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A Quantitative Assessment of Plant Agrobiodiversity Threats - a Case Study of Gachsaran

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Abstract

A study was conducted using a modified model to assess the level of threat and effective factors in villages with two ecologies, in Basht County, Gachsaran in Southwest Iran, including a protected area with a dominant mountainous topology and another with a plain-hilly situation. The results showed that level of threat increased with the decreasing distance of villages from the urban region and mountain villages had a lower level of risk than plain-hilly areas. Trends of agrochemical application, weed management techniques and acreage of fields receiving agrochemicals had the highest frequency of flooding and incidental fires and the acreage of agricultural land in the area made the least contribution to the threat of agrobiodiversity erosion. The results of cluster analysis divided villages into two clusters in which all mountainous villages, along with two plain-hilly villages were placed in one cluster and the others were located in the second cluster. Estimating the role of divergence factors in the clusters revealed that five factors including the distance to the main urban centers, distance to industrial developmental projects, ratio of irrigated to rain-fed lands, extent of use of modern varieties and exploitation rate of habitat species had the highest effects on divergence of the biodiversity threat in the model. Results showed that human activities are the main factors in genetic erosion threats, whereas natural factors as well as traditional agricultural and social practices and the availability of agricultural territories in the area resulted in the least risk to biodiversity.

Keywords: Biodiversity, Agrochemicals, Distance to urban centre, Protected area

ارزیابی تهدید فرسایش ژنتیکی برای تنوع زیستی کشاورزی؛ مطالعه موردی: گچساران

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چکیده

میزان تهدید فرسایش تنوع زیستی کشاورزی و عوامل موثر بر آن در روستاهای دو منطقه در جنوب غرب ایران شامل یک منطقه با توپوگرافی غالب کوهستانی حفاظت‌شده و دیگری با اقلیم دشتی کوهپایه‌ای در نزدیکی شهر باشت، با استفاده از یک مدل اصلاح شده مطالعه شد. نتایج نشان داد با نزدیک شدن به شهر، امتیاز تهدید فرسایش تنوع‌زیستی در روستاها افزایش یافت و روستاهای منطقه کوهستانی از سطح تهدید کمتری برخوردار بودند. عامل‌های تغییر در کاربرد نهاده‌های شیمیایی، تکنیک‌های کنترل علف‌های هرز و سطح زمین‌هایی که نهاده‌های شیمیایی دریافت کرده بودند، بیشترین و عامل‌های فراوانی سیلاب و آتش‌سوزی و نیز مساحت کل حریم روستا که در آن کشاورزی صورت می‌گرفت، کمترین نقش را در تهدید فرسایش تنوع زیستی نشان دادند. بر اساس آزمون تحلیل خوشه‌ای، روستاها در دو خوشه دسته‌بندی شدند، به طوری که همه روستاهای منطقه کوهستانی به‌علاوه دو روستای منطقه دشتی در یک خوشه و بقیه در خوشهٔ دیگر قرار گرفتند. برآورد نقش عامل‌ها در واگرایی دو خوشه نشان داد پنج عامل فاصله تا مرکز عمده جمعیتی، فاصله تا پروژه‌های توسعه، نسبت زمین‌های فاریاب به دیم، نسبت استفاده از واریته‌های نوین و میزان بهره‌برداری از گونه‌های زیستگاه بیشترین تأثیر را در تفاوت تهدید تنوع‌زیستی در مدل به خود اختصاص دادند.

کلیدواژه‌ها: تنوع زیستی، نهاده‌های شیمیایی، فاصله تا شهر، منطقهٔ حفاظت‌شده.

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Introduction

Biodiversity supplies essential components for a safe environment and sustainable livelihood (Johns *et al.*, 2006). A growing consensus is shaping on the basis of the role played by factors other than species richness, i.e. functional diversity, the amount and range of species characteristics and their interactions on determining the dynamism of ecosystem resources and its stability (Hajjar *et al.*, 2008). Although most ecosystem services are influenced by human activities (Balvanera *et al.* 2006), the mechanism of species distribution in different biomes is not understood well. Some regions with a small area may accommodate a greater number of species whereas some larger areas are very poor in species and endemism (Wilson, 1992). For instance, tropical rain forests account for about 50% of world species, while they encompass only 7% of the Earth's surface (Prance, 1997). Continuous demand for improved crops to cope with new environmental challenges and respond to the changing demands of consumers, have established a continuous requirement for genetic diversity. The pool of genetic diversity, however, is shrinking mainly due to the negative consequences of human activities (Guarino, 1999; Keisa *et al.*, 2007).

Considerable attempts have been made to prepare the list of factors threatening wild and cultivated plant diversity. To achieve the aims of the 1992 Convention on Biological Diversity for 2010, developing methods for monitoring temporal and quantitative variations in biodiversity is needed (Balmford *et al.*, 2005; Keisa *et al.,* 2007). Lack of simple and effective techniques for quantifying genetic erosion has restricted the efficiency of conservation innovations (Keisa *et al.*, 2007). In general, assessment methods for genetic erosion are divided in two groups: direct and indirect methods (Maxted and Guarino, 2006). Most studies have focused on estimating the degree of genetic erosion of crop species of high economic value or their wild relatives. Precise identification of factors and the quantitative measurement of their contribution in the process of genetic erosion in target areas would provide key information for the development of in situ as well as ex situ conservation strategies (de Oliveira and Martins, 2002).

Dahl and Nabhan (1992) studied factors threatening the genetic diversity of cultivated crops, global environmental changes and associated problems for agricultural crops. They prepared a list of threats and advocated for its application as an assessment tool. The list is also applicable to the assessment of jeopardies due to erosion (Majnounian, 2000). The methodology of Guarino (1995) provides an operational tool for indirect assessment of genetic erosion. De Oliveira and Martins (2002) applied the method successfully for the assessment of genetic erosion in ipecac (*Psychotria ipecacuanha*) a tropical medicinal plant species. They concluded that this method, with minor modifications, could be broadly used for conservation of plant species. This, along with the potential capacity for the spatial resolution of differences in threats of genetic erosion, renders the method of Guarino (1995) as a useful alternative for assessing the genetic erosion of wild and previously little studied plant species.

The objectives of the present study are to investigate biodiversity variation and genetic erosion of plant species in Basht County and to determine the factors affecting biodiversity of the area.

Materials and Methods

Study area

The study was conducted in 2008 in two areas in Gachsaran, Southwest Iran (Khamin mountainous protected area and Bavi (Babui) hilly-plain area), as two different ecogeographical locations (Figure 1). For this purpose, 5 and 6 villages were selected randomly in Khamin and Bavi, respectively. In Khamin, small villages are distributed along hillsides and there are lots of abandoned homes and villages due to intensive emigration during the last decades. In contrast, the villages in Bavi area were more developed due to their proximity to urban centers and being provided by social infrastructures. The demographic and geographic characteristics of the studied area are shown in Table 1.

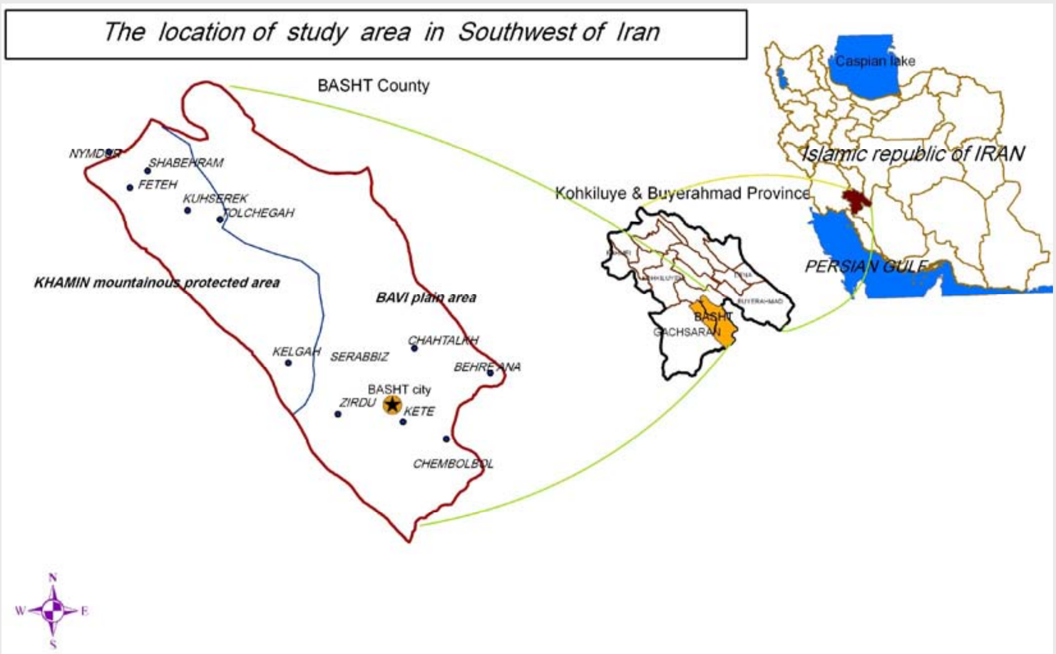

Figure 1. Distribution of villages studied in two areas of Gachsaran, Southwestern Iran.

Table 1. Demographic and geographic characteristics of the studied area.

Area	Village	Altitude (m)	Latitude/ Longitude	Distance to nearest city (km)	Number of households
Khamin protected area	Nimdur	985	30°36' N/50°49' E	45	12
	Fath	1190	30°34' N/50°51' E	44	26
	Shabahram	915	30°35' N/50°52' E	42	49
	Kuhsarak	1040	30°33' N/50°55' E	34	15
	Kalgah	1020	30°23' N/51°02' E	15	15
Bavi plain- hilly area	Sarabbiz	890	30°23' N/51°02' E	12	150
	Kateh	788	30°20' N/51°10' E	5	71
	Zirdu	823	30°18' N/51°05' E	15	15
	Chembolbol	750	30°19' N/51°14' E	12	41
	Bahrey Ana	804	30°23' N/51°16' E	25	147
	Chahtalkh	945	30°24' N/51°11' E	27	86

Assessment of threat of biodiversity erosion

In this study, a modified version of Guarino`s model (1995) was used for assessment of the threat of agrobiodiversity erosion. At first, a checklist of 23 factors of threat assessment was provided. Each factor received scores ranging between 0 (the least risk) and 10 (maximum risk). Each factor was awarded a score according to the calculated data and information (Hashemi Shadegan, 2009). Information sources were direct observation, local informants and related organizations (local Departments of Health, Agriculture and Natural Resources). Survey factors were related to threats encountered to wild and cultivated plants and considered at regional landscape level as well as that of plant societies. Factors were extracted from former studies (Goodrich, 1987; Guarino, 1995; de Oliveira and Martins, 2002) and optimized according to the study area. The magnitude of the agrobiodiversity erosion threat was calculated by summing the different scores up and threat levels were compared between villages.

Data Analysis

The erosion threat for plant agrobiodiversity was calculated by summing the scores of different factors. Cluster analysis was done by SPSS 16 for grouping villages according to their linkage and the similarity of villages' scores. The data were analyzed using Excel software. In each cluster, the percentage of relative contribution of factors to the erosion threat, both in total and in each cluster, and the relative contribution of factors to the divergence of results in clustering were calculated.

Results

Results for the threat scores in the studied area are presented in Table 2. Threat levels were not similar between villages and villages in the protected area encountered less threat. In order to clarify the comparison among threat levels, Nymdur village in Khamin, which had the lowest threat score, was selected as the base of comparisons with score value of 1, and the threat scores of other villages were compared accordingly. Afterwards, the most threatened villages (Sarabbiz and Kateh in Bavi area) showed a 95% higher threat than Nymdur. Based on village distance from the urban centre (Basht), there was a negative correlation between distance to the urban centre and threat to biodiversity (Figure 2).

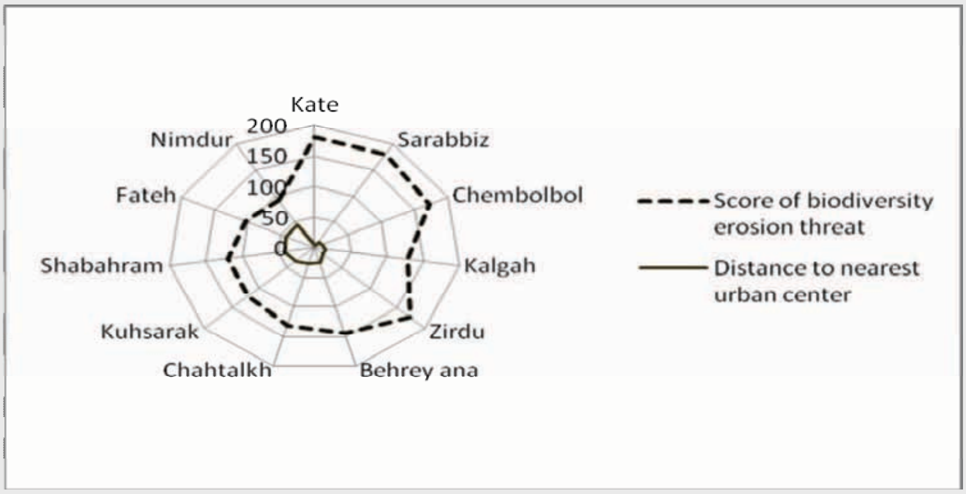

Figure 2. Relationship between distance from urban center and score of risk of biodiversity erosion.

A dendrogram was generated from individual pairwise comparisons of the scores attributed to 23 risk factors among 11 study areas (Figure 3). Cluster analysis divided the study areas into two major subdivisions (denominated group A and group B). In group A, four plain-hilly villages (Zirdu, Chembolbol, Kateh and Sarabbiz) were situated which were the villages nearest to Basht. Two other Bavi villages along with all mountainous villages were in group B. The average risk values for villages in groups A and B were 175.8 and 120.1, respectively. Furthermore, the relative rate for each of the 23 risk factors was calculated for agrobiodiversity erosion in the villages (Table 3). The results showed a high variation in the factors' contribution to risk.

Factors' contribution to explaining variations in overall threat of biodiversity erosion

Three factors, i.e. temporal trend of agrochemical application, weed management techniques and acreage of field receiving agrochemicals, had the highest relative contributions to total variation and, together, comprised 20.93% of total variation (Table 3). In contrast three factors, namely flood frequency, incidental fires frequency and acreage of agricultural land in the area, had the least relative contribution in agrobiodiversity erosion and, together, contributed only 3.89% of total agrobiodiversity risk scores.

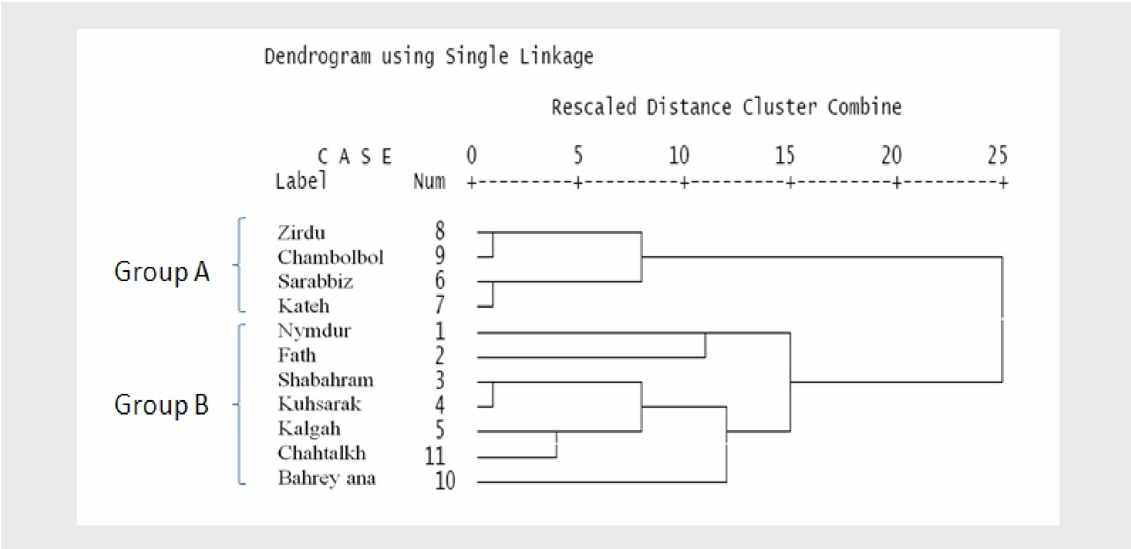

Figure 3. Dendrogram obtained using cluster analysis due to similarity of scores of biodiversity threat.

Table 2. Assessment of threat of biodiversity erosion in study area using the model.

Area	Village	Threat	Threat relative to base
Khamin protected area	Nimdur	92.48	1
	Fath	104.14	1.13
	Shabahram	119.98	1.3
	Kuhsarak	119.98	1.3
	Kalgah	128.32	1.39
Bavi plain-hilly area	Sarabbiz	180	1.95
	Kateh	180	1.95
	Zirdu	171.66	1.86
	Chembolbol	171.66	1.86
	Bahrey Ana	144.15	1.56
	Chahtalkh	131.66	1.42

Factor contribution to explaining threat scores in Group A

Results of calculating the factors' relative contribution in explaining biodiversity erosion in group A revealed that the dominant factors (mentioned in the previous section) made less maximum contributions and 9 other factors, each with the same 5.96% relative contributions, explained 51.2% of total variations. These factors were the extent of habitat species use within the area, distance of the area from major population centers, distance of the area from major roads, distance of the area from developmental projects, extent of agrochemical application, changing use of agrochemicals, extent of use of agricultural machineries, weeding technique and extent of agricultural extension services in support of new cultivars. Frequency of incidental fires in the area had the least score and flood frequency in the area had a very slight contribution suggesting that natural risk factors made the lowest contributions to biodiversity erosion.

Table 3. Relative contribution of 23 risk factors to plant agrobiodiversity in 11 study villages in Gachsaran. Groups A and B were two subdivisions in the hierarchical cluster analysis.

Factor	Threat score	Relative contribution in threat (Total) (percent)	Relative contribution in group A	Relative contribution in group B	Relative contribution in divergence
Extent of exploitation of habitat species	66.64	4.32	5.69	3.17	9.27
Changes in habitat type over past 20 years	95	6.15	4.98	7.14	0.27
Availability of agricultural territories in the area	82.5	5.34	5.33	5.35	4.42
Extent of agricultural land in the area	25	1.62	2.13	1.19	3.47
Agricultural pressure from surrounding areas on the area	95	6.15	5.33	6.84	1.74
Distance of area from major population centre	60	3.88	5.69	2.38	10.69
Distance of area from major roads	90	5.83	5.69	5.95	4.28
Distance of area from developmental projects	60	3.88	5.69	2.38	10.69
Human population growth within the area	30	1.94	2.84	1.19	5.35

Factor	Threat score	Relative contribution in threat (Total) (percent)	Relative contribution in group A	Relative contribution in group B	Relative contribution in divergence
Frequency of drought	55	3.56	2.84	4.16	0
Frequency of incidental fires	25	1.62	0.0	2.97	5.35
Frequency of flooding	10	0.65	1.42	0.0	3.74
Changes in grazing pressure	45	2.91	2.13	3.57	0.79
Present grazing pressure	86.62	5.61	5.21	5.94	3.04
Extent of chemical inputs application	103.32	6.69	5.69	7.53	1.42
Changes in chemical inputs application	110	7.12	5.69	8.33	0.0
Territory under house building and road construction	55	3.56	4.26	2.97	5.88
Changes in territory under house building and road construction	65	4.21	2.84	5.35	2.14
Proportion of irrigated against rain-fed agricultural territories	35	2.27	4.26	0.59	10.17
Extent of use of tractor and other agricultural machineries	86.65	5.61	5.69	5.55	4.99
Weeding technique	110	7.12	5.69	8.33	0.0
Extent of use of new cultivars	56.64	3.67	5.21	2.38	9.45
Extent of agricultural extension services (AES) in support of new cultivars	96.65	6.26	5.69	6.74	2.86

Factors' contribution to explaining threat scores in Group B

Results for consideration of risk factors for agrobiodiversity in this group indicated that two factors, changes in agrochemicals application and weeding technique, with an identical share of 8.33%, along with change in habitat type over the last 20 years and extent of use of agrochemicals with share of 7.14 and 7.53%, respectively, explained 31.33% of total value and were the most important risk factors.

Factors' contribution to explaining divergence

Divergence in this study refers to the absolute value of differences of the standardized threat amounts of two groups which is presented as a percentage in Table 3. Comparison of the relative contribution of factors in divergence showed that five factors, including distance from major population centers (urban centers) at 10.69, distance from developmental projects at 10.69, ratio of irrigated to rainfed systems at 10.17 and extent of the use of new cultivars at 9.27% caused the most variation and divergence between two groups and explained 50.27% of total divergence between the groups. On the other hand, four factors including weeding technique, changes in agrochemical application, drought frequency in the area and change in habitat type over the last 20 years displayed only the slight amount of 0.27% in total divergence between two groups.

Discussion

Results of the present study showed the considerable effect of distance from urban centers on the risk value of biodiversity erosion. Regression results confirmed this trend with a high explanation coefficient (r^2 = 0.84). The villages farthest from and nearest to Basht (Nimdur in Khamin and Kateh and Sarabbiz in Bavi, respectively) had the minimum and maximum values for erosion risk. Subsequently, factors such as distance from developmental projects, extent of habitat species exploitation within the area, extent of use of agrochemicals and extent of use of agricultural machinery play rather important roles in threatening the agrobiodiversity of studied areas. Furthermore, since the use of agrochemicals, acreage that received these inputs and application of modern techniques of weeding have increased in the studied area, it could be concluded that human activities are main factors in genetic erosion threats, whereas natural factors (such as flooding and incidental fires frequencies) as well as traditional agricultural and social practices and the availability of agricultural territories in the area caused the least effects on risk of biodiversity.

Hammer *et al.*, (1996) in their assessment of genetic erosion for landraces of some crop species in Italy and Albania, cited changes in farming systems and the introduction of exotic varieties as major drivers. Willemen *et al.*, (2007), in a study of the spatial patterns of genetic erosion in cassava landraces reported more erosion of cassava landraces in plains which had more accessibility to the market in contrast to an area with a hilly topography. Thapa and Rasul (2005), in a study of the patterns and determinants of farming systems in three categories including extensive, semi-extensive and intensive found that distance from market and service centers were determinants in orientation towards intensity. Tsegaye and Berg (2007) in a study in central Ethiopia, cited proximity to city and markets as a cause of the market-based and economic orientation of farmers and also a shrinkage in the cultivation of landraces of tetraploid wheat and replacement of other new marketable crops. Mitke (1999) and Bechere *et al.*, (2000), cited theroduction of improved new varieties as a major factor in the disappearance of landraces of tetraploid wheat.

The model presented here, however, seems to have a fundamental deficiency due to the lack of proper attention paid to survival of rural communities which are traditional agrobiodiversity centers. Although conservation of traditional lifestyles and also landraces is more secure in protected areas, but survival of rural communities has to be seriously considered, as even standards of the UN Convention on Biological

Diversity and the International Union for Conservation of Nature have recognized and emphasized the importance of the survival of traditional lifestyles and farming livelihoods in protected areas (McNeely, 1996). This model has exhibited appropriately the effect of proximity to urban centers and human populations on increasing the risk of erosion of agrobiodiversity. This deficiency seems to be considered in gap analysis in designation of protected areas.

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