 2013, IOSEA MoU 2014). Of particular concern are two endemic salamanders the Lorestan newt, *N. kaiseri*, and Kurdistan newt, *N. microspilotus*; (Sharifi et al. 2008b), and two other salamanders native to Iran the Azerbaijan newt, *N. crocatus*, and *Paradactylodon gorganensis.* Other species threatened by illegal collection include the Euphrates soft-shelled turtle, *Rafetus euphraticus*, the marine turtles, *Chelonia mydas*, *Eretmochelys imbricata*) and possibly the European pond turtle, *Emys oribicularis*, Fig. 11b, and the Caspian turtle, *Mauremys caspica*.

In the case of *Neurergu*s newts, collection of adults and subadults for the illegal national and international trade has resulted in severe population declines (Sharifi et al. 2013). *N. kaiseri* (Fig. 10) is the first species granted international protection due to e-commerce, and now is protected under the Appendix I of the CITES (AmphibiaWeb 2014).

Figure 10. The Loristan newt, *Neurergus kaiseri,* a landmark for the Iranian threatened taxa. *Image by Alireza Pesaraklu.*

Despite the fact that all species of sea turtles of coastal Iran are globally threatened, they are traded for their natural products such as their eggs and meats in the traditional medicine and for food. As turtles have delayed sexual maturity and require high juvenile and adult survivorship to sustain populations, illegal collection of adults and hatchlings can result in serious negative impacts on their populations (Congdon et al. 1993, Mifsud 2014). The Euphrates soft-shelled turtle, *R. euphraticus*, is an endangered species with limited populations in the Euphrates basin of Iran, Iraq, Turkey, and Syria, that has recently suffered increased harvesting for food for immigrant workers.

Trafficing. There have been multiple examples of arrests for trafficking of turtles, newts, and other herpetofauna and wild life in Iran; for instance in April 2014, a large consignment of 600

specimens of the smuggled European pond turtle, Fig. 11b, and 400 specimens of water snake, *Natrix* sp., Fig. 11c, was banned in Shiraz (the capital of Fars Province in south of Iran) by the Department of Environment (IRNA 2014).

These arrests only represent a very small proportion of the illegal harvest of herpetofauna of Iran and more policing is required, especially of rare and endangered species. Recently a new wave of studies concerning the conservation of Iranian herpetofaunas by preventing their illegal collection have been initiated, but many individuals of amphibians and reptiles are still collected regardless of the effect of overharvest on their sustainable management.

Exotic species and translocation of native species. There are no records of the establishment of exotic species of herpetofauna in Iran, but in the recent years large shipments of the North American red-eared slider (*Trachemys scripta*; Fig. 11a), were imported. *Trachemys scripta* is included in the *List of the world's 100 most invasive species* published by the International Union for the Conservation of Nature (Lowe et al. 2000). There are many cases where Iranian native tortoises, salamanders, and snakes were collected from their natural habitats and transferred to the other Iranian provinces for pet trade (Fig. 11b,c). This provides a possible means for the establishment of species exotic to an ecosystem.

Another threat to endemic and native herpetofauna comes from introduced fish species such as the common carp, *Cyprinus carpio,* and goldfish, *Carassius auratus*, especially on amphibians and native fishes. In recent years, the fish fauna of the Iranian basins have been modified by the introduction and translocation of exotic fish species for aquaculture, control of malaria, research, and through incidental release (Esmaeili et al. 2011, Esmaeili and Gholamifard 2011).

Introductions of fish species into Iran has a long history but was most prominent in the 1920s when the mosquito fish, *Gambusia holbrooki,* Poeciliidae, was introduced as an anti-malarial agent, and in the late 1930s when common carp, *Cyprinus carpio*, was introduced for aquaculture. Since then, about 27 fish species have been introduced or translocated. Some of them, e.g. *C. carpio* and *G. holbrooki*, have established breeding populations, while others are regularly stocked by the Fisheries Department of Iran, e.g. the major food carps *Hypophthalmichthys molitrix*, *H. nobilis* and *Ctenopharyngodon idella* (Esmaeili et al. 2010b).

Gambusia holbrooki is the most widespread exotic species in Iran (Esmaeili et al. 2010a). In Australia predation by *G. holbrooki* is a serious threat to the survival of the frogs *Litoria aurea* and *L. castanea*, both species listed as threatened under the Threatened Species Conservation Act, and to other frog species; in Australia predation by *G. holbrooki* is therefore listed as a key threatening process because it adversely affects two or more threatened species and it could cause species that are not threatened to become threatened (Threatened species 2014).

Threats from herpetofaunal translocations include interspecific competition, genetic pollution, parasites and diseases. A major disease causing many amphibian declines and extinctions globally is Chytridiomycosis (*Batrachochytrium spp.*) a suite of pathogens widely spread by vector translocation (Olson et al. 2013). *Batrachochytrium* infection has been reported in the

Figure 11. Introduced and translocated species of reptiles in Iran kept as pets: (a) Red-eared slider (*Trachemys scripta*), an exotic terrapin; (b) European pond turtle (*Emys orbicularis*), a native species of the Southern Caspian Sea basin translocated to other provinces; (c) the native water snake (*Natrix* sp.) with Chinese carps. *Images Ali Gholamifard.*

Table 3. Assessment of Iranian amphibians and reptiles according to criteria of the IUCN Red List. Recently described species have not yet been assessed for the IUCN Red List.

IUCN status	Lizards (Sauria)	Snakes (Ophidia)	Turtles (Testudines)	Amphibians (Caudata/Anura)
NE (Not Evaluated)	62	33	1	-/1
DD (Data Deficient)	10	4	-	-/1
LC (Least Concern)	62	36	-	1/12
NT (Near Threatened)	1	1	1	2/-
VU (Vulnerable)	2	2	3	1/1
EN (Endangered)	-	1	3	-
CR (Critically Endangered)	1	1	2	3/-

endangered *N. microspilotus* from the Kavat Stream in western Iran (Parto et al. 2013). According to the IUCN evaluation, an important threat to the endangered newt, *N. kaiseri* is the presence of non-native fish as a result of the damming of Dez River, which extends the water height close to the known localities of ephemeral springs that provide critical breeding habitat for this species (Sharifi et al. 2013).

The Sustainable Management of marine turtles and the mugger crocodile. To illustrate the particular conservation needs of species, we detail the conservation needs of two threatened species of sea turtles, the hawksbill turtle (*E. imbricate*) and green turtle, (*C. mydas*), and the mugger crocodile (*Crocodylus palustris*).

Marine turtle species and their habitats in the Persian Gulf. Hawksbill turtle, *Eretmochelys imbricate*, at Hendorabi Island: The Persian Gulf accommodates the main nesting habitats of *E. imbricata* and *Chelonia mydas*. Islands in particular provide the most important nesting sites for these two species. Some mainland Iranian nesting sites also exist, but at this stage there is no reliable estimate of the number of turtles nesting there. *Chelonia mydas* in different life stages are the main foraging turtle especially around islands. However, some feeding *E. imbricate* in juvenile stages are also been found. Moreover, there are some occasional records of the Vulnerable, Olive Ridley sea turtle, *Lepidochelys olivacea*, and the Critically Endangered, East Pacific Ocean subpopulation of the leatherback turtle, *Dermochelys coriacea*, in these waters (Wallace et al. 2013).

Turtle species and their habitats in the Oman Sea. The Sea of Oman accommodates important feeding grounds for *C. mydas* at different life stages throughout the year and a few important nesting sites (Mobaraki 2004). *Lepidochelys olivacea* have also been reported in the area (Kami 1997, Mobaraki 2003). Despite the fact that the area still provides some suitable nesting sites for *E. imbricate* and reports of its nesting have been recorded in the past (Kinunen and Walczack 1971), there have been no signs of turtles nesting in the past years.

Protection of marine turtles in Iran. Several measures have been introduced to promote the conservation of sea turtles in Iran, including the nomination of sea turtles as "endangered animals of the country". There is a 30 million Rials (€940, US$1050, 12th May 2015) fine imposed by the government for killing a turtle, and egg collection is punished with a fine of about 10 million Rials for each egg.

The nomination of nesting sites as "under management and protected area", such as the Dayyer and Nakhiloo National Park and the Sheedvar Wildlife Refuge, are other significant activities for the protection of marine turtle species and their habitats. In 2011, Hendourabi Island was designated as a protected area due to its importance for turtle nesting. Furthermore, the monitoring of sites by the Department of Environment guards during the nesting season minimizes harm to the turtles and their nest.

Main threatening factors for sea turtles. Sea turtles populations in the Iranian region are faced with a range of different threats including the collection of eggs for food and as aphrodisiacs. In some places, turtle meat is occasionally used by coastal residents, with mortality also due to the bycatch of turtles during fishing. In addition to these direct threats, different kinds of pollution such as debris, oil and artificial light are common (IOSEA MoU 2014). Unsustainable coastal development is a major threat to nesting sites and turtles. Other factors such as erosion are common in most places and damage to turtle habitats. At a cultural and political level poor cooperation and coordination within conservation and sustainable management programs, coupled in many cases with insufficient information and support, combine to create difficulty in the sustainable management of many species (IOSEA MoU 2014).

Conservation research initiatives for sea turtles in Iran. After research and studies on the nesting sites a tagging program for sea turtles was initiated in Iran for the first time in 2005 with the support of the Indian Ocean - South-East Asian Marine Turtle Memorandum of Understanding Secretariat (Fig. 4). About 500 hawksbill turtles and about 20 green turtles were tagged with titanium flipper tags with the number and the address of Department of the Environment of Iran (Mobaraki 2010). Iran was also one of the cooperating countries in the "Persian Gulf Turtle Project" for satellite tracking of hawksbill turtles, conducted in 2010 with the support of World Wildlife Fund for Nature - Emirate Wildlife Society and Marine Research Foundation, with other participants including Oman, Qatar, and the United Arab Emirates (IOSEA MoU 2014).

Genetic assessments. Genetic assessment of Iranian sea turtles informs about interbreeding between nesting sites, and the connections between Iranian sea turtle populations and those of the surrounding regions. The long migration routes of Iranian sea turtles span the Persian Gulf and also extend to other parts of the world. Four main nesting sites have been genetically assessed for at least two years, and 100 tissue samples taken and analyzed with Next-Generation Sequencing (IOSEA MoU 2014). The sites grouped into two main regions that may be considered Evolutionary Significant Units for conservation purposes, being Sheedvar–Hendourabi to the west and Ommolkaram–Nakhiloo to the east.

Final remarks and recommendations. There is a crucial need for international cooperation for the conservation of sea turtles. Sea turtles are highly migratory species with shared populations and habitats and thus can only be conserved through common international conservation policies. To enable sea turtle conservation, a cooperative genetic study for the western and eastern parts of the Persian Gulf and Sea of Oman is needed to identify Evolutionary Significant Units and those under most threat. Satellite tracking of turtles also offers a powerful research method to assess range, distribution, habitat reproductive frequency and breeding site fidelity. The formation of expert specialized groups for the region could be of significant value for conducting these activities.

Conservation of the mugger crocodile (*C. palustris*). A small population of the mugger crocodile, *C. palustris* (Lesson 1831), is distributed along the Sarbaz, Kaju and Bahukalat Rivers and their headwaters and ponds in Sistan and Baluchestan Province, southeast of Iran. The Iranian population inhabits the westernmost global range of *C. palustris,* is isolated and divided into several sub-populations (Mobaraki et al. 2013).

Parts of the range of *C. palustris* (about 465,000 ha) in Sistan and Baluchestan Province are the "Gandou" (local name for *C. palustris)* Protected Area. The main distributional area of *C. palustris* in Iran extends from Sarbaz and the southeastern part of Nikshahr along the Kaju River, which joins to Sarbaz River before entering the sea. Part of this area, Govater Bay and Hur-e-Bahu with an area of 75000 ha, were designated as a 19th international wetland (Ramsar site) in 1999 (Mobaraki et al. 2013).

Regional characteristics of *C. palustris* populations in Iran are their scattered distribution, and their presence in artificial ponds in villages. The area consists of riverine and estuarine wetlands of the lower Sarbaz River, including permanent freshwater pools and marshes, mangrove swamps and intertidal mudflats, and extends to the sandy beach of Gulf of Oman coast in the extreme southeast of Iran (Persian Baluchestan) to the Pakistan border.

Crocodylus palustris potentially occupy all suitable water bodies in the region, mostly small or large ponds along rivers with thick bankside vegetation, sandy banks and water depths of more than 6 meters. Artificial water bodies, consisting of small or larger ponds constructed for rainwater storage next to villages, also play an essential role as *C. palustris* habitats.

Dams of different sizes also provide artificial habitats for *C. palustris*, of which the Pishin Dam is the most important along with the Zirdan Dam on the Kaju River, and play a very important role for populations of *C. palustris* by providing reliable habitats during prolonged droughts. A survey program was conducted over 10 days in May 2011, with nocturnal and diurnal counts. Most available habitats were visited at night, where spotlights were used to locate and identify *C. palustris*. A total of 326 *C. palustris* were observed, with the Pishin Dam Reservoir, 120 crocodiles, and Shirgovaz Regulatory Dam Reservoir, 35 crocodiles, reporting the highest counts, with almost all crocodiles in the Pishin Dam Reservoir being large adults. Considering the extent of unsurveyed habitat, the total population was estimated to be greater than 500 *C. palustris* (Mobaraki and Abtin 2013).

Most of the habitats of *C. palustris* are close to villages where the species can even pass through houses. Village ponds are visited by people many times during the day, especially women and children. With the close contact of *C. palustris* and local people, the most important factor preventing human harm to the species are cultural and religious beliefs. In the dry Sistan and Baluchestan Province, *C. palustris* are respected as water living creatures whose existence depends on the presence of water, consequently, people not only never harm *C. palustris* but also prevent others harming them. Despite of such a close contact, direct conflict between humans and *C. palustris* are very rare as the crocodiles rarely attack adults or children swimming in village ponds. This cultural feature is unique in respect to crocodile habitats globally.

In the past years two centers in Dargas and Rikokash have been established for the purposes of rehabilitation, short period keeping of problem *C. palustris*, and rearing/reproduction of some *C. palustris*. There are plans to expand the facilities of a farm and research center for *C. palustris* and to increase the participation of local people.

Threats. Threats to *C. palustris* are mainly natural, when in some years flooding destroys most of the nests or a lack of water causes death of most hatchlings. The Bengal monitor lizard (*V. bengalensis*), predatory mammals (fox, jackal, and mongoose), and the large water birds (herons) also predate nests and hatchlings (Mobaraki et al. 2013). The most evident human activity that causes mortality for *C. palustris,* and especially juveniles, are collisions with cars (Mobaraki and Abtin 2007). Agriculture is the main activity of the local people and its expansion is reducing potential *C. palustris* natural habitat.

Conservation measures. The main cause of human-crocodile conflict are *C. palustris* attacks on the livestock of the villagers; sometime very severe when a large *C. palustris* is in a small pond with small amount of available food. There is a compensation program conducted by the Department of Environment but sometimes compensation is not in time or enough. There is a plan to expand the program to provide more support. In some instances, troublesome *C. palustris* are removed from the village by DOE guards and translocated to safe habitats in less contact with people. As an Endangered Species in Iran *C. palustris* are legally protected with a fine of 100 million Rials for illegal killing and capture from March 2013.

Fortunately there is high potential for the conservation of crocodiles in Iran as the local people respect them as culturally important and never hunt or harm them. Considering this situation, and need for conservation activities, a National

Management Plan for the Mugger Crocodile Population in Iran was prepared and submitted to the related bodies for proper planning and implementation (Mobaraki and Abtin 2008).

The plan consists of four main approaches: 1) research and information, 2) conservation of *C. palustris* in the natural habitats, 3) captive breeding program, 4) public awareness/ education and ecotourism.

The sustainable management of Iranian herpetofauna. The following principles and criteria are recommended to promote the sustainable management of Iranian herpetofauna.

In spite of the high diversity in the Iranian herpetofauna, and the high number of endemic species, the autecology and habitat requirements of most Iranian species are poorly known. Consequently, the assessment of the conservation status and required management for most Iranian herpetofauna is difficult. Many Iranian species are categorized as Least Concern (LC), or Not Evaluated (NE) in the IUCN Red List (IUCN 2013) (Table 3). More species are likely to become threatened in the near future unless the reasons for their declines are defined. For a large part of herpetological diversity in Iran the major threats are intrinsic factors affecting species such as low population densities within restricted distributions, therefore, conservation research and management should be focused on these species.

It is considered that the following conservation actions are needed for the conservation of Iranian herpetofaunas; the establishment of protected areas by the Department of the Environment (DOE), Species Management Plans, Environmental Impact Assessments, regulating the capturing and trading of threatened species, participation of NGOs in conservation programs, increasing attention of media to wildlife conservation, and more research on endemics with limited known ranges Fig. 10).

Habitat management. The habitats of the Iranian herpetofauna and especially those of endangered and endemic species should be protected and managed to maintain or restore populations of declining species. A quantity and diversity of habitats should be protected and managed to conserve and perpetuate the Iranian herpetofauna. Prior to approval of any alteration in natural habitats Environmental Impact Statements should be conducted to determine the current status of habitats and their biodiversity, and special requirements needed to protect the environment.

In the sustainable use and conservation of biological diversity the negative effects of habitat loss and fragmentation should be minimized by user groups, regulatory agencies, and boards when making resource conservation and allocation decisions. Adverse effects of proposed developments should be avoided or mitigated by improved habitat management elsewhere, compensatory habitat through protection or restoration, or through threatened species rehabitation or supplementation.

Population management. Iranian herpetofaunas should be managed to maintain healthy populations, habitats, and ecosystem functions. Any adverse effects of direct or in-direct exploitation of Iranian herpetofauna should be assessed and minimized. In environmental management decisions the function of herpetofaunas in ecosystems should be considered.

Minimum viable population sizes of harvested species in each population unit should be established to support their sustainable management.

Public involvement. Management systems that produce public information or encourage the involvement of the public for sustained use and conservation of herpetofauna should be encouraged and supported. Programs to encourage and involve private landowners in sustainable land management, including the conservation of herpetofauna and other biodiversity, should be created or expanded. These can include voluntary conservation agreements where a landowner protects important habitat in exchange for conservation resources, such as any necessary fencing of the habitat and weed control.

Conservative programs of Iranian herpetofauna should be managed to assure adequate public access, without detriment to the species, populations, habitats, or ecosystems. Public information and education programs about the sustainable use and conservation of Iranian herpetofauna should include materials on the biological importance of these creatures, their habitat requirements, threats, population status, and regulatory processes. Decisions involving the sustainable management of Iranian herpetofauna and associated biodiversity should be made in an informed and timely fashion, using the best available information and expertise, and be open to all stakeholders.

Conclusion. Iran provides unique opportunities and challenges in the sustainable management of its highly diverse herpetofaunas, especially endemic localized species and marine species that range beyond Iranian borders. Some of these opportunities and challenges offer significant opportunities to engage local communities in herpetofaunal conservation. Community engagement in the sustainable management of biodiversity conservation is one of the key factors in embedding conservation ethics in the wider community.

The sustainable management of herpetofauna requires an adequate biological knowledge of species, including taxonomy, population genetics, autecology, critical habitat components, range and distribution, and migratory patterns. Sustainable management also requires well implemented management plans supported by society at the political, cultural, and individual levels.

Many groups are working toward herpetofaunal sustainability in Iran, however, the development of specialist groups for particular threatened species will yield improvements in the effectiveness of conservation initiatives.

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Authors biographies

Nasrullah Rastegar-Pouyani completed his Ph.D. in Gothenburg University, Sweden in 1999 under the advisement of Professor Göran Nilson, working on taxonomy and biogeography of Iranian Plateau agamids with *Trapelus* as the main object. he has described numerous new taxa of lizards from the Iranian Plateau, and his research interests include taxonomy and biogeography of the Iranian Plateau, the Middle East and Central Asian herpetofauna.

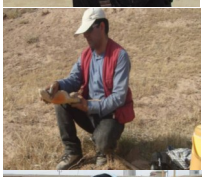
Ali Gholamifard is currently a Ph.D. student at Razi University of Kermanshah, Iran under the advisement of Prof. Nasrullah Rastegar-Pouyani. His PhD thesis concerns systematics of the tiny gecko, Microgecko helenae, populations in Iran. His scientific interests focus on systematics, biodiversity, biology and ethology of Amphibians and reptiles of Iran.

Rasoul Karamiani is currently a Ph.D. student at Razi University of Kermanshah, Iran under the advisement of Prof. Nasrullah Rastegar-Pouyani and Dr. Eskandar Rastegar-Pouyani. His Ph.D. thesis concerns systematics and phylogeny of the snake-eyed skink *Ablepharus* in Iran. His research interests include behavior, ecology, conservation and phylogeography of amphibians and reptiles.

Zahed Bahmany earned his M.Sc. in Animal Biosystematics from Lorestan University Khoramabad. His research interests include taxonomy, ecology, conservation and phylogeograpy. Now, he is collecting *Trachylepis spp* in Iran to start a PhD project on systematics, phylogeny and morphology of the genus in Iran.

Asghar Mobaraki works in the Department of the Environment (DOE) of Iran and is currently engaged in PhD degree. as well as head for reptilian and amphibian section in Biodiversity and Wildlife Bureau of DOE. Main interest is on sea turtle populations in the Persian Gulf and Oman sea area as well as Mugger crocodiles and softshell turtles. Moreover I also conduct works on different species of snakes, lizards and amphibians.

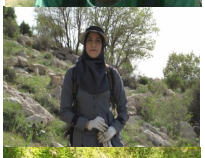
Elham Abtin works on crocodiles, sea turtles and some rare reptilians as well as other important wildlife species. She is the only Iranian female member of the IUCN/SSC Crocodile Specialist Group. Planning for the conservation and protection of the species and their habitats specially wetlands are the other important part of her research.



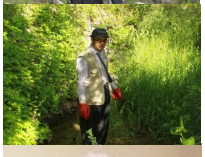
Hiva Faizi studied the genus *Trachylepis* in Iran at different perspectives includes morphology, osteology, parasitology and systematics of the *Trachylepis aurata transcaucasica*. He also described a new species of *Asaccus*, *Asaccus kurdistanensis* with his supervisor Prof. Nasrulla Rastegar-Pouyani and his collaborator Prof. Goran Nilson. He also had studies on near eastern fire salamander *Slamandra infraimmaculata semenovi* from Kurdistan province, western Iran.

Nastaran Heidari's PhD dissertation research project was on phylogeny and molecular systematics of the genus *Acanthodactylus* (Sauria: Lacertidae) in the Iranian Plateau. Currently Nastaran is working as an assistant professor at Kharazami University, Karaj, Iran.

Mohsen Takesh is now studying as a PhD student at the Department of Biology, Faculty of Science, Razi University, Kermanshah, Iran under the advisement of Prof. N. Rastegar-Pouyani. His research interests include ecological, phylogeographical and taxonomical investigations of amphibians and reptiles with special emphasis on the genus *Neurergus.*



Farhkondeh Sayyadi Farkhondeh Sayadi received her M.Sc. in Animal Biosystematics from the University of Razi, Kermanshah, on the systematics and distribution of the lacertid *Acanthodactylus nilsoni*. Currently she is a Ph.D. student in the Department of Biology at the University of Razi, Kermanshah. Concerning the biology and natural history of the Iranian Plateau agamids.



Nabi Ahsani obtained his BSc in Natural Resources Engineering in 1995. In 1999, he earned his MSc degree in Natural Resources Engineering. Currently he is a PhD student in the Biodiversity Department of Environment & Energy, Science and Research Branch, Islamic Azad University, Tehran, Iran. His is interested in habitat assessment of *Salamandra infraimaculata semenovi,* Nesterov 1916 in Western Iran.

Robert K Browne has wide range of experience and publications in scientific fields concerning herpetological conservation. His response to the global biodiversity conservation crisis has focused on the sustainable management of amphibian and reptile biodiversity in the USA, Peoples Republic of China, Australia, Russian Federation, Islamic Republic of Iran, and Cameroon.