Rangeland degradation assessment: a new strategy based on indigenous ecological knowledge of pastoralists

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Abstract

In the changing world, the prevalence of land degradation is becoming a serious problem worldwide especially in countries with arid and semiarid rangelands. There are many techniques to assess rangeland degradation but most of them rely on classic science. So a study was conducted to find out how indigenous people assess rangeland degradation and how their ecological knowledge can be used for rangeland degradation assessment. We interviewed pastoralists of two sites (Mirza-Baylu and Dasht) where part of both areas is located in Golestan National Park (NE Iran). A structured questionnaire was designed based on some indicators taken from literature and also primary discussions with pastoralists in order to evaluate land degradation. A qualitative Likert scale was used for scoring rangeland degradation indicators. The results revealed that pastoralist pay first attention to edaphic indicators than vegetative and other indicators. There were significant differences between inside and outside of the park in rangeland degradation indicators for both sites. The results show that the rangelands outside the park in both sites were degraded compare to inside the

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park especially in the areas near to villages. It can be concluded that pastoralists own a vast amount of knowledge on the vegetation and grazing animal habits that can be used in rangeland degradation assessment and it is necessary to document their ecological indigenous knowledge and involve them in rangeland degradation assessment process.

1 Introduction

Rangelands are the vastest terrestrial ecosystems on the earth, covering close to 40% of the world landscape, of which more than 80% located in arid and semiarid zones. Soil is the most important component of rangeland ecosystems that has an interdisciplinary nature and is associated with biodiversity, biogeochemical cycling, hydrology, human health and social sciences (Brevik et al., 2015). Rangeland soils moreover offer services to the human societies and makes the Earth System stable (Keesstra et al., 2012; Berendse et al., 2012). Unfortunately, rangelands have undergone (and continue to undergo) rapid transformations as a result of factors such as overgrazing, deforestation, woody-plant encroachment, and invasion by non-native plant species (Wilcox and Thurow, 2006). Each of these factors has led to the reduction in the quantity or nutritional quality of the vegetation available for grazing that called rangeland degradation. And this resulted also in higher soil and water losses (Cerdà, 1998; Kröpfl et al., 2013; Li et al., 2013) .

It is believed that livestock grazing is associated with rangeland degradation. Grazing is the most important factor affecting vegetation and soil in all rangelands of the world, having critical impacts on the rangeland biodiversity and species composition (Sharafatmandrad et al., 2014; Angassa, 2014), biological groups (Sharafatmandrad et al., 2014; Tarhouni et al., In press), structure (Eckert and Spencer, 1987; Noy-Meir, 1979, 1993; Walker and Noy-Meir, 1982), goods and services (Papanastasis et al., 2015), function (White, 1979; Sousa, 1984; Hobbs and Huenneke, 1992), soil erosion (Tadesse and Penden, 2002; Palacio et al., 2014; Mekuria and Aynekulu, 2013), nutrient cycling (Frank et al., 1998; Ritchie and Tilman, 1995; Fernandez et al., 2008) and hydrological processes (Cerdà and Lavee, 1999; Hiernaux et al., 1999; Sharafatmandrad et al., 2010). However, there are evidences that grazing management activities, not grazing, is the main cause of rangeland degradation in arid and semi-arid environments (Gulelat, 2002). Pastoralism is a traditional range management activity, which focuses mostly on the natural forage rather than cultivated fodder (Sandford, 1983). Pastoralists usually own a vast amount of knowledge on their grazing lands, attained through

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long experiences and observations in herding practices (Oba and Kotile, 2001; Mapinduzi et al., 2003). To combat rangeland degradation, it is recommended that rangeland management systems integrate community perceptions and practices (Khwarae, 2006). Thus, the indigenous knowledge of the local communities can be used in conjunction with technical knowledge to manage natural resources (Khwarae, 2006). In many developing countries where rangelands are a dominant land type and critically important in livelihoods of a significant portion of the population, severe rangeland degradation can create significant social, economic, and environmental problems (Bedunah and Angerer, 2012). So scientific and indigenous knowledge should be integrated so that local communities be able to realize their capacity for monitoring and responding to the land degradation and environmental changes (Stringer and Reed 2007). The resulting system for environmental management would improve the communities' livelihood and decrease rangeland degradation at the same time (Khwarae, 2006). That is interesting that pastoralists and ecologists are unanimous on most of the rangeland degradation indicators.

If we want rangeland degradation indicators to be applicable in land management, they must then be easy to use by local communities, accurate to assess environmental sustainability and result in conservation (Reed et al., 2008). In the other hand, the involvement of the pastoralists in planning and implementing land conservation programs require conservationists and technicians to be aware of environmental indicators used by pastoralists for assessing rangeland degradation. There are too many studies that conveying combination of local and scientific ecological knowledge may contribute to easy and accurate monitoring and management of natural resource changes by local communities (e.g., Folke et al., 2002; Thomas and Twyman, 2004; Fraser et al., 2006; Reed et al., 2007; 2008).

Bottom-up or local participation approaches implicate that pastoralists have accumulated a wealth of knowledge over time, based on long-term experiences that can complement scientific knowledge in environmental assessment and conservation (Richards, 1980). Recently it has become known that indigenous knowledge and local management play an important role in natural resource conservation (Warren, 1992; Berkes et al., 2000) and combat land degradation. Additionally, there is growing interest on how indigenous ecological knowledge and management practices can be used in collaboration with standard scientific methods for improved understanding of the environment and its changes (Dahlberg, 2000; Reed et al., 2007).

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The history of pastoralism in Iran goes back to several thousand years ago, but indigenous ecological knowledge of pastoralism is neglected in most studies related to the rangelands. So our main objective was to evaluate pastoralism' knowledge of rangeland degradation assessment, based on their perceptions and experiences. Our research questions were as fallow:

a) what are the pastoralist' land evaluation criteria?

b) what indicators do the pastoralists use for degradation assessment? and

c) is there a possibility to combine scientific land degradation indicators with the pastoralists one to assess rangeland degradation?

2 Materials and Methods

2.1 Study area

The sites used for this study are parts of Golestan National Park located in Golestan Province in North-eastern Iran (37.31N-53.04E to 37.17N-55.43E). The park was established in 1957 as the first National Park and Biosphere Reserve of the Middle East. Golestan National Park spans an area of 87,242 hectares, comprising Caspian forests, steppe rangelands and the Juniper woodlands. The two rangeland sites selected for this study were Mirza-Baylu (37°19′29"– 37°21′35"N and 56°13′56"–56°19′20"E; 1248–1310 m asl) and Dasht (37°18′12"–37°19′37"N and 56°13′–56°1′33"E; 993–1058 m asl). In each site, under grazing parts outside the park are separated from the exclosure parts inside the park by a narrow road (Fig 1).

The Mirza-Baylu site is located at the eastern the park and is mostly flat, with slopes less than 5%, and some hilly lands occur just in a few parts. In this site, outside the Park, there is a village known Robat-e Qarebil, 5 km away from the Mirza-Baylu site. The mean annual temperature is 12.9 °C .The study site receives about 236 mm of annual precipitation. The site is dominated by relatively pure stands of the dwarf shrub Artemisia sieberi accompanied by some grasses. There are some saline parts in the site that are mostly occupied by halophytes such as Salsola dendroides, Phragmites australis, Suaeda physophora and Anabasis aphylla. Also some rare species can be seen in the plains (e.g. Diaphanoptera stenocalycina).

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The Dasht site is located in the southern part of the Golestan National Park. Most of the site is hilly but there are also a few flat areas. The mean annual precipitation and the mean annual temperatures are 191 mm and 11°C respectively. The vegetation of this semi-steppe rangeland is consisting of grasses and shrubs, dominated by grasses Bromus danthonia, Festuca ovina, Eremopyrum bonaepartis and Phleum paniculatum and dwarf shrubs Acantholimon pterostegium and Artemisia kopedaghensis.

Regarding to grazing, inside the park is only grazed by wildlife but outside the park is grazed by the pastoralists herds consist of sheep and a few goats from early morning till afternoon. The herds are in their own fields all the seasons specified by the Department of Natural Resources. Dry forages and agricultural residuals (straw and hay) are used as winter forage for livestock in the both study sites.

2.2 Land degradation assessment

2.2.1 Selection of indicators

The pastoralists' first encounter is generally plagued by suspicion and fear because of government regulatory restrictions on rangeland use. As a first step, we tried to build a foundation of trust by connecting with educated ones, volunteering our personal information, showing interest in the pastoralism and lifestyle that were completely effective. The pastoralists have been then informed how important their indigenous knowledge is and no research in the region will be fulfilled without their viewpoints and help. So we go through the explaining the research and its objectives and make sure that the pastoralists are convinced how effective would be the results in their profession, economic status, rangelands health assessment and management.

Descriptive research was used to obtain information. So data were collected using both the documentary and field survey. By being present between the pastoralists, we have tried to gather data through participation and using Focus Group Discussion (FGD) technique, directive interviews and the narrative threads of the key figures and experienced persons. Through meetings and individual and group interviews, pastoralists were asked about ecological knowledge on rangeland degradation indicators and assessment. The most important part of the study was to discuss with interviewees about the importance of the

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pastoralist ecological knowledge on recognition of rangeland degradation and its assessment. To understand how pastoralists assess degradation at landscape level, the key questions were: What are the pastoralist' land evaluation criteria, what indicators did the pastoralists use for degradation assessment, and what are the roles of the degradation assessment in rangeland health assessment and restoration?

To understand pastoralists' perceptions of land degradation and its influence on rangeland conservation, the questions posed were: What do pastoralists think of a "good" or "bad" rangeland, and what indicators do the pastoralists use as signs of rangeland change from "good" to "bad", for the purposes of rangeland health and management? (Roba, 2008). The results of meetings and interviews were used to identify indicators related to rangeland degradation.

The indicators taken from the literature were discussed in the pastoralists' interviews with their own language and terminology so that they could understand the exact concept of the indicators. As it was expected, most of them had the same indicators as taken from literatures but with their own language. So the duplicates were remove and the new ones were added to the list. A structured questionnaire was designed based on the identified indicators to obtain data on rangeland degradation according to the Land Degradation Assessment in Drylands (LADA, 2009). So the indicators were assessed on a 5-point Likert-type scale ranging from very poor (0-20) to very good (80-100). Qualitative scale was used because of being more intuitive and easier to understand for pastoralists but it was necessary to convert it to a quantitative scale to compare inside and outside the park.

2.2.2 Field assessment

For the Mirza-Baylu site, 28 8-m2 quadrats were randomly located throughout the region, 12 quadrats inside and 16 quadrats outside the Park. For the Dasht site, 22 8-m2 quadrats were randomly located throughout the region, 15 quadrats inside and 18 quadrats outside the Park. Each quadrats was assessed by the 3 selected pastoralists (i.e. there were 3 replications). In total, 84 and 99 questionnaires were respectively filled for the Mirza-Baylu (36 inside and 48 outside the Park) and Dasht (45 inside and 54 outside the Park) sites. So the pastoralists were ranked the rangeland degradation indicators in each quadrats.

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2.3 Data analyses

Each pastoralist was considered as a replication. The mean scores for each indicator was calculated and used to compare inside and outside the park. Comparisons were based on quantitative scale. Two-sample t-tests were used for each site separately to determine if degradation indicators differed between two sites pastoralists. Indicators with significant differences were then compared for both sites as total to see if there is any differences between inside and outside the park. Statistical Package for the Social Sciences (SPSS, Version 18) was used for data analysis.

3 Results

Based on literature and indigenous ecological knowledge of pastoralists, 18 degradation indicators were identified and used for questionnaires preparation (Table 1). From 18 indicators, 56% were classified as vegetative indicators, 33% as edaphic indicators and 11% as other indicators (i.e. indicators related to different aspects of rangelands apart from vegetation and soil).

Regarding the Likert scale, plots in Mirza-Baylu site had higher mean scores inside the park (3.249) than outside the park (3.026). According to pastoralists' assessment, vegetation indicators including of "decrease of vegetation productivity", "loss of phytodiversity", "removal of palatable plants", "decrease of ground cover" and "loss of litter mass" had higher scores inside the park while the soil indicators excepting "increase in bare soil" had lower scores inside the park (Table 2).

In the Dasht site, total mean scores of indicators inside and outside the park were 3.318 and 2.899 respectively. The indicators with the most different scores inside and outside the park were "increase in bare soil", "loss of phytodiversity", "removal of palatable plants", and "loss of litter mass". However, the rangeland is in better condition inside the park. Although "decrease of vegetation productivity" was evaluated as a significant indicator but there was no much differences between inside and outside the park. "decrease of vegetation productivity" had higher score inside the Park. Some indicators including "increase in soil looseness" and "decrease of soil sandiness" were given little importance in this site (Table 2).

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Soil and vegetation were fundamental to indigenous ecological knowledge of pastoralists on rangeland degradation assessment. Rangeland degradation was firstly described in terms of

vegetation indicators by pastoralists. In the areas with high grazing pressure and lower productivity potential presumed to have more annual plants than perennial forage plants, accordingly indicators “increase in annual plants” and “decrease of shrubs” had higher and lower scores in Mirza-Baylu site inside the park respectively. Pastoralists believed that in the areas with high productivity potential, forage plants are diverse which itself increases palatability. So livestock can find various types of forage. The soil looseness was test by pastoralists through being soil crusts held between the index finger and thumb. They believed that soil of the rangelands in good condition breaks more easily. Muddy soils occur in the some parts of rangelands with low productivity potential where infiltration rate is low and soil becomes waterlogged. These areas are not suitable for the pastoral settlement in wet season. In the Mirza-Baylu site, there are large areas of inter-patches scattered on some hills mostly outside the park that is sign of pests (kind of mouse), feeding on the plants roots and making several holes on the soil surface.

Of the 18 indicators in the questionnaire, there were significant differences between inside and outside the park for 7 indicators (38%) and 6 indicators (33%) in the Mirza-Baylu and Dasht sites respectively. “Decrease of ground cover”, “increase in the distance between plants” and “loss of litter mass” were the most sensitive indicators in the Mirza-Baylu site while “increase in bare soil”, “loss of phytodiversity” and “removal of palatable plants” were considered as the best indicators in the Dasht site (Table 3). Moreover, pastoralists of the both sites ranked “increase in bare soil”, “loss of litter mass” and “increase in the distance between plants” as good indicators for assessing and evaluating degradation of their own rangelands.

4 Discussion

Pastoralist's indigenous ecological knowledge on rangeland management is the result of their historical environmental management over time (Fernandez-Gimenez, 2000). As is generally known, local knowledge is a rich source of information about land degradation, environmental sustainability, and their indicators. Local ecological knowledge of pastoralists has the capability to be used for the natural resources management. This capability will substantially increase if it is linked with a more general scientific understanding (Reed et al., 2008). The current research tried to integrate indigenous ecological knowledge on rangeland degradation with scientific ecological methods. This research shows that pastoralists can realize the biophysical changes in the rangeland ecosystems caused by livestock grazing and climate changes. Looking more closely into the indicators list, it can be understood that

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pastoralists focus more on the soil indicators than the vegetation and other indicators as the signs of degradation. Therefore they were preferring these indicators for degradation assessment of their own rangelands during the discussions and interviews (Oba, 2012 and Reed et al., 2008).

In the present study, in the Mirza-Baylu site, before field assessments and during discussions and interviews, pastoralists believed that there is not obvious difference between inside and outside the Park. They believed that to some extents outside the park has better condition and less degradation. They believed livestock grazing makes the plants to grow faster and leads to more vegetation diversity, freshness and palatability. In contrast, after field assessments, they had evaluated inside the park to have better condition than outside the park based on given scores to the indicators. It shows the difference between holistic and detailed assessments of pastoralists based on the indicators scoring in this site. This can be studied more deeply in further researches.

Pastoralists of the Dasht site believed that increased risk of wildfires is a sign of upward trend in the rangeland condition and indicate the increase in vegetation cover. In fact, pastoralists focus more on ecologic aspect of wildfires.

Based on the results in both sites, the rangelands outside the park especially the areas around the villages were degraded in comparison to inside the Park. Pastoralists pay first attention to soil indicators in assessing rangeland degradation. During the discussion with pastoralists, it was obvious that they are not seeing indicators related to livestock and their emphasis was given to vegetation, soil and other indicators. So this gap can be clearly seen in the indicators list. All pastoralists must be involved in the planning and managing strategies with full participation, they have the most knowledge on the livestock grazing habits and vegetation of their environment and rangelands (Abate et al., 2010). Indigenous knowledge can provide possibility of rapid assessment of rangeland condition (Oba, 2012). Range scientists become more familiar with indigenous knowledge, its concepts and functions (Mapinduzi et al., 2003).

Generally, there are different approaches for assessing land degradation worldwide. There is no single best method to assess land degradation. Many researchers and scientists emphasize that land degradation assessment can be complex because more than one type of degradation may occur in any one place. Therefore, complexity makes it impossible to use the same tools, techniques and methods for assessing different types of degradation. Many methods have

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been improved and justified to gather as much useful data as possible. However, development of any method requires people with good understanding of ecosystems and socio-economic drivers of land degradation. Developing and using simple but yet robust methods (e.g. classes of 0-5, very good to bad; simple indicators) are good because they can be easily adapted and used even by non-experts (Kapalanga, 2008). This helps in comparing areas, involves stakeholders as much as possible, and aids in land use and restoration planning and projects prioritizing (Kapalanga, 2008).

5 Conclusions

The traditional knowledge of local pastoralists in the both study sites was useful and important in the management of rangeland resources. Pastoralists have a wealth of interests for emphasizing on their own indicators to be more practical for the rangeland assessments. The pastoralists have a broad knowledge base covering materials from rangelands vegetation and animal habits to land characteristics. Controlling degradation in grazing lands without considering the people who have a substantial role in that will be imperfect. So matching the scientific land degradation indicators with the ones pastoralists are believed in and understand, can lead to the successfully control of land degradation. Involvement of pastoralists and documenting their knowledge on rangelands can provide useful bases for the sustainable utilization and conservation of natural rangelands. It is believed that such plans that are based on indigenous knowledge can be easily accepted by local people.

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Table 1. Identified rangeland degradation indicators based on literature and indigenous ecological knowledge. Indicators related to each category is shown with a check mark.

Attributes	Indicators	Literature	Mirza-Baylu Pastoralists	Dasht Pastoralists
Vegetation	Decrease of vegetation productivity	√	√	√
	Loss of phytodiversity	√		√
	Removal of palatable plants	√		√
	Increase in poisonous plants	√	√	√
	Decrease of shrubs	√		
	Increase in annual plants	√		
	Increase in the distance between plants	√		
	Decrease of plants height	√		
	Loss of litter mass	√		√
Soil	Soil salination	√	√	
	Decrease of ground cover	√	√	√
	Increase in bare soil	√	√	√
	Soil muddiness		√	
	Decrease of soil sandiness		√	
	Decrease of soil infiltration	√	√	√
	Increase in soil looseness		√	√
Other	Increased risk of wildfires			√
	Increased risk of pest damage		√	

Table2. Comparison of all identified rangeland degradation indicators between inside and outside the park for each site separately.

Indicators	Sites					
	Mirza-Baylu			Dasht		
	Inside the park	Outside the park	P	Inside the park	Outside the park	P
Decrease of vegetation productivity	3.35±0.64	3.24±0.75	0.85	3,44±1.036	2,64±0.69	0.04
Loss of biodiversity	3.22±0.56	3.15±0.91	0.58	3,51±0.92	2,55±0.73	0.009
Removal of palatable plants	3.26±0.7	3.28±0.92	0.64	3,55±1.06	2,57±0.66	0.02
Increase in poisonous plants	3.35±1.32	4.42±0.81	0.02	4,35±0.51	4,55±0.24	0.38
Decrease of shrubs	2.99±0.79	3.39±0.86	0.1	2,66±0.56	2,52±0.58	0.58
Increase in annual plants	2.99±0.77	2.24±0.77	0.02	3,11±1.47	2,59±0.69	0.63
Decrease of ground cover	3.55±0.53	2.71±0.79	0.003	2,79±1.25	2,15±0.74	0.19
Increase in the distance between plants	3.59±0.52	2.86±0.72	0.005	3,44±0.95	2,68±0.47	0.03
Soil salination	4.35±0.23	4.62±0.57	0.02	4,19±0.88	4,73±0.40	0.06
Loss of litter mass	2.97±0.73	2.17±0.85	0.008	3,27±1.21	2,33±0.76	0.03
Increase in bare soil	3.95±0.71	3.24±0.77	0.01	3,86±1.05	2,796±0.69	0.007
Soil muddiness	3.57±1.01	3.84±0.89	0.5	3,14±1.04	2,68±1.20	0.31
Decrease of plants height	2.89±0.37	2.84±0.63	0.76	3,15±0.74	2,73±0.44	0.08
Decrease of soil sandiness	2.53±1.38	2.51±1.21	0.85	3,13±0.95	3,04±0.94	0.82
Decrease of soil infiltration	3.71±0.56	3.42±0.73	0.32	3,13±1.05	3,02±1.01	0.56
Increase in soil looseness	2.19±0.84	2.29±0.78	0.77	2,28±0.94	2,33±0.87	0.8
Increased risk of wildfires	2.17±0.59	1.08±0.15	2.58E-06	2,79±1.53	1,99±0.78	0.3
Increased risk of pest damage	4.08±0.26	4.15±0.99	0.17	3,66±0.59	3,93±0.54	0.22

Table3. Comparison of significant degradation indicators between inside and outside the park for both sites as total.

Indicators	Rank	CV inside the Park	CV outside the Park	p
Decrease of ground cover	1	0.003	0.29	0.15
Increase in the distance between plants	2	0.005	0.25	0.14
Loss of litter mass	3	0.008	0.39	0.24
Increase in bare soil	4	0.01	0.24	0.18
Soil salination	5	0.02	0.12	0.05
Increase in annual plants	6	0.02	0.34	0.26
Increase in poisonous plants	7	0.02	0.18	0.39
Increase in bare soil	1	0.007	0.25	0.27
Loss of biodiversity	2	0.009	0.28	0.26
Removal of palatable plants	3	0.02	0.25	0.29
Loss of litter mass	4	0.03	0.33	0.27
Increase in the distance between plants	5	0.03	0.18	0.27
Decrease of plant production	6	0.04	0.26	0.29

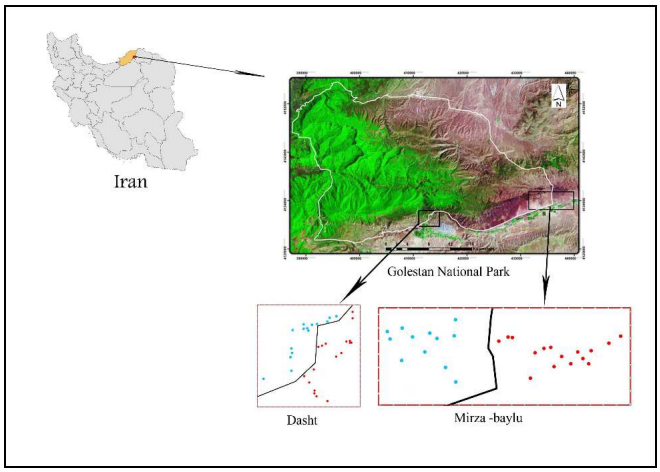

Figure 1. Map of study area in Golestan National Park, Golestan Province, Iran. Dasht site was located in the southern park and Mirza-baylu site was located in the eastern park. The points are sampling plots.