

Changes in Community Structure and Species Diversity of Water Birds as Ecological Indexes of Hor-Al-Azim Marsh

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Abstract

Diversity variations, community structure, and biodiversity indexes of water birds are a good indicator of the ecological function of the wetlands ecosystems. Counting the water bird's community using the total count method with a 15 × 60 telescope and a 10 × 4 Zeiss binocular in February 2006, 2011 and 2016. Globally threatened species are identified by the IUCN (IUCN, 2015) criteria and protected species in Iran by the Department of Environment, Iran, rules, and standards. Hor-al-Azim wetland water bird's community consisted of two types of water beds, swimmers with 21 species and shore birds with 30 species. The total number of water beds in the Hor-al-Azim in February 2006 with an area of 118,000 ha, 2011 with an area of 5000 ha., and 2016 with an area of 10,000 ha., were 18337 individuals belonging to 51 species, 2257 individuals with 33 species and 3914 individuals with 43 species respectively. Margalef species diversity for all water beds of the wetland (aquatic swimmer and shorebirds) in February 2006, 2011, and 2016 were, 5.078, 4.139, and 5.093, respectively, for shorebirds were 3.296, 3.292, and 3.245 and for swimmer aquatic birds, were 2.264, 1.830, and 0.648 respectively. The decline in the water beds has been 87.7% since 2006 to 2011, and 78.66% from 2006 to 2016. The number of species decreased from 51 species in 2006 to 35 species in 2011 (reduction was 31.38 %) and from 2006 to 2016 reduction was 8 species (15.69%). Changes in biodiversity indicators have also been considerable. The main reason for reducing the number of birds and species diversity was the drying of the wetland from 2006 to 2016. The reason for drying the wetland is, drought, harvesting water in the uplands and constructing dam on the rivers (The area of the wetland decreased from 118,000 ha to 10,000 ha, which reduction was 91.53%).

Keywords

Ecological changes; Community of water birds; Hor-al-Azim; wetland Ecosystem

Introduction

In the world for several decades, the structure of the community and the diversity of wetland birds are considered as indicators of the ecological function of the wetlands [1-3]. In Iran, since 1969, the counting and determination of the populations of water birds in Iranian wetlands is carried out by the Department of Environment of Iran. The Hor-al-Azim wetland is a part of the permanent wetlands in the eastern Mesopotamia in Khuzestan province, on the border between Iran and Iraq. The wetlands area varied from 500000 to 300000 hectares [4]. In Iran varied from 300,000 to 118000 hectares. Diversity variations, populations, biodiversity and aquatic animal densities as well as water birds are a good indicator for determining the ecological conditions of wetland ecosystems [5]. Iran has 250 wetlands with an area of about 2.5 million hectares [6,7]. Among them, 24 wetlands with a total area of 148,638 hectares have been registered at the Ramsar Convention. In the world by June 2016, 2200 wetlands in 169 countries with a total area of 219,175,951 hectares have been listed on the Ramsar Convention List [8]. The area of the 24 international wetlands in Iran is 0.68% of the area of the world's international importance wetlands. Hor-al-Azim wetland is one of the major wetlands in Khuzestan province in southwest of Iran, which was protected in 2011, and proposed to be registered in the list of international wetlands ratified by the Convention. [9]. since 1994, it has been listed in the Important Birds Area (IBA) [10]. In assessing the Iranian wetlands by the Department of Environment of Iran, based on the criteria of the water birds population, Hor-al-Azim was in the first in 2004 before drying. [11]. On the other hand, Iranian wetlands, including Hor-al-Azim, in West Asia, are of particular importance for the survival and conservation of a large number of wintering and breeding water birds [12]. In addition to wintering water birds 11 species of water birds were globally threatened such as Ferruginous Duck *Aythya nyroca* and Marbled Teal *marmaronetta angustirostris* [13], and two native species of Mesopotamia marshes (Little Grebe *Tachybaptus roficollis* and Darter *Anhinga rufa*) were reported [14]. On the

other hand, the mudflats of the Hor-al-Azim wetland is important habitat for wintering and conserving of protected species in Iran such as White Stork *ciconia ciconia*, and seven species of Ardeidae [15]. After drying much parts of the Hor-al-Azim in last years, a number of species have been eliminated and some have also reduced population. An overview of the population of water birds in Iran's wetlands shows that in 1970, 12 million water birds were migrating to Iran's wetlands, decreasing by 3-4 billion water birds in 2016 [16]. Drying wetlands and their ecological changes reduce the population of water birds. For this reason, changes in the population of water birds are the ecological indicators of wetlands. In the world, many studies have been done on water birds population and species diversity as an ecological indicator of wetlands, including. Bechir *et al.* (2013) [17], Musgrove *et al.* (2011) [18] Rotenberry (1985) [19] and Torres (1995) [20]. Yahkat *et al.* (2017) [21]. In Iran well-known studied of Variety and density of water birds in southern wetlands at Caspian Sea coasts [22], the preparation of ecological view of Hor-al-Azim wetland [23]. Contrasting changes in the abundance and diversity of Northern Iranian birds' assemblages from 2011 to 2015 [24]. Migratory waterfowls as indicators to assess the protection efficiency in Iran [25]. Classifications of Iranian wetlands are noted [11]. The purpose of this study was to investigate the variation of species diversity and the structure of the water birds communities in Hor-al-Azim during wet and dry periods and to change the land use of Hor al-Azim wetland. Because the changes in the structure of the population and species diversity of water birds in wetlands are a significant indicator of the changes in the ecological status of the wetlands

Materials and Methods

Hor-al-Azim or Hor-al-Hoveizeh is part of the permanent wetland of Mesopotamia marshes located in the west of Khuzestan

province at the end of the Karkheh River in Azadegan plain between the two countries of Iran and Iraq at a geographical location of 31°53'N47°16'30"E in near cities of Bostan, Howeizeh and Rofaie [4,14]. The area of the Hor-al-Azim has been reported to be 500000 to 300000 hectares [2,4, and 14]. 300000-118,000 hectares (about 30 percent) are located in Iran. The main source of water supply is surface waters, mainly the Tigris and Karkheh rivers. Figures 1 and 2 show the status and changes of the wetland between 1987 and 2016. The average annual rainfall is 119 mm, and average temperatures is 24 °C [23]

The eastern boundary of Hor-al-Azim, on the Iran, extends from the west of the city of Bostan to Tang-e Chazbeh and extends to the south to Shat Ali by a length of about 50 km. The access road to the wetland starts from north of 5 km after crossing the bridge of Hoffel in Bostan to the west of the wetland. At Tang-e Chazbeh, turn 90° to the south, about 50 km along the path of Shahid Bakeri and Shahid Hemmat roads to the southern part of the wetland, Shat Ali road comes in the 2000 dedicate, the wetland was filled with water and in the decade of 2011 the vast majority of dry wetlands and an area of about 5000 hectares and in 2016 the area of the wetland with the amount of water flowing from the flood waters and Karkheh overflow had reached about 10,000 hectares, (Figures 2 and 3).

Data Collection

Water birds' counting was carried out on 15 February 2006, on 17 February 2011, and on 18 February 2016, with a 10×40 binoculars and a 15×60 telescope with total count method, by walking along the paths around the wetland, by car on the roads that constructed by Oil Company and by boat on the open water of marsh. The Wetlands International used and recommended this method for counting wetland birds in the world's wetlands since 1969 [26]. For this reason, the counting of water birds in the Hor-



Figure 1: Location of Mesopotamian Marshes and Hor-al-Azim Wetland (Internet, 2016 and Google earth, 2016).

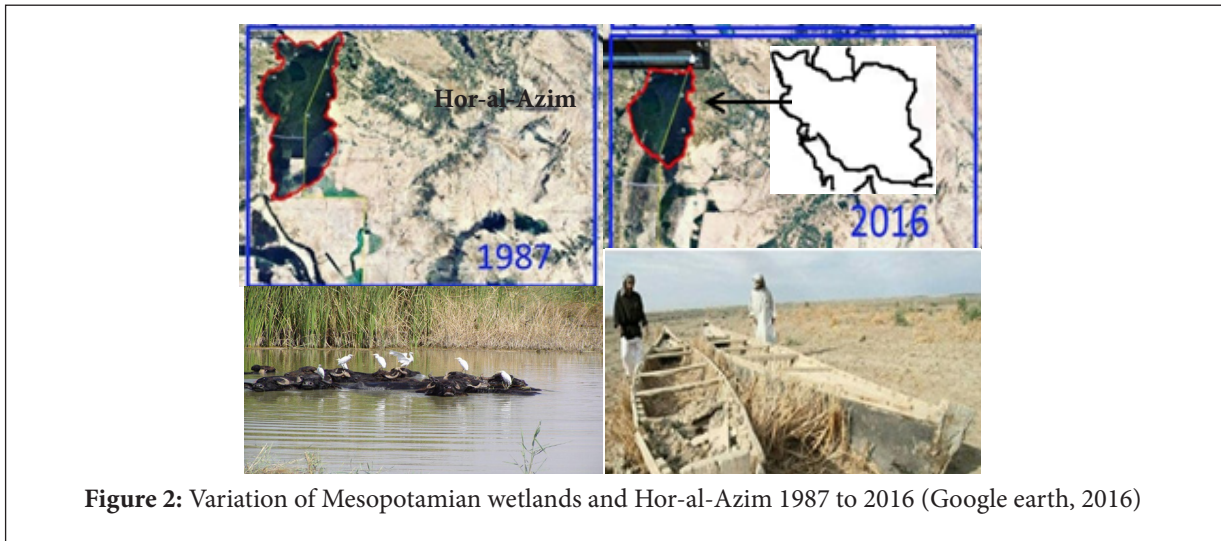


Figure 2: Variation of Mesopotamian wetlands and Hor-al-Azim 1987 to 2016 (Google earth, 2016)

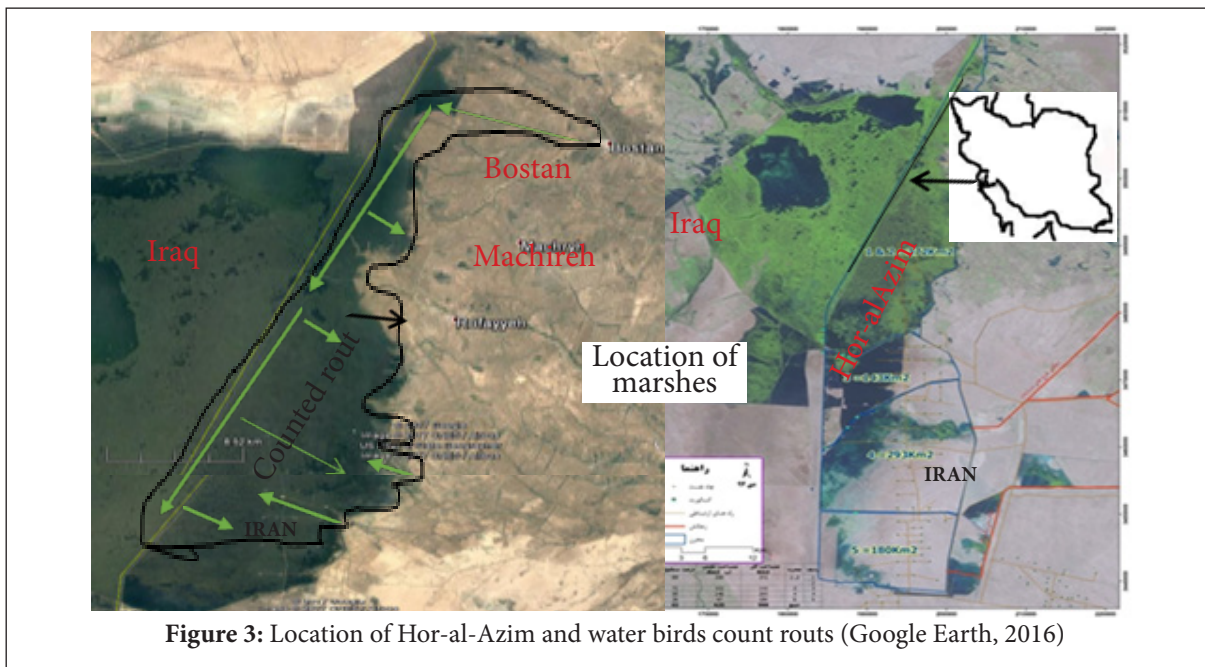


Figure 3: Location of Hor-al-Azim and water birds count routes (Google Earth, 2016)

al-Azim has been carried out with a total count method. The path of counting water birds every three years from the north of the marsh from Tang-e Chazbeh to its south Shat Ali on the roads of Shahid Hemmat, Imam Reza, Shahid Bakeri and roads built by the oil company in the southern part and inside the wetland, as well as by boat on open water of wetland, which remained intact due to the drying of the wetland into small and interrupted ponds, it was carried out on the same day from 8 am to 4 pm. Water birds were identified using the Field Guide to the Asian Water birds [27]. The biodiversity indicators calculated in this study were

$$\text{Shanon-Winnier } H' = -\sum_{i=1}^s Pi \ln(Pi)$$

$$\text{Simpson dominance } 1-D = 1 - \sum_{i=1}^s \left[\frac{ni(ni-1)}{N(N+1)} \right]$$

$$\text{Margalef and Mehinck richness } R = \frac{S-1}{\ln N}, \quad D_{mn} = \frac{S}{\sqrt{N}}$$

$$\text{Species evenness } E = \frac{H'}{\ln(S)}$$

$$\text{Berger-Parker evenness } d = \frac{N_{max}}{N}$$

$$\text{Brillouin } H_g = \frac{1}{N} \log \left(\frac{N!}{n_1! n_2! n_3! \dots} \right)$$

$$\text{Equitability } E = \frac{H'}{\ln(S)}$$

$$\text{Fisher-alpha } S = a \ln(1+n/a)$$

Alpha, Beta, and Gamma diversity have been used by Whitaker (1972), α Diversity is the variety of species found in a community, habitat, or specific ecosystem, β diversity $\beta_r = \frac{G+L}{2a}$ and γ diversity is the richness of a range of habitats in a geographic region and percentage similarity coefficient and Euclidean difference measured with Past Software [28]. Globally threatened species distinguished by the IUCN 2010 criteria's, and protected species in Iran are distinguished Department of Environment of Iran rules [16].

Results

In total, in February 2006, 2011 and 2016, 18337 individuals belonged to 51 species, 2257 individuals belonged to 33 species and 3914 individuals belonging to 43 species reported respectively (Table 1). Figure 4 shows that the number of birds counted in 2006 was 4.16 times in 2016 and 8.12 times in 2011 and the relative frequency of birds was 75% in 2006 (wet year), 9% in 2011 (drought) and 16% in 2016. Distribution, numbers, density and diversity, alpha, beta, and gamma diversity and density of water birds in the wetland is shown in table 1. The number of water birds species decreased by 15.69 % from 2006 to 2016.

Fifty-one species of water birds identified in Hor-al-Azim were classified into two groups:

- 1- Swimmer water birds, this group are swimmer
- 2- Shore birds (Waders and wading) are not swimmers and live on the shores of the water ecosystems

Swimmer water birds

Total number of swimmer water birds was 10720, on February 2006 which decreased by 80.4% to 2102 on February 2011, with a decrease of 73.55% to 2836 individuals in February 2016. (Tables 1). The average reduction in swimmer water birds from 2006 to 2016 was 73.55% (Table 1). Table 2 shows the Teal *Anas crecca* in 2006 with 21.10%, in 2011 with 43.08%, and the Coot *Fulica atra* in 2016 was the most frequent with 16.72%. Species diversity and biological indices of swimmer water birds have been decreased from 2006 to 2016. The largest decrease was observed in 2011, as most of the wetland was drought (Table 4). The status of the protected, swimmer water birds species, native to the holly wetland and globally threatened species was as follows:

The native species of the Mesopotamian marshes Little Grebe were 219 individuals in 2006. Decreased by 27% to 160 individuals in 2011 and decreased by 36.53% to 139 individuals in 2016. Darter *Anhinga rufa chantrei* was not observed in three years of study but reported 2 individuals in 2004 (Panadm Consultant Engineering, 2006). The population of protected species Greater Flamingo *Phoenicopterus ruber* has dropped by 90% from 120 individuals in 2006 to 12 individuals in 2016. The population of the Pygmy Cormorant *Phalacrocorax pygmeus* (Globally threaten species) has been decreased 18% in 2016 (150 to 123 individuals). The protected and globally endangered species of Marbled Teal were 120 individuals in 2006, but in 2016 only 2 individuals were present in the Hor-al-Azim. Reduction of this species was 98.4%. Two species Ferruginous Duck (4 individuals) and Shelduck (50 individuals) were present in 2006 but declined to

Water birds Group	2006	2011	2016
Number of swimmer water birds	10720	2102 Reduction 80.4%	2836 Reduction 73.55%
Species number of swimmer water birds	21	15 Reduction 28.58%	19 Reduction 9.53%
Number of shore birds (Waders and Wading birds)	7617	155 Reduction 97.97%	1078 Reduction 85.85%
Species number shore birds (waders and wading birds)	30	18 Reduction 40%	24 Reduction 20%
Total Number	18337	2257 Reduction 87.53%	3914 Reduction from 2006 78.68%
Area of wetland (In Iran)	11800	5000 ha. 85%Reduction	10000 ha. Reduction 69.85%
Total Number of species	51	35 Reduction (37.25%)	43 Reduction 11.26%
Density of water birds	0.55	0.45	0.39 per hectare
α diversity of water birds	51	33	43
α diversity of swimmer birds	21	15	19
α diversity of waders and wading birds	30	18	24
γ diversity of total water birds	51		
β Diversity	2006-2011	2011-2016	2006-2016
β diversity of total water birds between three years	0.214	0.342	0.085
β diversity of waders and wading birds between three years	0.25	0.428	0.111
β diversity of swimmers birds between three years	0.166	0.235	0.050

Table 1: Species number, density of water birds and area of Hor-al-Azim in 2006, 2011and 2016.

Name of Species	No. 2006	Abundance 2006	No. 2011	Abundance 2011	No. 2016	Abundance 2016	Population Reduction from 2006 to 2016
Little Grebe <i>Tachybaptus ruficollis</i>	219	1.20(2.04)	160	7.08(7.61)	139	3.55(4.90)	36.53%
Great Crested Grebe <i>podiceps cristatus</i>	58	0.32(0.54)	4	0.16(0.19)	12	0.30(0.42)	79.32%
Great Cormorant <i>Phalacrocorax carbo</i>	1720	9.38(16.04)	23	1.01(1.09)	12	0.30(0.42)	99.31%
Pygmy Cormorant <i>Phalacrocorax</i>	150	0.81(1.39)	90	3.95(4.28)	123	3.14(4.33)	18%
Slender-billed Gull <i>Larus genei</i>	155	0.84(1.44)	0	0(0)	121	3.09(2.66)	21.94%
Black-headed Gull <i>Larus ridibundus</i>	1200	6.54(11.19)	56	2.45(2.66)	131	3.35(4.61)	89.09%
Greater Flamingo <i>Phoenicopterus ruber</i>	120	0.66(1.11)	0	0(0)	12	0.30(0.42)	90%
Greylag Goose <i>Anser</i>	520	2.83(4.85)	0	0(0)	12	0.30(0.42)	97.7%
Shelduck <i>Tadorna</i>	50	0.27(0.46)	0	0(0)	0	0(0)	100%
Eurasian Wigeon <i>Anas penelope</i>	20	0.10(0.18)	15	0.65(0.71)	123	3.14(4.33)	615% increased
Gadwall I	155	0.84(1.44)	614	26.96(29.21)	321	8.20(11.31)	207% increased
Common Teal <i>Anas crecca</i>	3870	21.10(36.10)	981	43.08(46.66)	564	14.42(19.88)	85.43%
Mallard <i>Anas platyrhynchos</i>	220	1.20(2.05)	10	0.44(0.47)	431	11.02(15.19)	195% increased
Pintail <i>Anas acuta</i>	13	0.07(0.12)	4	0.16(0.19)	12	0.30(0.42)	7.7%
Shoveler <i>Anas clypeata</i>	750	4.09(6.99)	75	3.29(3.56)	56	1.43(1.97)	92.54%
Marbled Teal <i>Marmaronetta angustirostris</i> *	120	0.65(1.11)	0	0(0)	2	0.05(0.07)	98.34%
Pochard <i>Aythya ferina</i>	213	1.16(1.98)	4	0.16(0.19)	65	1/64(2.19)	69.49%
Ferruginous Duck <i>Aythya nyroca</i> *	4	0.02(0.03)	0	0(0)	0	0(0)	100%
Common Moorhen <i>Gallinula chloropus</i>	7	0.04(0.6)	2	0.08(0.09)	45	1.14(1.58)	642% increased
Purple Swamphen <i>Porphyrio porphyria</i> *	6	0.03(0.5)	4	0.16(0.19)	1	0.02(0.03)	83.34%
Eurasian Coot <i>Fulica atra</i>	1150	6.27(10.72)	60	2.63(2.85)	654	16.72(23.03)	43.14%
Total Species	21 species	100	15 species	100	19 species	Total species	9.53%
Total	10720	100	2102		2836	100	73.55%

Table 2: Number and relative abundance of swimmer water birds in Hor-al-Azim in 2006, 2011 and 2016

+ protected in Iran * Globally threatened species

Numbers inside the parentheses are relative abundance of swimmer aquatic birds in the same year

Numbers outside the parentheses are relative abundance of swimmer aquatic birds to total water birds in the same year

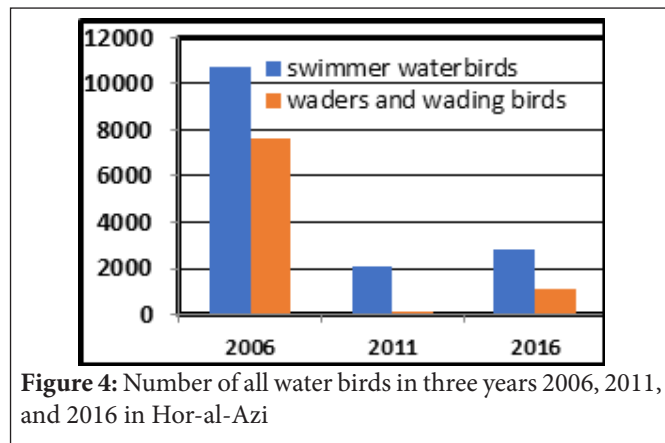


Figure 4: Number of all water birds in three years 2006, 2011, and 2016 in Hor-al-Azim

zero in 2016.

Shore Birds (Waders and wading Birds)

The number of waders and wading birds were 30 species with a population of 7617 individuals in 2006, 18 species with a population of 155 individuals in 2011 (reduction was 97.97%), and 24 species with a population of 1078 individuals in 2016 (reduction was 85.85%) (Table 1). The *calidris minuta* with 12.27% in 2006, the *Bubulcus ibis* with 1.97% in 2011 and the *Vanellus leucurus* with 3.99% in 2016 had highest relative abundance (Table 3). The *Threskiornis aethiopicus* were 9 in 2006 has dropped to zero in 2016 (reduction was 100%). Table 3 shows that the population of 7 species of protected herons in Iran decreased to 386 individuals by 84/63% reduction from 2510 individuals in 2006. Figure 4 shows the relative frequency of birds counted in three study years. Because of the changes in the water birds population from 2006 to 2016, their biodiversity indicators also naturally changed and decreased. Changes in biodiversity indicators of waders and wading birds were similar to those of swimmers water birds, but their decrease was higher than those. Table 4 shows the variations in the biological indices of water birds. Table 4 shows the highest Simpson dominance for all water birds in wetland (swimmers water birds and shore birds) were 0.091 in 2006 reduced to 0.08 in 2016. The highest Margalef variety for all water birds was 5.093 in 2006 for waders and wading birds was 3.296 and for swimmer water birds was 2.264 in 2016. The highest percentage similarity among swimmer water birds was 51.81 between 2006 and 2016 and the lowest similarity was 49.15% between 2006 and 2011. The highest percentage similarity among shore birds was 63.66% between 2011 and 2016 and the lowest similarity was 37.46% between 2006 and 2011. The highest Euclidean difference among swimmer water birds was 856.448 between 2006 and 2016. The lowest difference was 49.51 between 2006 and 2011. The highest Euclidean difference between shore birds was between 2006 and 2016 (543.435) and the lowest was between 2011 and 2016 (236.5). In general, the most similarity between the total water birds was between 2006 and 2011 (49.35%) and the lowest similarity between the total water birds of the wetland was between 2006 and 2011 (40.45%). The highest Euclidean difference between the total water birds of the wetland was between 2006 and 2011 (685/697) and the least Euclidean difference between the

total water birds was between 2011 and 2016 (133.247). Darter (native to Mesopotamia marshes) was observed in 2004 [10,14], but this species was not observed in three study years. Little Grebe is an endemic species of Mesopotamia marshes and Hor-al-Azim [4,10]. Its population reduced 36.53%.

In 2001, 11 globally threatened species were reported in Hor-al-Azim [4, 10] but only 4 species were observed and reported in three study years (Tables 2 and 3). Seven species of globally threatened species were not observed during three study years. The water bird's population has fallen from 18,337 individuals in February 2006 to 3914 in February 2016. The reduction was 78.66%. The number of species decreased from 51 species on February 2006 to 43 species on February 2016. The reduction was 15.69%. The number of species reported 53 species in Hor-al-Azim in 1975 [12]. Reduction from 1975 to 2015 is 3.78% The presence of endangered species, such as the Pygmy Cormorant, Ferruginous Duck, Purple Gallinule, Marbled Teal, and seven protected species of Ardeidae and two endemic species in the Hor-al-Azim marsh add to the its ecological value. For this reason, in 2011, the wetland has been added to the list of protected areas of Iran and it has been proposed for registration in the Ramsar Convention as an important international wetland [9]. Reduction of species diversity, elimination some globally threatened species, decreasing of populations of water birds and protected species since 2006 to 2016 has been shown in tables 1, 2, 3,4. Reducing the biodiversity indices of swimmer water birds from February 2006 to February 2016 is evident in table 1. Table 4 shows that the highest Margalef diversity index was 2,264 in 2016 and the lowest was 0.684 in 2006, also the lowest Shannon-Wiener Diversity Index was 0.382 in 2006 and the highest was 2.242 in 2016. The highest Simpson's 1-D evenness index was 2.084 in 2006 and its lowest value was 0.860 in 2016 for swimmer water birds. The Menhinick Diversity Index for all water birds in 2006 was 0.377. Its highest level in 2011 was 6.092. These changes are due to changes in the population and the area of the wetland. As the population increases and the number of species is constant, the evenness increases, and diversity decreases. The highest Dominance-D for all aquatic birds in 2011 was 0.268 and its lowest value in 2016 was 0.080. The highest Evenness_{e^H/S} in 2016, and the lowest in 2011, were 0.442 and 0.196 respectively. The number of swimmer water birds species in February, 2006, 2011, and 2016 was 21, 15, and 19, respectively (Table 1). Reductions and changes in the number of species and population of water birds in 2011 and in 2016 are not the same. Because the area of Hor-al-Azim was not the same in 2011 and 2016. The area of the marsh in 2011 was 5000 hectares and in 2016 it was reported at 10,000 hectares [9, 23]. The decrease was in 2011 more than in 2016. Diversity, alpha and beta also decreased from 2006 to 2016 (Table 1). Beta variation, alpha diversity, and gamma diversity by Whittaker were presented in 1972. Based on the idea that species diversity in the landscape (γ) is determined by two different criteria, namely, the average species diversity in the wetland (α) and the distinction between wetlands (β). Beta variation is a disparity in the diversity among bird communities in wetlands, so diversity (β) is also called habitat diversity [29]. The alpha and

Scientific Name	No 006	Abundance 2006	No. 2011	Abundance 2011	No. 2016	Abundance 2016	Population Reduction from 2006 to 2016
Grey Heron <i>Ardea cinerea</i> +	193	1.04(2.53)	2	0.08(1.29)	56	1.43(5.19)	70.91%
Purple Heron <i>Ardea purpurea</i> +	20	0.10(0.26)	2	0.08(1.29)	14	0.35(1.29)	30%
Great White Heron <i>Cosmerodius albus</i> +	359	1.97(4.71)	2	0.08(1.29)	45	1.15(4.17)	87.87%
Little Egret <i>Egretta garzetta</i> +	1570	8.56(20.61)	23	1.01(14.83)	98	3.50(9.09)	93.76%
Cattle Egret <i>Bubulcus ibis</i> +	135	0.74(1.77)	25	1.97(16.12)	98	2.50(9.09)	27.41%
Squacco Heron <i>Ardeola ralloides</i> +	121	0.66(1.58)	6	0.24(3.87)	21	0.53(1.94)	82.65%
Black-crowned Night Heron <i>Nycticorax nycticorax</i> +	123	0.67(1.61)	0	0(0)	54	1.38(5.00)	56.1%
Sacred Ibis <i>Threskiornis aethiopicus</i>	9	0.05(0.11)	0	0(0)	0	0(0)	100%
Glossy Ibis <i>Plegadis falcinellus</i>	30	0.16(0.39)	10	0.44(6.45)	12	0.30(1.11)	60%
Spoonbill <i>Platalea Leucorodia</i>	195	1.06(2.56)	0	0(0)	4	0.10(0.37)	97.95%
Brack-winged Stilt <i>Himantopus himantopus</i>	328	1.78(4.30)	14	0.61(9.03)	163	4.16(15.12)	50.31%
<i>Recurvirostra avosetta</i>	228	1.21(2.99)	14	0.61(9.03)	111	2.83(1.29)	51.32%
Spur-winged Plover <i>Vanellus spinosus</i>	4	0.02((0.05)	1	0.04(0.64)	6	0.15(0.55)	150% increased
White-tailed Lapwing <i>Vanellus leucurus</i>	220	1.20(2.88)	14	0.61(9.03)	156	3.99(14.47)	29.1%
Red-wetted Lapwing <i>Vanellus indicus</i>	221	1.20(2.90)	20	0/88(12.90)	76	1.94(7.05)	65.62%
Ringed Plover <i>Charadrius hiaticula</i>	210	1.15(2.75)	1	0.04(0.64)	31	0.79(2.87)	85.24%
Little Ringed Plover <i>Charadrius dubius</i>	5	0.03((0.06)	0	0(0)	1	0.03(0.09)	80%
Kentish Plover <i>Charadrius alexandrinus</i>	5	0.03(0.06)	3	0.12(1.93)	2	0.05(0.18)	69%
Eurasian Curlew <i>Numenius arquata</i>	170	0.93(2.23)	0	0(0)	0	0(0)	100%
Black-tailed Godwit <i>Limosa limosa</i>	123	0.67(1.61)	10	0.44(6.45)	12	0.30(1.11)	90.25%
Spotted Redshank <i>Tringa erythropus</i>	85	0.46(1.11)	2	0.8(1.29)	12	0.30(1.11)	85.89%
Redshank <i>Tringa totanus</i>	120	0.64(1.57)	4	0.16(2.58)	23	0.59(2.13)	80.84%
Marsh Sandpiper <i>Tringa stagnatilis</i>	25	0.14(0.32)	2	0.08(1.29)	12	0.3(1.11)	52%
Common Greenshank <i>Tringa nebularia</i>	80	0.43(1.05)	0	0(0)	6	0.15(0.55)	92.5%
Wood Sandpiper <i>Tringa glareola</i>	15	0.08(0.19)	0	0(0)	0	0(0)	100%
Common Sandpiper <i>Actitis hypoleucos</i>	3	0.01(0.03)	0	0(0)	0	0(0)	100%
Ruddy Turnstone <i>Arenaria interpres</i>	15	0.08(0.19)	0	0(0)	0	0(0)	100%
Dunlin <i>Calidris alpina</i>	750	4.09(9.84)	0	0(0)	0	0(0)	100%
Little Stint <i>Calidris minuta</i>	2250	12.27(29.53)	0	0(0)	60	1.43(5.56)	97.34%
Temminck's Stint <i>Calidris temminckii</i>	5	0.03(0.06)	0	0(0)	5	0.13(0.46)	stable
Total 30 species	7617	100	155	100	1078	100	85.85%

Table 3: Number and abundance of Shore birds (waders and wading) in Hor-al-Azim in 2006, 2011 and 2016

+ Protected Species in Iran

Numbers in parentheses are relative abundance of waders and wading birds in the same year and numbers outside of parentheses are relative abundance of waders and wading birds to total water birds in the same year.

Biodiversity indices	Swimmer water birds			Waders and Wading Birds			Total Number of Birds		
	2006	2011	2016	2006	2011	2016	2006	2011	2016
Dominance-D	0.810	0.313	0.140	0.150	0.124	0.088	0.091	0.268	0.080
Simpson_1-D	2.084	0.686	0.86	0.849	0.875	0.911	0.909	0.732	0.92
Shannon_H	0.382	1.528	2.242	2.418	2.383	2.658	2.902	1.864	2.944
Evenness_e^H/S	2.078	0.307	0.495	0.374	0.602	0.594	0.357	0.196	0.442
Brillouin	0.202	1.511	2.225	2.407	2.22	2.607	2.893	1.835	2.916
Menhinick	2.155	0.327	0.356	0.343	1.361	0.732	0.377	0.692	0.688
Margalef	0.684	1.83	2.264	3.245	3.292	3.296	5.093	4.139	5.078
Equitability_J	2.512	0.564	0.761	0.711	0.824	0.836	0.738	0.533	0.783
Fisher_alpha	0.361	2.183	2.736	3.968	5.032	4.354	6.407	5.469	6.759
Berger-Parker	0.810	0.466	0.230	0.295	0.257	0.151	0.211	0.431	0.167

Table 4: Biodiversity indices of all water birds in Hor-al-Azim in 2006. 2011 and 2016

beta variation of swimmer water birds in Hor-al-Azim marsh decreased 15.69%, 60.29% from 2006 to 2016, respectively. Despite the decline in the diversity and population of water birds, a number of swimmer water birds and migratory water birds are migrating to Hor-al-Amiz marsh yet. For this reason, there is a similarity of 49.53% between the all water birds in 2006 and 2016. But changes in the diversity and population of water birds from 2006 to 2016 have led to a Euclidean difference of 6,157.87. Reducing waders and wading birds is due to the destruction of the habitats of the margin of the wetland and shallow parts of it, which is an appropriate habitat for the shore birds, but due to the drying most part of the wetland and converting of marginal land into agricultural land, The diversity of habitats of waders and wading birds has completely disappeared and has reduced the population and diversity of shore birds, tables 2 and 4 and Figure 4 show these changes. The population and diversity of all water birds also decreased from 2006 to 2016 due to changes in the area of the wetland and the amount of water, the reduction of habitat diversity and possibly other factors such as security in the wetland (Table 2). The area of the wetland in Iran in 2006 was 118,000 hectares, but in 2011 it decreased to 5000, however, in 2016, by dewatering the wastewater of the region and slightly from the Karkheh River, it increased to 10,000 hectares [9], and the number of water birds and their diversity have also been changed by reducing and increasing the area of the wetland. Number of all water birds and species diversity increased from 2011 to 2016 (Table 1). Similar study had been carried out by Behrouzi-Rad in 2009 in Hamoon wetland and reported, the population changes in the water birds in relation the fluctuation of amount of water in the Hamoon and concluded that the diversity and number of water birds in the wetland is related to the depth of water and wetland area. Reducing the depth and area of the wetland decreases the diversity and number of all water birds. With fluctuations in the water level and the area of the Hor-al-Azim marsh, from 2006 to 2016, the population and diversity of water birds in the wetland have fluctuated and decreased, and this decrease has been higher in the fish-eating bird's population,

such as Greater Cormorant decreased from 1720 to 12 individuals. Reduction was 99.32%. The population of Great Crested Grebe decreased from 58 to 12 individuals, reduction was 32.29% in 2016. In similar studies by Bechir et al in 2013, 88 species of waterbirds reported in water ecosystem including 42 large dams reservoir, 41 small dams reservoir, and 20 natural wetlands, and reported 48 species of water birds in natural wetlands and 41 species in dam reservoirs. The number of water birds in the safe and natural wetlands was more than damaged wetlands [17]. In 2006, the Hor-al-Azim had area of 118,000 hectares and had numerous securities and was suitable habitats for water birds. The number of species and population was higher than in the years 2011 and 2016 (Table 1). Rotenberry (1985) studied the role of habitat in the composition of water birds populations, it has been concluded that the composition of the water birds population of wetlands is related to the natural and security of habitat. Because each group of birds prefers a specific part of a water habitat in relation to vegetation, food, security, and other environmental factors [19]. The results of the study of the water birds in the Hor-al-Azim confirmed that result. Moula and Makvandi (2008) reported 86 species of water birds in the Hor-al-Azim [23]. In 2011, the number of species decreased to 43, less than half in 2016. In a similar study Khalilipour and Behrouzi-Rad (2009) investigated the relation between the diversity and number of water birds in the southern wetlands of the Caspian Sea, and concluded that in larger wetlands, species diversity and number of water birds were higher than small wetlands [23]. This result confirms the results obtained from the study of water birds in Hor-al-Azim. Yazdan-Dad (2011) has reviewed variations, abundance, and diversity of water birds in water ecosystems in Khorasan Razavi province and reported that in larger wetlands, the number of species and population of water birds were higher [31]. This result confirms the results obtained from Hor-al-Azim. Amat and Green (2010) reported that population changes and water birds species variation are affected by the quality of the environmental factors in the wetlands, such as water content and depth of water. He was concluded that the changes in the popu-

lation and diversity of water birds species are the indicator of the environmental health of the wetlands [1]. That findings are similar to and consistent with the results obtained from Hor-al-Azim. Behrouzi-Rad (2016) studied the effect of water reducing of Urmia Lake on species diversity and population of water birds in Kaniborazan wetland and concluded that the decrease in water of Lake Urmia has reduced the species diversity and the populations of water birds of the Kaniborazan wetland [31]. Review of all published articles shows that diversity and populations of water birds are related to the status of the wetland environment and are an ecological indicator. Table 1 show the decrease in the area of the Hor-al-Azim and the loss of factors such as security, amount of water, food availability and etc. has led to a reduction in water birds population and species diversity. This decrease is due to the changing ecological conditions of the Hor-al-Azim. Therefore, it is essential to carry out maximum effort in the identification biodiversity of the country conservation sites and preservation of the endangered species which includes water birds and other wildlife.

Conclusion

Hor-al-Amiz is part of Mesopotamian marshes, more than two thirds of which are located in Iraq. The area of the Hor-al-Amiz marsh varies from 500000 to 300000 hectares. The area of wetland was 118,000 in 2006, less than 5000 hectares in 2011 and about 10,000 hectares in 2016 in Iran. Drying of Hor-al-Azim wetland, lack of connection between different parts of Mesopotamian marshes and Hor-al-Azim, fragmentation of Hor-al-Azim due to the construction of drainage channels, Seizure of wetland grounds, land allocation of northern part of it to farmers as rice fields, wheat, drilling oil wells in the marsh, construction of roads in the marsh, illegal fishing and hunting with the construction of rick hunting in the marsh, trips among marsh, grazing of livestock inside the marsh, especially in the spring, easy access to the marsh, entry of fertilizers and pesticides into the marsh by west waters, harvesting of aquatic plants including "Reed" and " forage", Unpacking the wetland by building roads for extraction of petroleum, the lack of applied rehabilitation programs, prevention of water entry across the marsh and the prevention of water exchange between its different parts, the establishment of unauthorized livestock units in most northern part of marsh, failure to manage wastewater entering to the marsh, burning of reeds, and evacuation of oil waste in the wetland, finally, drought is one of the most important threats and changes in the ecological function of the Hor-al- Azim marsh. These factors have reduced the area of the wetland from 118,000 hectares in 2006 to 10,000 hectares in 2016. Reducing the area of the wetland has reduced the biodiversity index of water birds, population structure and species diversity (Table 4). Wetland drying and reducing its area has reduced the population, diversity, and density of water birds. As shown in Table 1, the decrease in the number of swimmer water birds was 73.55%, species number was 9.33%, population

of shore birds was 85.85% species number of shore birds was 20%, total population of water birds was 78.68%, and their species number was 11.26%. The water birds are more dependent on the wetland, Their population and diversity varies more by changing the ecological conditions of the wetland. As shown in Table 1, population decline and species diversity of shore birds were higher than swimmer water birds. Because shore are dependent on fish and benthos's in terms of nutrition, due to the drying of the wetland, the proper conditions for feeding and the source of food for shore birds have been reduced. As shown in Table 4, Margalef and Berger-Parker diversity indexes declined from 5.093 to 5.078 and 0.211 to 0.167 respectively. Against the decline in species diversity, the evenness index has increased from 0.375 to 0.44. As shown in table 2, the reduction of each swimmer water birds species population fluctuated between 100% and 7.7%. The highest reduction was found in two species of shelduck and Ferruginous Duck (100%), and the lowest reduction was in Pintail population (7.7%). Only population of 4 species of Mallard, Gadwall, Eurasian Wigeon, and Common Moorhen increased. Their increase was 1.95, 2.07, 6.15, and 6.42 time respectively. As shown in table 3, the fluctuation range of the population reduction of shore birds was between 30% and 100%. Of the shorebirds, only the population of Spur-winged Plover has increased 1.5-fold. Population of 4 species, Wood Sandpiper, Common Sandpiper, Ruddy Turnstone and Dunlin decrease 100% Timmins's Stint population was stable and the population of Purple Heron had the lowest decrease (% 30). In the absence of attention and planning to protect and manage the ecosystem of the wetland and its restoration, a small number of remaining water birds and other wildlife dependent on the wetland will also be eliminated. More importantly is the lack of restoration of the wetland has increased dust storm in the region, because the ecosystem of the Hor-al Azim and the Mesopotamian marshes plays an important role in protecting the wetland birds and reducing dust storm in the region. Drying the Mesopotamian marshes both in Iran and in Iraq has increased the amount of sand storms that has caused the Khuzestan province to reach about 21 times more than health standards with dust [9]. Reduced area of the marsh from 118,000 hectares in Iran in 2006 to less than 10000 hectares in 2016 caused a decrease of 78.68% of the population and 26.11% of the species of water birds. As a result, change in the ecological conditions of the wetland has caused changes in the population and the diversity of water birds. Therefore, water birds are excellent bio indicators of health of biodiversity as well as particular habitat and its productivity. They are also important in monitoring environmental changes because of their ecological diversity. All these changes indicate that aquatic birds are an indicator of the ecological conditions of wetlands. Population stability and species diversity depend on the sustainable conditions of the wetland. Therefore, the ecological sustainability conditions have decreased in Hor-al-Azim Wetland, which has reduced population and diversity of birds. For this reason, aquatic birds are the ecological indicator of wetlands.

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