Crop Diversity and Socio-economic Factors: A Case Study of Hashilan Wetlands

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Summary

Agricultural biodiversity has always been influenced by several factors and socio-economic factors have an undeniable effect on crop diversity. The purpose of this study was to examine the diversity of crops in the Hashilan wetlands protected area in western Iran using indices of biodiversity and determining the effective socio-economic and environmental factors. Data collection was carried out by direct observation, interview and questionnaire (N=119) with the farmers. The survey was conducted in nine villages, six inside the wetland protected area and three outside it. The results showed that 10 species were cultivated in the study area and wheat occupied the most acreage. The highest numbers of species were in the Poaceae and Leguminosae families. The species richness index in the wetland area (10 species) was greater than outside it (5 species), but the Shannon diversity index was higher in villages outside the wetland because of uniform species abundance. In the wetland, species richness was high, but the dominance of wheat and barley decreased the Shannon index. The results of correlation testing for the effect of land factors, distance to the river, farm type, number of land plots, farmer education, income from the wetland, farmer age and experience, use of chemical fertilizers and the number of farmer family members on species richness and the Shannon indices showed great diversity of crops in the villages surrounding them. It can be concluded that regional protection has not created the differences between the two areas, but other factors have contributed to the change.

Key words

agrobiodiversity, Hashilan Wetlands, regional protection, sustainable agriculture

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Received: June 3, 2017 | Accepted: June 26, 2019

Introduction

Biodiversity addresses the complex interrelationships among all living organisms (Johns et al., 2006). Agriculture is a major contributor to biodiversity and global food security depends upon it (Piha et al., 2007, Wood et al. 2015). Agricultural biodiversity includes all agricultural plants and animals, their wild relatives, pollinators, pests, parasites, predators and competing organisms (Qualset et al., 1995; Smith, 2016). The importance of this diversity goes beyond food production to positive effects such as distribution of food, control of pests, diseases and weeds.

The loss of biodiversity in agro-ecosystems is a serious threat to the survival of ecosystems and global food security (Altieri, 1999, Stefani et al., 2017). The development of intensive cultivation systems has created a desirable environment for the growth of some species and a poor one for the growth of many others by simplifying the cultivation structure of an ecosystem (Johns et al., 2006). For thousands of years, farmers have maintained agricultural biodiversity; however, agricultural compression is widely agreed to be the main factor in the loss of biodiversity (Rana et al., 2007, Rana et al. 2016).

Khoshbakht and Hammer (2010) studied agriculture and crop biodiversity in plant families with an emphasis on the management of biodiversity and climate change in northern Iran. Khoshbakht et al. (2006) also studied the socio-economic aspects of crop cultivation biodiversity of Savadkouh in Iran. They found that the highest plant diversity was for fruit (33 species), followed by vegetables (28 species), beans (9 species) and other products (6 species). Animal husbandry is the first source of income in all sub-areas. Occupations: the following occupations were reported by 78 percent of the sample population: 1) farmer, 2) animal husbander, 3) homegardener, 4) student, 5) housekeeper, 5) miscellaneous jobs. Siribut?et al. (2007) studied the effect of socioeconomic factors on wetland biodiversity management in the village of Dangsan in Thailand. The analysis of the socio-economic factors (Masomzadeh and Khoshakht, 2018) demonstrated their effect on agricultural biodiversity wetland resources management and found that early education of households, the primary residence of the household, the income from the wetland and the number of livestock significantly affected farmer participation in wetland management activities. Di Falco et al. (2008) examined agricultural biodiversity and fragmentation of land in Bulgaria. They showed that land fragmentation reduced farm profitability and would be followed by product diversity.

Biodiversity also plays a useful role in field profitability. Structure, composition, species and cultivar diversity of fields are influenced by changes in the socioeconomic conditions and cultural values of the households that maintain these fields. Interdisciplinary studies with attention to socioeconomic and biophysical aspects are necessary for better understanding of agrobiodiversity benefits and function. This fact has been considered in lot of agrobiodiversity literature. The purpose of this study is to examine the diversity of crop species in the study area using indices of biodiversity and determining the effective socio-economic and environmental factors. This is the first specific study of agrobiodiversity in this area.

Materials and Methods

The study area was the Hashilan wetland in the Allahyarkhani district of Kermanshah Province in Iran. The wetland is 36 km northwest of Kermanshah at 46°54'15" E longitude and 34°34' to 35°34' N latitude. The mean annual precipitation of the wetland is 450 mm and the maximum precipitation of the area usually occurs in early spring and winter. The study area comprised nine villages with a proper geographical distribution based on the area map. These were the samples investigated in February 2013 to evaluate the area (Table 1).

Table 1. Demographical characteristics and sampling results of studied villages

Sampling unit	Houshold number	Village	Village
8	17	Malek tappeh	Wetland areas
22	34	Khvoshinan-e Vosta	
7	17	Hashilan	
11	40	Amirabad	
9	11	Kolah Kabud-e Vosta	
20	69	DoChogha	
15	20	Khvoshinan-e Sofla	Marginal wetlands
12	29	Kolah Kabud-e Sofla	
15	23	Jelugireh	

Information on the socio-economic parameters and biodiversity of crops in the area was collected through direct observation, interviews and a semi-structured questionnaire. The questionnaire consisted of parts on the diversity of crop species and socio-economic factors. In each village, each male farmer head-of-household was interviewed so that in each village 25% to 30% of households were evaluated for a total of 119 households (Table 1). In each household, the features of diversity on the farm were documented in the presence of the heads of households and their fields and gardens and orchards were visited for further validation of the acquired information.

Conventional biodiversity indices were used to assess the status of agrobiodiversity. Overall species richness indices were compiled for the farms and separately for the number of species in each category for an individual farm. The Shannon-Weiner index, in addition to existing species, includes scores for the relative frequencies of each species as well as a more appropriate index that explains biodiversity. The Shannon-Wiener index for farms was calculated as $H' = - \sum p_i \ln p_i$, where p_i is the ratio of the total area under cultivation of species i and S is the number of species using Ecological Methodology software (Shannon, 1948). SPSS software was used to calculate the mean comparison (LSD test) and factor correlation (Pearson and Spearman tests) for the biodiversity indices.

The Sorenson index (Ss) evaluates the similarity among populations and is calculated as:

$$Ss=(2j)/(a+b+2j)$$

where j is the number of species found in both communities and b is the number of species found only in the b population.

Results and Discussion

State of Crop Species

The results of this study showed that there were 10 crop species belonging to five plant families in the study area. Among these, the Poaceae and Leguminosae families had the greatest number of species. Wheat, peas, barley and maize were cultivated in all villages studied (Table 2). Wheat covered the maximum acreage in the area and was either dry cultivated or irrigated[1]. Of the 10 species, four were common to both areas (inside and outside the protected wetlands) and additional five species that were not cultivated outside the protected area were cultivated inside it (Figure 1).

Species Richness Index

The species richness index for villages inside the protected wetland (10 species) was greater than for the villages outside it (5 species). The maximum species richness index was recorded in the village of Amirabad with eight species. The villages of Hashilan and Jelugireh had four species in common and recorded the minimum species richness index values of all villages studied (Table 3). Diversity in protected areas was higher than in neighboring areas and the diversity of crop species was greater inside the protected wetland area.

The mean comparison between villages represents the difference between them (Table 3). This index shows the number of species cultivated regardless of acreage or frequency in a specific area (Shannon, 1948). In general, it is not considered as an accurate index for representing diversity (Nagendra, 2002). Species richness alone cannot show the real value of diversity without considering the frequency of a species.

[1] Koocheki et al. (2008) studied agricultural biodiversity in Iran and reported that agricultural systems in Iran are based on wheat and rice

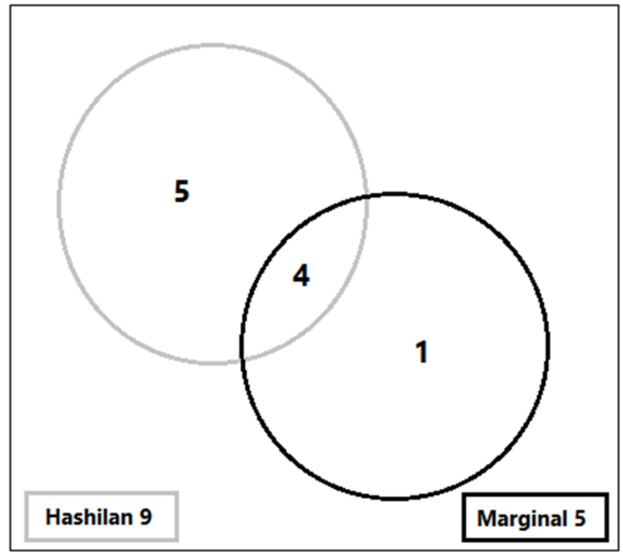

Figure 1. Assessment number of species in region

Shannon-Wiener Index

Diversity must be determined by considering species abundance along with the number of species. In the Shannon-Wiener index, diversity is calculated by factoring in the acreage covered by each species and its proportion to the total acreage, as the value of diversity is a combination of species richness and uniformity (Magurran, 2004). Table 3 shows the Shannon-Wiener indices for area villages and shows that the values for eight villages are roughly similar with minor differences. Hashilan had a Shannon index value of 0.5, but a minimum diversity value in terms of the Shannon-Wiener index because of the dominance of wheat.

Table 2. Distribution of cultivated agronomic species in villages of two regions

Scientific name	Family	Wetland areas					Marginal wetlands			
		Malek tappeh	Khvoshinan-e Vosta	Hashilan	Amirabad	Kolah Kabud-e Vosta	DoChogha	Khvoshinan-e Sofla	Kolah Kabud-e Sofla	Jelugireh
Triticum aestivum L	poasea	*	*	*	*	*	*	*	*	*
Cicer aritinum	Leguminosae	*	*	*	*	*	*	*	*	*
Zea mays	poasea	*	*	*	*	*	*	*	*	*
Hordeum vulgare	poasea	*	*	*	*	*	*	*	*	*
Beta vulgaris	Chenopodiaceac	*			*		*			
Lens culinaris Medic	Leguminosae		*		*					
Medicago sativa	Leguminosae		*		*					
Citrullus lanatus	Cucurbitaceae		*							
Brassica napus	Brassicaceae				*					
Cucumis melo	Cucurbitaceae							*		

Table 3. The content of richness and Shannon index and statistical comparison of villages

	Malek tappeh	Khvoshinan-e Vosta	Hashilan	Amirabad	Kolah Kabud-e Vosta	DoChogha	Khvoshinan-e Sofla	Kolah Kabud-e Sofla	Jelugireh
Species richness	5	7	8	5	5	4	5	5	4
Mean richness	2.5 bc	2.31 bc	2 c	3.36 a	2.88 ab	2.6 bc	2.83 ab	2.8 ab	2.66 bc
Shannon index	0.78 ac	0.69 bc	0.5 c	0.87 ab	0.87 ab	0.82 ab	0.77 ab	0.77 ac	0.95 a

Jelugireh had a Shannon index value of 0.95 and the maximum Shannon-Wiener index value. Overall, the area showed appropriate diversity in terms of the Shannon-Wiener index.

Nassiri et al. (2005) examined the diversity of crop species cultivated in Iran and determined that the Shannon index in Kermanshah province was 0.98, which is similar to the values obtained in the present study. The mean comparison of the index was different between villages, with some villages having statistically greater values.

Sorenson Similarity Index

The main application of this index is to examine the similarity or compare areas in terms of their similar species (Magurran, 2004). This numerical index falls between 0 and 1. If all species in two areas are the same, the value will be equal to 1, denoting 100% similarity (Boyce and Ellison, 2001).

Using the Sorenson similarity index, village similarity was compared in terms of crop species. Table 4 shows that Malektappeh and Dochogha, Hashilan, Kolahkabud-Vosta and Sofla, and Khvoshinan-Sofla and Jelugireh were the most similar. The reasons for these similarities was the similarity of the soil in these villages in terms of fertility, water availability, farm slope and the short distance of the villages from each other. The minimum Sorenson index values were recorded for Amirabad, Khvoshinan-Sofla, Kolahkaboud-Vosta and Jelugireh. These three villages are located outside the protected wetland area. The results reveal that the villages in the study area are limited in width and the similarity of farms is demonstrated by the high Sorensen similarity index.

Effective Factors

The socio-economic and farming characteristics of the farmers determined their status to some extent. The average age of farmers was fairly high and they were experienced in agriculture. The main income of the villagers was agriculture, which comprised more than 90% of their income. A large percentage of farmers had not attended high school. The participation of the women in the villages differed according to the type of crop, but it was very important to the area agriculture (Table 5).

Table 4. Sorenson similarity index values between the villages of similar species

	Malek tappeh	Khvoshinan-e Vosta	Hashilan	Amirabad	Kolah Kabud-e Vosta	DoChogha	Khvoshinan-e Sofla	Kolah Kabud-e Sofla	Jelugireh
Malek tappeh	1	0.72	0.9	0.71	0.88	1	0.88	0.88	0.88
Khvoshinan-e Vosta		1	0.72	0.8	0.72	0.66	0.72	0.72	0.72
Hashilan			1	0.66	1	0.88	1	1	1
Amirabad				1	0.66	0.76	0.66	0.66	0.66
Kolah Kabud-e Vosta					1	0.88	1	1	1
DoChogha						1	0.88	0.88	0.88
Khvoshinan-e Sofla							1	1	1
Kolah Kabud-e Sofla								1	1
Jelugireh									1

Table 5. Socioeconomic status and agronomic characteristics farmers

Variable		Malek tappeh	Khvoshinan-e Vosta	Hashilan	Amirabad	Kolah Kabud-e Vosta	DoChogha	Khvoshinan-e Sofla	Kolah Kabud-e Sofla	Jelugireh
Age of household head	years	51.6	47.8	52	34.8	49.5	54.3	38.3	62.3	55
Farming experience	years	37.3	31	42	20.8	39	42.4	25.2	48.5	39.1
Household members	(no.)	5.2	5.9	3.8	4.4	5.5	4.7	7.4	4.6	4
Farm size	ha	10.7	14.3	5.2	9	8.8	7.3	13.6	11.5	7.5
Worker	(no.)	2.1	0.7	0.4	0.8	0	0.6	0.4	0.3	0.4
Land lots	(no.)	4.6	3.8	3.8	6.2	6.3	5.8	5	6.2	7
Level of literacy %	illiterate	25	23	57	0	42	35	20	44	33
	less than diploma	37	50	14	73	33	55	47	33	47
	diploma	25	27	29	27	25	10	20	22	13
	academic	13	0	0	0	0	0	13	0	7
Income %	agronomic	91	96	90	83	79	97	97	86	86
	husbandry	2.3	4	10	17	6.6	3	3	0	9.4
	horticultural	0	0	0	0	0	0	0	0	0
	other	6.7	0	0	0	14.4	0	0	14.4	4.6
Organic fertilizer	ton	16.6	1.5	2.8	2	0	0	0.13	10	1.13
Chemical fertilizer	kg	490	191	84.6	135	315	225	222	294	113
Toxin	kg	1.44	1.84	2.28	2.28	6	2.2	1.43	4.16	2.2
Participation of women	more than 50%	12.5	22.7	0	18.2	0	10	0	8.3	40
	less than 50%	50	45.5	100	45.4	77.7	85	80	83.3	40
	zero	37.5	31.8	0	36.4	22.2	5	20	8.4	20

Factor Correlation

The results of correlation testing showed a significant relationship between acreage and species richness (r = 0.31**) and the Shannon indices (r = 0.18*) in the area. The acreage diversity increased on farms with more acreage, because they cultivated more diverse crops (Table 6).

A significant relationship between two areas demonstrates the importance and effect of a factor on species diversity of crops. The correlation between the number of plots of land cultivated by each farmer and species richness (r = 0.23*) and Shannon indices (r = 0.2*) were significantly positive. As the number of plots of land increased, the diversity of crops also increased (Table 6). With the fragmentation of agricultural land, farmers may cultivate different crops in each plot of land, which will increase species diversity.

It can be concluded that an increase in acreage and the number of plots of agricultural land increased the diversity of crops in the study area. Di Falco et al. (2008) reported that fragmentation of agricultural land would increase product diversity and farm profitability. The greater the number of plots, the greater the number of species used on the land, which increases diversity (Henderson and Seaby, 2002).

Table 6 shows a significant positive relationship between the distance from the village to the river with the Shannon index (r = 0.27*) and species richness index (r = 0.27*). As the distance to the village from the river or other water source increased, the Shannon index also increased because of farmers' tendency to monoculture with increasing access to water resources. This resulted in loss of biodiversity of crops and crop cultivation. Behbahani (2010) found a positive and significant correlation between access to water and the Shannon index for crop species in Jajrood.

Other effective factors were the relationship between farmer education level and diversity. The correlation with the species richness index (r = -0.2*) and Shannon index (r = -0.24**)

Table 6. Correlation values between the studied factors and indicators of biodiversity in the region

	Total		Hashilan		Maginal	
Variable	Correlation Coefficients-sig.(2-tailed)		Correlation Coefficients-sig.(2-tailed)		Correlation Coefficients-sig.(2-tailed)	
Area	Species richness	Shannon	Species richness	Shannon	Species richness	Shannon
Cultivation area	0.31**	0.18*	0.27*	0.24*	0.47**	0.01 ns
Distance to river	0.27*	0.27*	0.33*	0.23 ns	0.06 ns	0.31*
Distance to road	-0.26**	-0.14 ns	-0.35**	-0.21 ns	0.09 ns	0.08 ns
Type of farm	0.21*	0.09 ns	0.17 ns	0.17 ns	0.19 ns	0.03 ns
Land lots	0.23*	0.2*	0.19 ns	0.19 ns	0.3*	0.17 ns
Level of literacy	-0.2*	-0.24**	-0.11 ns	-0.1 ns	-0.38*	-0.51**
Wetland incom	0.16 ns	0.21*	0.18 ns	0.24**	0.03 ns	0.01 ns
Age	0.07 ns	0.14 ns	0.01 ns	0.05 ns	0.23 ns	0.38*
Chemical fertilizer	0.1 ns	-0.12 ns	-0.04 ns	-0.03 ns	0.47**	0.06 ns
Experience	0.1 ns	0.17 ns	0.05 ns	0.09 ns	0.27ns	0.4**
Household size	0.15 ns	0.03 ns	0.06 ns	0.7 ns	0.32*	-0.09 ns

* ($P<0.05$) , ** ($P<0.01$)

was statistically significant. The higher the level of education, the lower the diversity of crops in the area. Better educated farmers cultivated fewer plants and turned to monoculture of economically advantageous crops to improve their economic outlook. Malakmohammadi et al. (2010) reported an inverse relationship between farmer education and crop diversity in Kermanshah province, which is similar to the results obtained in the present study.

Factors such as the type of farm, distance to the main road, income from the wetlands, age of farmer, use of chemical fertilizer, farming experience and number of farm family members had significant effects on diversity indices, but their effects on the diversity of crops were not general, but regional (within wetlands and its margins) (Table 6).

Conclusion

Overall, crop diversity was low, but the villages in the protected wetland had more desirable diversity than the other villages. Four species in the study area were cultivated both inside and outside the protected area, but five other plants were cultivated in the wetland area alone. The Shannon index was similar for the villages under study. The minimum value of this index was for Hashilan because of the dominance of wheat. Another overall result is that, because of the area topography, the proximity of the villages to each other, the similarity of agricultural land in the villages and the small distances between them, the area farmers tended to cultivate the same species. The analysis of the effective factors of the diversity indices showed that the similar distances of the farms from the river or water resources and the decrease in the level of water in the wetland caused by improper management made access to water similar for all village farms.

The results of this study demonstrate that the protected status of the area has not affected the diversity of crops. No apparent difference has been found between the areas inside and outside the protected area. Factors such as the amount of land, number of plots, distance to the river and education have had an effect on diversity. The findings of this study show that, by analysis of agricultural systems of the area, the range of biodiversity and its proper distribution patterns could be better understood and used as the groundwork for creation of appropriate policies and decision-making in relation to sustainability of agricultural systems.

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aCS84_48