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Assessment of socio-economic factors and plant agrobiodiversity (Case study: Kashan city, Iran)

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Abstract

Conservation of agrobiodiversity is essential to achieve sustainable agricultural systems. A study was conducted in Kashan city in Iran in 2013 to assess the effects of socio-economic factors on agrobiodiversity Six villages were chosen so that they provided a uniform distribution over the region. Data were gathered using semi-structured questionnaires and explored using stepwise linear regression, principle components analysis and cluster analysis. Species richness, Shannon-Wiener index and Sorenson Similarity index were calculated as criteria of agrobiodiversity status. Results showed that the lowest species richness (10) and Shannon-Wiener index (2.48) were observed in Shadian and Sensen villages, respectively. Nashalj village had the best status of agrobiodiversity regarding both studied diversity indices. Results also revealed that farmers' age, years of farming experience, the percentage of income from non-agriculture sector, level of education and the number of land pieces were responsible for 28% of variation in data. Also the results showed that the percentage of income from agronomy sector, the number of land pieces, the percentage of income from livestock sector, years of farming experience and the percentage of income from non-agriculture sector had significant effects on Shannon-Wiener index. Overall, household income was as important factor effect on agrobiodiversity in studied villages.

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Introduction

Agrobiodiversity is a prerequisite for sustainable development of agriculture and it is an important issue in the world. Numerous studies have illustrated the importance of biodiversity in agricultural ecosystems (Anon 2001; Thrupp 2004; Small and Catling 2008) and in achieving food security (Thaman 2008). Diversity of agricultural plants is important because every living species has a valuable role in the food chains and crop diversification reduces the negative impacts of agricultural production on environment (Cutforth *et al.* 2001). However, intensification of agricultural production has reduced the number of plant species grown in a region and has resulted in simplification of agroecosystems structure and the marginalization of many plants (Chloupek, Hrstkovaa and Schweigert 2004). In today agriculture, the loss of many plant/crop species as a result of agroecosystems simplification threatens the sustainability and resilience of agroecosystems (Pimentel *et al.* 1992). About 7000 (Khoshbakht and Hammer 2008) out of 300000 (Groombridge and Jenkins 2002) plant species are currently being cultivated as a source of food.

In general, there are two groups of factors which determine crop diversity in an agroecosystem, namely natural (environmental) (Dufour *et al.* 2006) and socio-economic (Mea 2005; Albuquerque, Andrade and Caballero 2005) factors. Natural conditions such as climate (Peters 1988; Stocking 2001; Rababa'h and Al-Qudah 2004) and soil fertility (Upreti and Upreti 2002; Enright, Miller and Akhtar 2005) limit cultivation of many crops, while socio-economic factors such as income of field, age of farmers, farmers experience in agriculture sector, level of education and their indigenous knowledge cause variation in plant diversity (Wilson 1997; Upreti and Upreti 2002; Turpie 2003; Benin *et al.* 2004). So, identification of factors influencing the crop diversity is important for socio -economic policy-making with the ultimate goal of maintaining or even increasing diversity in rural areas in the future. Hence, study of agrobiodiversity has been the focus of many agroecologists and has been studied from different aspects (Stocking 1999).

Different researchers have emphasized on socio-economic factors (Ten Brink 2009; Di Falco *et al.* 2010). Benin *et al.* (2003) stated that there is a significant relationship between the diversity of agricultural products and the greater availability of family labor. Winters, Cavatassi and Lipper (2006) stated that turning to other occupations other than agriculture reduces diversity. Also, Scott *et al.* (1998) reported that land use change and improper use of land cause damage to ecosystems and reduce species diversity. Baudry *et al.* (2000) and Kristensen, Thenail and Kristensen (2001) found that cropland acreage is an important factor in the proportion of land cultivated by farmers and stated that larger pieces of croplands favor cultivation of more diverse crops. Also, it has been stated that the more use of croplands for food purposes affects biodiversity through reducing species richness (Schmitzberger *et al.* 2005). Numerous studies have indicated that the income status is a factor impacting agrobiodiversity conservation (Peyre *et al.* 2006; Redford and Agrawal 2006; Jackson, Pascual and Hodgkin 2007). Coomes and Ban (2004) showed that homegardens diversity has positive relationships with land ownership and the number of farms. In their study in Mexican homegardens, Blanckaert *et al.* (2004) reported that no relationship existed between households' age and the number of family members with homegarden species richness. According to what mentioned in the preceding paragraphs, quantification of agrobiodiversity is of great importance. Different methods have been used in the literature to achieve this goal. Meul, Nevens and Reheul (2005) had proposed the number of varieties, species or groups of agricultural plants as criteria for the assessment of crop diversity. Several species diversity indicators (indices) are also available that make the assessment of diversity possible (Gliessman, Engles and Jrieger 1998). SWI is the most common of them that includes the number of species and the relative frequency of each species (Smale *et al.* 2003; Gozdowski, Roszkowska-Madra and Madry 2008; Kunhikannan *et al.* 2011). Sunwar *et al.* (2006) used species richness and SWI to quantify biodiversity status in two ecological regions in Nepal and found that SWI in both areas was more than 4.2. Koocheki, Nassiri Mahallati and Nadjafi (2004) found a SWI of 0.64 for medicinal and aromatic plants in Iran and stated that the reason for such a low value was cultivation of few species of these plants. Farjadian *et al.* (2010) used SWI and Simpson index to assess the diversity of medicinal plants and found that both indices had values below 1 which indicated low diversity in the study region. Razavi, Rahmani and Sattarian (2009) also used the same indices to evaluate the biodiversity of perennial species and its relationship with physiographic factors such as elevation from sea level and hillside slope. Despite Iran had had high genetic and crop species diversity in the past, but this diversity has been greatly reduced and bulk of production only comes from few crop cultivars. In recent decades, vast crops monoculture has reduced plant biodiversity in the country (Koocheki 2005). Despite the importance of plant diversity and its role in agroecosystem stability on one side and being among the centers of domestication of some important agricultural crops (Koocheki *et al.* 2008) on the other side, studies on Iran agrobiodiversity status is scarce. Khoshbakht, Hammer and Amini (2006) showed that socio-economic factors such as area of land and labor availability in homegardens affect species diversity. Hashemi Shadegan (2009) showed that with increase in the number of family members and the percentage of income from agronomy and horticulture, species diversity increased significantly.

To our knowledge, no study has been conducted in Kashan city in Isfahan province for evaluation of the status of agrobiodiversity. Given the importance of plant diversity and theimpact of environmental and socio-economic factors on sustainability of agricultural systems, the present study was conducted to assess the plant diversity status in this region.

Materials and methods

Study area

The present study has been conducted in 2013 in Kashan which is a city in Isfahan province and covers an area over 5500 km2 (Fig. 1). Isfahan is located in the center of the country and has an arid and semi-arid climate. The city lies between 33° 37' and 34° 25' N, and between 51° '00 and 51° 31' E. The mean annual temperature and rainfall of the city are 19°C and 145mm, respectively. It has hot summers with mild winters and rainfall mainly occurs in autumn and winter. The economy of the study area is primarily based on agriculture. The majority of the population in this region is in the middle age group and is illiterate or has no college education. The study included six villages chosen on the basis of providing suitable coverage of various geographic conditions in the region (Table 1). agriculture sector and the number of seasonal workers. Agronomic characteristics were area of land under cultivation, farm location and the number of land pieces owned by each farmer.

Table 1. Demographic and geographical characteristics of the studied villages in Kashan city.

Division	Rural district	Village	Longitude	Latitude	Altitude (masl*)	Distance to city (km)	Number of households	Number of sampling units
Niasar	Niasar	Nashalj	51°04´23”	33°59´22”	2000	30	663	30
Niasar	Kuhdasht	Borzabad	51°07´17”	33°04´53”	2000	27	32	13
Markazi	Miandasht	Sensen	51°06´40”	33°15´08”	835	29	399	30
Markazi	Kuhpayeh	Hasanabad	51°25´19”	33°57´31”	1000	2	674	30
Markazi	Khoramdasht	Shadian	51°36´18”	33°51´28”	1206	25	39	13
Barzok	Gholab	Viduja	51°08´47”	33°50´38”	2100	28	243	30

* Meter above sea level

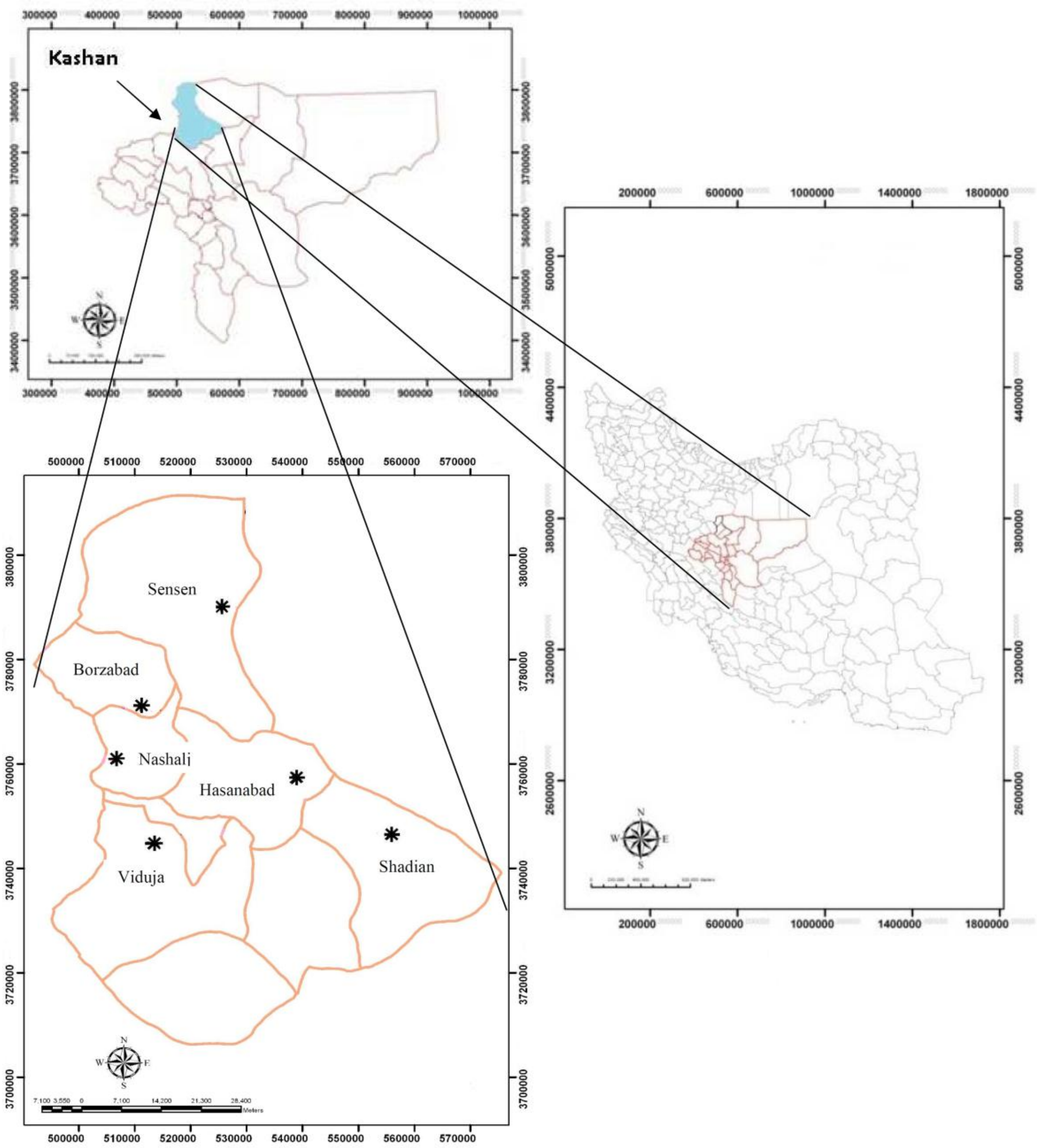

Fig. 1. Geographical location of Isfahan province in Iran, Kashan city in Isfahan province and studied villages in Kashan city.

Biodiversity indices

In order to quantify agrobiodiversity in the studied villages, species richness, Shannon-Wiener and Sorenson Similarity indices were calculated. Species richness was obtained through the information gathered on the number of species cultivated in each village. Shannon-Wiener index (SWI) was calculated according to Equation (1) (Banwa 2011):

$$H = -\sum PilnPi \qquad \text{Equation (1)}$$

$$Pi = \frac{ni}{N}$$

where ni is the area devoted to species i and N is the total area under cultivation. Sorenson Similarity index (SSI) was obtained using Equation (2) (Banwa 2011):

$$S = \frac{2Vij}{Vi+Vj} \qquad \text{Equation (1)}$$

where Vij is the number of shared species between two regions, and Vi and Vj are the number of species in the areas 1 and 2.

Data analysis

Data were extracted from the questionnaires and categorized into quantitative and qualitative variables. In order to analyze the qualitative data, they were first scaled numerically by appropriate coding. The analysis of variance (ANOVA) assumptions were tested to ensure whether or not parametric statistical techniques could be used on data. As a result of failure of ANOVA assumptions for almost all qualitative and quantitative variables, Kruskal-Wallis test was used to compare traits' medians between villages. In the second phase, spearman correlation coefficient and stepwise linear regression (SLR) were also employed to explore the relationship between variables. The SLR was used to determine the most effective traits on biodiversity indices. In this regard, each biodiversity index was considered as dependent variable and all other measured variables were considered as independent. To ensure that the variables entered the model have not any linear correlation with one another, test of collinearity was applied on them. A tolerance value smaller than 0.1, indicated no collinearity. Principle Components Analysis (PCA) was applied to further explore the relationships between different variables. Principle components (PC) with Eigenvalue greater than 1 were considered as significant. Also, whenever, a variable within a PC had Eigenvector greater than 0.3, it has had significant effect on partial variance explained by that PC. In order to group similar villages regarding the measured variables cluster analysis based on Average Linkage method was used.

Minitab and SAS softwares (SAS Institute 2000) were used for all statistical analyses. PCA, spearman correlation coefficient and SLR were calculated using PRINCOMP, CORR and REG procedures in SAS, respectively. Cluster analysis was performed using Minitab.

Results and discussion

Status of Agrobiodiversity

The results showed that Viduja, Borzabad and Nashalj villages had highest values of species richness (39, 38 and 37 species under cultivation, respectively) (Fig. 2), while Shadian village with only 10 species had the lowest species richness. Lack of life-prerequisite facilities in this village and low income from agronomy and horticulture sectors have caused migration of farmers from the village to find work in non-agriculture sector in order to earn more money. Positive correlations between the percentage of income from agronomy and horticulture sectors and species richness (0.16 and 0.12, respectively) and also negative correlation (-0.26) between percentage of income from non-agriculture sector and species richness confirm the above result (Table 2). Some studies showed that migration of people from rural villages to cities and land abandonment are among factors influencing species diversity and delivery of ecosystem services to agroecosystems (Jackson, Pascual and Hodgkin 2007; Stoate *et al.* 2009). As stated earlier, agronomy and horticulture sectors do not provide enough money for farmers in this village. As a result, farmers do not have any tendency to cultivate different crops on large acreage but their private needs. This is a reason of reduced species richness. Positive correlations between the percentage of income from agronomy and horticulture sectors and species richness mentioned earlier also confirm our findings and highlight the importance of income per unit land in achieving satisfactory species richness. Studies have shown the importance of culture and household income on species richness and species diversity (Peyre *et al.* 2006; Rana *et al.* 2007). Also, small number of household members employed in agriculture in Shadian village is another reason for the decline in species richness. As a result of low-income agronomy and horticulture, more family members have abandoned farming and shifted to other jobs. Positive correlations between the number of employees in agriculture and income from agronomy and horticulture (0.26 and 0.09 respectively, Table 3) show that by an increase in the income from agriculture sector, more people are attracted to work in this sector. Households with greater numbers of their members employed in agriculture, favor simultaneously the experience and education which lead to cultivating more diverse species. A significant positive correlation (0.33, Table 2) between the number of employed family members in agriculture sector and species richness confirms this finding.

Table 2. Spearman correlation coefficients between species richness and Shannon-Wiener index (SWI) and various socioeconomic factors in the studied villages in Kashan city.

Independent variable	Species richness	SWI
Age of farmers	0.12	0.15*
Years of farming experience	0.26**	0.27**
The number of family members employed in the agriculture sector	0.33**	0.30**
Percentage of income from livestock sector	0.19*	0.27**
Percentage of income from agronomy	0.16*	0.46**
Percentage of income from horticulture	0.12*	-0.21**
Percentage of income from non-agriculture sector	-0.26**	-0.19**
Crop acreage	0.33**	0.17*
The number of seasonal workers	0.31**	0.13
The number of land pieces	0.20**	0.33**
Level of education	0.17*	-0.24**

* and **: Significant at P ≤ 0.05 and P ≤ 0.01 probability levels, respectively.

Rababah and Al- Qudah (2004) also stated that if for some reason enough opportunities are not provided for the employment of family labors in agriculture sector, it may possibly negatively affects the farm diversification and conservation. Small farms in this village limit farmers to grow many different crops. A significant positive correlation (0.33) between species richness and area under cultivation confirms our justification (Table 2). Despite limited access to water in all the studied villages, this factor along with other factors mentioned earlier has decreased the area of arable lands in the villages. Furthermore, water limitation forces farmers to grow specific crops which can tolerate water stress. Rana *et al.* (2007) also stated that limited access to irrigation water reduces the choice of plant species. Our results also indicate that there is a positive relationship between the number of seasonal workers in the field (i.e. work hours per worker) and species richness (0.31, Table 2). Small number of seasonal workers in Shadian village was another reason of low species richness in this village. Distance between pieces of croplands is another factor affecting species richness. Unlike Shadian village, there is considerable area of land under cultivation in other villages and farmers almost allocate all their land to plant species. Villages with high species richness have greater participation of family members in agriculture sector and agriculture is the main source of income. These result in more investment of farmers in this sector in order to better provide market demand. Reardon and Barrett (2000) also showed that a balance between the market needs and the kind of cultivated crop, affects species diversity positively. Farmers with more experience in agriculture sector and lower education level have been able to maintain species richness at a higher level. The reason is that most experienced farmers are old which could not find the opportunity to continue their education. Farmers with more experience in the agriculture sector could consider their farm conditions as well as market needs to grow more diverse plants to reduce any possible risk from the market side. The results of the correlation analysis between level of education, experience and species richness confirm our justification (Table 2). Significant and positive correlation (0.19) between the percentage of income from livestock and species richness was observed. Those farmers who grew livestock on the side of their agronomy and horticulture had higher species richness. These farmers have to grow fodder crops as well in order to provide forage of their livestock which ultimately results in higher species richness. Also, Rana *et al.* (2007) reported a direct relationship between the number of cattle and the cultivation of native plants. Although farmers in Shadian village grew livestock and had high income from this sector, but small farm lands have resulted in excessive grazing of farms by livestock which came at the expense of loss of species richness.

Results showed that all villages had relatively high SWI (Fig. 3). Hasanabad and Nashalj had the highest SWI, respectively. Sensen ranked the lowest in this regard. The reason of lower SWI in Sensen could be attributed to little experience of farmers and also to more income from non-agriculture sector. Individuals with low experience in the agriculture sector tended to non- agricultural jobs and also to monoculture to make more money. Positive correlation (0.27) between experience and SWI also confirms the above result (Table 2). Negative correlation (-0.19) was found between percentage of income from non-agriculture sector and SWI (Table 2). Turpie (2003) stated that experience in the agriculture sector is an important factor in conservation of plant diversity. On the other hand, close distance of Sensen village to the Qom – Kashan road has caused the farmers in this village to devote their lands to industrial applications and other services other than agriculture. Burianek (1996) and Scott *et al.* (1998) also stated that land-use change causes degradation of ecosystems and loss of species diversity. In addition to low access to irrigation water in Sensen village, low water quality due to salinity has made soils in this village saline and thus less suitable for plant growth. Power (2010) has stated that increase in water supply is a prerequisite for maintenance of crop diversity. Shaltout *et al.* (2002) stated that low diversity in the Red Sea coastal area is a result of soil salinity. In Sensen village farmers have mainly allocated their lands to products such as pomegranate, pistachio and melon. This is also a consequence of soil salinity in this village which has forced farmers to plant more salt- resistant tree crops. Many studies have shown that type of plants is an important factor in determination of the intensity of land use (Baudry *et al.* 2000; Kristensen, Thenail and Kristensen 2001). Koocheki, Nassiri Mahallati and Nadjafi (2004) stated that the reason for low value of SWI for medicinal and aromatic plants in Iran was cultivation of few species of these plants. Higher SWI in Hasanabad is a result of more income that farmers make in this village from agronomy sector. High income from agronomy has acted as an incentive to cultivate more plants. A significant and positive correlation (0.46) between the percentage of income from agronomy and SWI indicated greater diversity and appropriate distribution of crop species in this village (Table 2). Wilson (1997) also stated that income from agriculture influences agrobiodiversity. Positive correlation (0.17) between SWI and the cultivated area also shows that the greater cultivated area will lead to more appropriate distribution of lands between different crops (Table 2). Close distance of consumption market and farmers' living locations (agricultural lands) are among other reasons of high SWI in this village. Closer distance to consumption markets has facilitated the supply of products to the markets while maintaining the quality of the products. Blaikie (1971) also stated that distance to consumption market is an important factor in biodiversity conservation. Wilson (1997) stated that the distance of agricultural lands to the farmers living places is important in conserving biodiversity. In addition to the above mentioned advantageous, close distance between a village and city provides easier access of farmers to information. Winters, Cavatassi and Lipper (2006) have noted that increased access to seed, data, consumption markets and main roads had positive roles in maintenance and enhancement of agrobiodiversity. Long distance to markets increases transportation costs and thus cultivation of some products may not be economical for farmers. Farmers in Hasanabad village accessed to improved seeds which serves as another incentive for higher diversity. Older and experienced farmers who play vital role in increment of agrobiodiversity have low level of education which is consistent with results obtained from correlation between the SWI and education (-0.24, Table 2).

According to both diversity indices, it can be seen that Nashalj village has the best status of agrobiodiversity. This indicates that in addition to high species richness, the distribution of crops is also satisfactory in this village. In a nutshell, the higher number of agricultural land pieces and existence of more experienced farmers were the most important factors which have contributed to agrobiodiversity in this village.

The results showed that there were similarities between some of the villages for cultivated agricultural plants so that Borzabad village had highest similarity with Viduja and Hasanabad villages (SSI of 0.75 and 0.73, respectively) (Table 4). This result is in agreement with those obtained in case of SWI in which Borzabad and Viduja villages had similar situations (SWI of 2.83 and 2.89, respectively). Similarity between Borzabad and Viduja could be attributed in part to the geography of the two villages (altitude and dominate soil texture) that resulted in cultivation of similar plant species. Also, the number of species present in the two villages (species richness) was close to each other. Regarding Borzabad and Hasanabad villages, large crop acreage and high percentage income from agriculture sector caused farmers to allocate their cropland to different plants which inhibited the domination of certain species. Simpson's index calculated for Borzabad and Hasanabad villages (0.80 and 0.88, respectively) also confirmed this result (Rajabzadeh Kashani 2012).

Table 3. Spearman correlation coefficients between various socioeconomic factors in the studied villages in Kashan city.

	Age of farmers	**Level of education**	**Years of farming experience**	**Percentage of income from agronomy**	**Percentage of income from horticulture**	**Percentage of income from livestock sector**	**Percentage of income from non-agriculture sector**	**The number of seasonal workers**	**The number of family members employed in the agriculture sector**	**Crop acreage**	**The number of land pieces**
Age of farmers	1										
Level of education	-0.85**	1									
Years of farming Experience	0.83**	-0.63**	1								
Percentage of income from agronomy	0.04	-0.26**	0.17*	1							
Percentage of income from horticulture	0.37**	-0.19**	0.33**	-0.46**	1						
Percentage of income from livestock sector	0.03	-0.21**	0.02	0.10	-0.20**	1					
Percentage of income from non-agriculture sector	-0.32**	-0.45**	-0.35**	-0.29**	-0.19*	-0.53**	1				
The number of seasonal workers	0.03	0.04	0.02	-0.46**	0.16*	-0.02	-0.17*	1			
The number of family members employed in the agriculture sector	0.58**	-0.37**	0.61**	0.26**	0.09	0.15*	-0.31**	0.15*	1		
Crop acreage	0.11	-0.06	0.10	0.41**	0.06	-0.05	-0.37*	0.66**	0.29**	1	
The number of land pieces	0.33**	-0.44**	0.42**	0.38**	0.05	0.08	-0.33**	0.23**	0.27**	0.40**	1

* and **: Significant at P ≤ 0.05 and P ≤ 0.01 probability levels, respectively

Table 4. Sorenson similarity index (SSI) for the studied villages in Kashan city.

	Nashalj	Borzabad	Sensen	Hasanabad	Shadian	Viduja
Nashalj	1					
Borzabad	0.66	1				
Sensen	0.51	0.57	1			
Hasanabad	0.45	0.73	0.62	1		
Shadian	0.21	0.29	0.51	0.37	1	
Viduja	0.63	0.75	0.46	0.61	0.20	1

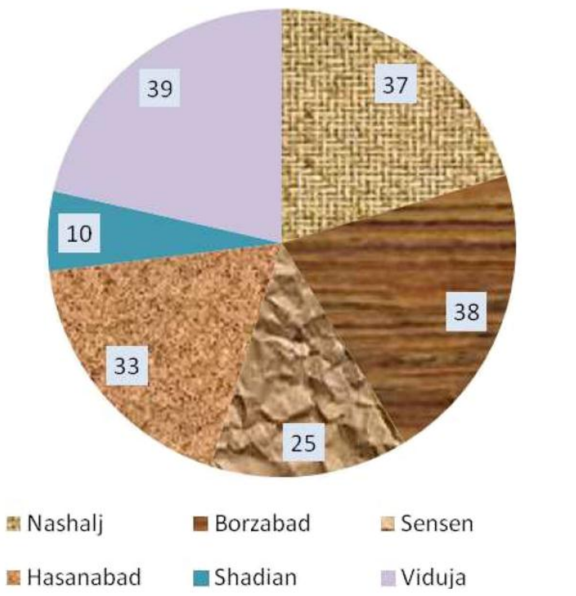

Fig. 2. Species richness in the studied villages in Kashan city.

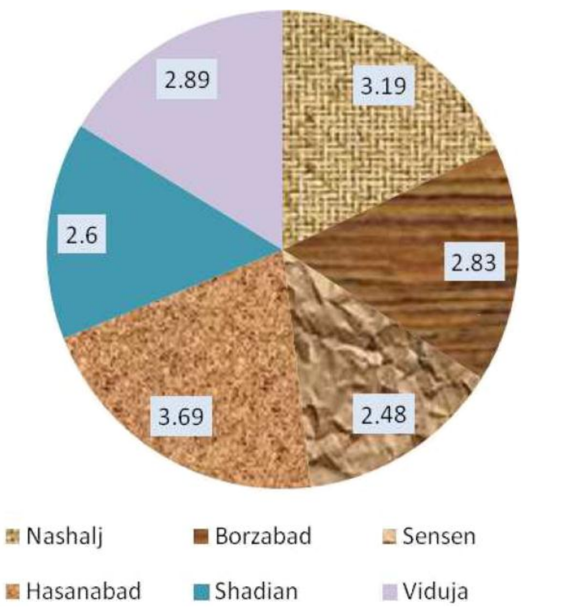

Fig. 3. Shannon-Wiener index (SWI) values in the studied villages in Kashan city.

Effects of socio-economic factors on species richness

SLR revealed that the number of family members employed in the agriculture sector, the percentage of income from non-agriculture sector and the number of seasonal workers where the three most influencing variables on species richness (Table 5). These three variables accounted for 17% of total variation observed in species richness. The number of family members employed in the agriculture sector was responsible for almost half of the variation accounted for. The relationships between species richness and the number of family members employed in the agriculture sector and the number of seasonal workers were positive while the relationship was opposite in case of the percentage of income from non-agriculture sector. By an increase in the participation of family members in agriculture, cultivation of crops on the goal of household consumption only decreases and the family tries to manage the farm to cultivate crops with high market demand so that they make more money from this sector. Benin *et al.* (2003) stated that significant relationship existed between crop diversification and access to family labor. As observed in the present study, increase in the number of seasonal workers also increased species richness. Increase in this variable means that more people spend their time in the field which has positive implications on species diversity and crop cultural activities. Our results also indicated that by increase in the percentage of income from non-agriculture sector species richness reduced. This shows that farmers have low-income from agriculture sector and thus they attract to other jobs. Shift of people to other jobs decreases the agrobiodiversity (Winters, Cavatassi and Lipper 2006).

Table 5. Variables significantly influencing species richness in the studied villages in Kashan city according to stepwise linear regression.

Steps	Variables	df	Standardized beta coefficient	Partial R^2	Cumulative R^2
1	The number of family members employed in the agriculture sector	1	0.26	0.111	0.111
2	Percentage of income from non-agriculture sector	1	-0.17	0.034	0.146
3	The number of seasonal workers	1	0.16	0.025	0.171

Effects of socio-economic factors on SWI

The results showed that the percentage of income from agronomy sector, the number of land pieces, the percentage of income from livestock sector, the level of experience in agriculture sector and the percentage of income from non-agriculture sector had significant effects on SWI (Table 6). As observed, 14% of all changes in this index could be explained by the percentage of income from agronomy. By an increase in the percentage of income from this sector, farmers tended to allocate their croplands more uniformly to various crops and people were less likely to work in other businesses. A study in Bulgaria showed that biodiversity is correlated with increased income and profitability of the farm (Di Falco *et al.* 2010). Low income from agriculture sector and high costs of energy and transportation lead to reduced attention to habitat conservation (Jackson, Pascual and Hodgkin 2007). Studies have shown that income is an effective factor in biodiversity conservation and is affected by changes in government policies and economic conditions of the society (Turpie 2003). As the results showed, the number of land pieces had positive association with plant diversity in the farm. More land pieces means suitable opportunity to cultivate more diverse crops. Therefore, it is expected that the economic profit would be more in smaller parts. Positive correlation between the number of land pieces and income from the agronomy and horticulture sectors (0.38 and 0.05, respectively, Table 3) also confirm our findings. Di Falco *et al.* (2010) also showed that increase in the number of land pieces increased agrobiodiversity. Such farmers have better opportunity to take their lands under cultivation of different crop species including forage crops due to differences in their lands productivity (Rana *et al.* 2007).

Table 6. Variables significantly influencing Shannon-Wiener index (SWI) in the studied villages in Kashan city according to stepwise linear regression.

Steps	Variables	df	Standardized beta Coefficient	Partial R^2	Cumulative R^2
1	Percentage of income from agronomy	1	0.40	0.149	0.149
2	The number of land pieces	1	0.19	0.055	0.204
3	Percentage of income from livestock sector	1	0.35	0.043	0.248
4	Years of farming experience	1	0.27	0.029	0.277
5	Percentage of income from non-agriculture sector	1	0.23	0.027	0.305

Being involved in works other than agriculture also affects biodiversity. However, this may also have a positive aspect. Turning of individuals to other jobs can provide capital for the agriculture sector and thus can impact agrobiodiversity positively. The results of the study of Redford and Agrawal (2006) confirm our findings. These researchers stated that there is a positive relationship between agrobiodiversity and income from other sources, and wealthier people usually tend to cultivate more diverse species. As shown in Table 6, the percentage of income from livestock sector also affected plant diversity positively. Due to the higher profitability of livestock for farmers, some farmers tend to this industry, which means cultivation of fodder crops along with other crops and thus improvement in agrobiodiversity status. Gozdowski, Roszkowska-Madra and Madry (2008) also showed that livestock has positive effects on agrobiodiversity. The experience of farmers in the agriculture sector also helps increase the diversity of agricultural plants. Experience of farmers is an indication of high indigenous knowledge in relation to agriculture. A significant and positive correlation (0.27) between SWI and experience of farmers also confirmed the present result (Table 2). Various studies have emphasized at the role of indigenous knowledge in agrobiodiversity conservation (Dahl and Nabhan 1992; Upreti and Upreti 2002).

Principal components analysis

PCA grouped data into four significant components (PC1 to PC4) explaining 68% of the total variation (Table 7). Variables farmers age, years of farming experience, the percentage of income from non-agriculture sector, level of education and the number of land pieces were responsible for 28% of variation explained by PC1 (Table 7). Farmers age, years of farming experience and the number of land pieces had positive relationships with each other but negative association with the percentage of income from non-agriculture sector and level of farmers education. Gauchan *et al.* (2005) found significant relationship between age of farmers and their level of education in an area while this was not the case for another area. These authors stated that older farmers that usually have less education use native varieties more than improved varieties which help biodiversity conservation. Jackson, Pascual and Hodgkin (2007) stated that lack of information, awareness and proper knowledge about plants are reasons of losses in genetic diversity. The lack of awareness about the important plant aspects prevents the development of appropriate and sustaining program (Hammer, Heller and Engles 2001). The large number of land pieces increases plant diversity and income from the agriculture sector causing the income from non-agriculture sector decreases. PC2 was mainly affected by the interaction between the percentage of income from agronomy, the crop-cultivated area and the number of seasonal workers (Table 7). These three variables explained 17% of variation in the data. Results showed that with an increase in the crop-cultivated area, the number of workers involved in agriculture also increased. Result of correlation between the two traits also confirms PCA finding (Table 3). Increase in the number of workers involved in agriculture results in timely field operations and thus better cultural management of the crops which ultimately increase income from this sector. PC3 which explained 13% of the total variation in data is mainly dominated by the effect of the percentage of income from horticulture sector (Table 7). Increase in this variable improves farmers' income and livelihood which has positive effects on the crops that they plan to cultivate. PC4 also showed that access to improved seeds explained 9% of total variation in data (Table 7). Access to improved seeds is a prerequisite for obtaining higher yields and thus income from the farm. Increase in the income of farmers favors agrobiodiversity as they will be able to not only cultivate different crops but also apply high standard cultural practices.

Table 7. Results of the principle components analysis (PCA) on different variables gathered from six villages in Kashan city. Only, components with significant effects have been demonstrated.

Variables	PC1	PC2	PC3	PC4
Age of farmers	0.42	-0.12	0.18	0.08
Years of farming experience	0.46	-0.11	0.07	0
Percentage of income from agronomy	0.15	0.40	-0.49	-0.08
Percentage of income from horticulture	0.21	-0.18	0.59	-0.13
Percentage of income from non-agriculture sector	-0.35	-0.16	0	-0.01
Crop acreage	0.1	0.57	0.24	0.07
The number of seasonal workers	0.05	0.44	0.42	0.06
The number of land pieces	0.33	0.24	-0.13	0.04
Level of education	-0.45	0.12	0.21	-0.04
Access to improved Seeds	-0.06	0.22	-0.1	0.65
Partial R^2	0.28	0.17	0.13	0.09
Cumulative R^2	0.28	0.46	0.59	0.68

Cluster analysis

Cluster analysis revealed that Nashalj and Viduja villages were ranked in one cluster while Shadian and Borzabad were grouped in another cluster (Fig. 4). As

Fig. 4 showed, each of Sensen and Hasanabad villages fell into distinct clusters. Similarity between Nashalj and Viduja could be attributed to similar percentage of incomes from agronomy and horticulture in the two villages. In both villages the percentage of income from agronomy sector was low and more than half of the family income relied on horticulture. Also, the whole farming system of the two villages regarding crop rotational programs and livestock were similar to each other. Farmers in Borzabad and Shadian villages use crop rotation in their farming practices and over 60% of farmers in these two villages use rotational crop programs. In both villages no farmer had college education.

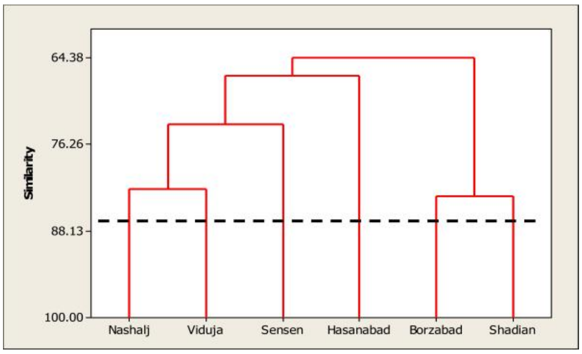

Fig. 4. Dendrogram of cluster analysis of different variables in the studied villages in Kashan city.

Also, the percentage of income from agronomy sector was low compared to other sources of livelihoods. What distinguished Sensen village from other villages was its younger low-experienced farmers. This village had the highest percentage of college-educated farmers. Due to the geographical status of Sensen village, most of the farmers are involved in industrial and other non-agricultural activities from which they get considerably more income. Hasanabad village had the highest percentage of old farmers among studied villages. Cropland acreage was also substantially larger in this village than other villages. Due to the closer distance of this village to city, farmers attempt to grow cash crops such as vegetables which dramatically increase their income from agronomy sector compared to other villages. On the other hand, in this village the percentage of income from horticulture is lower than other village. Although farmers had many land pieces in this village but they mainly relied on monoculture in each of the land pieces. Access to improved seeds was also better in this village than in other villages.

Conclusion

Overall, it was concluded that agrobiodiversity in Kashan is relatively in good status and a combination of years farming experience, higher income from agronomy and livestock sectors and the number of land pieces favors agrobiodiversity in this city. It appears that interest in conservation of agrobiodiversity mainly relies on farmers' income from agriculture sector. Nevertheless, access to adequate resources with sufficient quality (such as water resources) is a challengeable issue in achieving satisfactory agrobiodiversity in the studied villages. So, further identification of factors influencing the crop diversity is important for socio-economic policy-making with the ultimate goal of maintaining or even increasing diversity in rural areas of the city in the future.

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