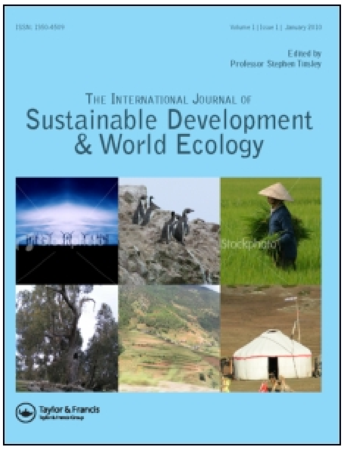

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Agriculture is the mainstay of rural populations, especially in the developing world. Increasing population and the demand for food, fodder and fuelwood have threatened the sustainability of the land resources. Without understanding farmers' perceptions on land-related issues, sustainable management of land resources is impossible because they have intimate knowledge of their land. Besides technical solutions to land-related problems, socio-economic appraisal also plays an important role for solutions to these problems. Therefore, the objectives of this article are to find farmers' perceptions on land degradation and to examine the socio-economic determinants of land degradation in the study area. In this study, a structured questionnaire was used to collect information on different socio-economic parameters affecting land degradation and farmers' perceptions on the status of land degradation in Pishin sub-basin, Pakistan. Farmers' perceptions are presented using simple descriptive statistics, whereas socio-economic determinants of land degradation in the study area were investigated using a binary logistic regression technique. The model predicted seven determinants of land degradation in the study area: household size, number of educated male members in the household, frequency of visits of extension workers, security of tenure, access to credit, cropping pattern and livestock population.

Keywords: socio-economic appraisal; farmers' perceptions; land degradation; binary logistic regression

Introduction

Land is a non-renewable natural resource (UNEP 2002; Niroula and Thapa 2005; Irshad et al. 2007). Each year 10 million hectares of the world's land become non-productive (Amin 2004) through human activities and natural factors. Land degradation, defined as the loss of potential or actual productivity or utility of land due to human-induced or natural factors (Eswaran et al. 2001), is a global ecological problem (Liu et al. 2003; Gisladottir and Stocking 2005; Luo et al. 2005; Salavati and Zitti 2005; Yang et al. 2005); severe land degradation causes desertification (Nianfeng et al. 1999; Luo et al. 2005).

The impacts of land and soil degradation have huge economic implications for developing countries (Maiangwa et al. 2007), for instance, impacts through food security for the growing population of the world (Scherr and Yadav 1996; Stocking and Murnaghan 2001; Shalaby and Tateishi 2007). The Millennium Ecosystem Assessment reported that 110 countries are affected by land degradation and desertification, and 80 of these are the world's poorest countries (MEA 2005). Land degradation affects nearly one-third (4 billion hectares) of the world's land area and more than 250 million people in developing countries (Peng et al. 2005; Adamo and Crews-Meyer 2006; Irshad et al. 2007). These adverse impacts appear in the form of increased landlessness, reduced and unreliable food supplies, increased labour requirements and reduced incomes (FAO 1994; Shalaby and Tateishi 2007). The degraded land forces the people either to cultivate marginal lands or to migrate to other areas (Irshad et al. 2007). According to Dumanski and Pieri (2000), instead of cultivating new lands for increased production, sustainable use of the present cultivable land is needed.

The driving forces of land degradation are biophysical, socio-economic (Lu et al. 2004, 2007; Danfeng et al. 2006; Rowntree and Fox 2008) and political (Eswaran et al. 2001; Boardman et al. 2003). Land degradation is not only an environmental issue but also a socio-economic problem (Liu et al. 2003; Qi and Cai 2007) and results from intricate relationships between nature and society at all scales (Qi and Cai 2007), thus indicating a key role of anthropogenic factors in causing land degradation (Thomas and Middleton 2004). The main causes of land and soil degradation are poor land husbandry and unsustainable agricultural practices (Hellin 2006). Natural degradation is balanced by natural processes, but anthropogenic processes of degradation make it difficult to rehabilitate naturally (Stocking and Murnaghan 2001). Hence, it is essential to understand the status and causes of land degradation (Taddses 2001), and such understanding will help in finding solutions to ameliorate it. Since local farmers and land users are the main actors, it is necessary to understand farmers' perceptions on causes and effects of land degradation (Hammad and Borresen 2006; Joshi et al. 2006) and its severity and impacts (Kessler and Stroosnijder 2005), especially in areas with a paucity of data for understanding the causative factors and farmers' willingness for adoption of conservation measures (Asrat et al. 2004; Hammad and Borresen 2006; Tiwari et al. 2008) and also for

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implementing government programmes and technologies in the degraded areas (Joshi et al. 2006).

The agriculture sector in Pakistan faces a number of land degradation problems (FAO/Regional office for Asia and the Pacific (RAPA) 1994). According to ESCAP (1995), the causes of land degradation in Pakistan, especially Balochistan, are deforestation, overgrazing and over-exploitation of vegetation. In almost 90% of the rangelands, livestock rearing is the mainstay of the rural population in Balochistan, and because of the tribal and communal land tenure system, rangeland resources are used free of cost, with no individual accountability. Similarly, deforestation in the past has exacerbated the land degradation and desertification. Most of the farmers cultivate rented lands; they do not pay attention to sustainable use of land and water resources and also lack collateral for loans to invest in agriculture. Repetitions of the same crops over the years and nutrient-exhaustive cropping patterns have caused the depletion of essential nutrients in the soils. The situation is that marginal lands are increasingly cultivated in order to feed the increasing population. Not only low literacy ratio is a hurdle in adopting improved conservation technologies, but also there is a lack of training programmes and farmers' organisations in the study area. Based on this premise, that the socio-economic conditions of the people greatly affect the land degradation process, it is important to understand the drivers and processes involved. Such information can help in finding solutions for the conservation of these land resources. The objectives of this article are, therefore, to find the farmers' perceptions about the status of land degradation and examine the socio-economic causal factors of land degradation in Pishin sub-basin, Pakistan.

Study area

The study area, Pishin-sub basin (29°10′–31°N, 66°14′–67°31′E), covers 7004 km^2 and is a part of Pishin Lora, one of the major basins in the northeast of Balochistan province, Pakistan. The study area is intermontane, bounded in the north by the Toba range, in the west by the Khwaja Amran range and in the southeast by the Mashelakh and Ajram Ghar ranges, and can be divided physiographically into mountain highland, piedmont plain and valley floor. Pishin lora is the main stream in the area, entering from the east and southeast extremities. The elevation of the area ranges from 1365 to 3137 m a.s.l. The climate is arid and semi-arid, warm in summer and very cold in winter. According to GoP (1998a), the monthly 30-year mean annual precipitation, maximum and minimum temperature and relative humidity are 260.75 mm, 24.42°C, 6.95°C and 46.91%, respectively.

Administratively, the Pishin sub-basin covers three districts, Pishin, Killa Abdullah and Quetta, with areas of about 2490, 3281 and 1233 km^2, respectively. According to GoP (1998b), the population of the sub-basin was 471,316. The two major tribes in Pishin sub-basin are the *Pashtoons* and the *Baloch*, who live in a joint-family system. It is common that decision-making authority lies with the father or senior male member of the family. Almost all females in the rural areas normally live inside their homes and are not allowed to take part in outside agricultural or trade activities. Females are strictly advised to cover their faces with veils when going outside their homes.

The reason for selecting Pishin-sub basin as the study area was that this sub-basin covers a wide area with different physiographic characteristics. It is also extremely stressed in terms of the use of land and water resources by the people of the area, demonstrating the anthropogenic factors involved in land degradation. The formation of rills and gullies through water erosion is common in areas with loose soils. Destruction of vegetation cover through fuelwood collection and severe overgrazing has further degraded the rangelands. The preference for apple orchards as a cash crop and rainfed wheat cultivation has led to development of monocropping, which is gradually undermining soil health through nutrient decline. Similarly, over-abstraction of ground water for orchard cultivation has led to depletion of the ground water table, decelerating the water recharge process.

Methods

Data collection

In this study, we used a structured questionnaire for interviews with farm households and field observation for collecting primary data. As no updated population statistics were available, the total number of households was estimated as 72,572, based on GoP (1998b). Using sample size estimation following Yamane (1967), with a precision level of 7%, a sample size of 200 households was determined as necessary for conducting the questionnaire survey. Initially, proportionate sampling was carried out to determine the number of households from each district, namely Pishin, Killa Abdullah and Quetta. At the second stage, a random sampling method was adopted to select sample households for the questionnaire survey. A structured questionnaire was administered to gather the required information from the sample households in the study area during the field survey between December 2008 and May 2009. The questionnaire was pre-tested and necessary corrections were made before conducting the field survey. The male heads of households were selected for interview because of their experience in the agricultural sector and their involvement in decision-making processes. As stated earlier, females are not allowed to take part in agricultural and trade activities and their man task is limited to that of housewives. Therefore, in view of such strict religious and cultural limitations, females were not interviewed.

Data analysis

The primary data gathered through questionnaire survey were analysed statistically using the computer software Statistical Package for Social Sciences (SPSS) version 15.

Percentages and frequencies were calculated to explain the farmers' perceptions on land degradation. A binary logistic regression model was used to find the socio-economic driving forces of land degradation. In this study, 13 socio-economic variables were used to identify the determinants of land degradation through regression analysis, as discussed below.

Model selection

Dichotomous phenomena (binary responses) can not be studied with ordinary regression as it violates several statistical assumptions (Hair et al. 1998). The binary response behaviour is explained generally using three models, linear probability model (LPM), logit and probit models (Sheikh et al. 2003). Discriminant analysis can also be used for such studies but requires more restrictive assumptions than logistic regression (Grimm and Yarnold 1995). The LPM is not bound between 0 and 1 and cannot be used for dichotomous dependent variables. However, the logit and probit models provide better options for binary responses, as the predicted probabilities under both these models always lie between 0 and 1 (Sheikh et al. 2003; Asrat et al. 2004).

Here, we chose a logistic regression model because of its advantages over probit models and mathematical simplicity that gives meaningful results (Asrat et al. 2004). It is useful for the effects of continuous, categorical and dummy independent variables on a dichotomous dependent variable (Tiwari et al. 2008). It is used for convenience in computation, direct interpretation in terms of the logarithm of odds and is based on cumulative logistic probability function. The logit model can be used for transferring dependent variables to predict probabilities between 0 and 1 (Sheikh et al. 2003). Besides the utility of the coefficient of variable (B) for testing the usefulness of predictors, odds ratio or Exp (B) is easier to interpret and represents the ratio change in the odds of degradation happening for a one-unit change in the predictor (Wahid et al. 2008). In this study, land degradation (LD) is considered as a dependent variable influenced by independent variables. In order to make the qualitative variable quantitative for fitting in the regression model, artificial variables with values of 1 and 0 are created, where 1 indicates the presence and 0 the absence of that attribute (Gujrati 2003). We assumed $LD = 1$ if land degradation exists, and 0 otherwise. The 13 independent variables hypothesised to affect land degradation are shown in Table 1.

Results and discussion

Basic information of the respondents

Table 2 summarizes the major socio-economic characteristics of the farm households in the study area. The majority of households (77%) were in the medium-size (6–10 persons) category; average age of the head of the household was 57.23 years; 63.43% of the population was illiterate. Respondents with primary, secondary or college/university education numbered 6.3%, 25.99% and 3.75%, respectively. The majority (53.39%) of households had marginal land holdings, followed by small (28.18%), medium (9.32%), large (6.7%) and very large (1.69%) holdings. The average livestock unit (LSU) was 16.15. Average farm income was larger than average off-farm and non-farm incomes (Table 2). Only 15% of households were visited by extension agents in a year. A total of 57.5% of households had full ownership of their lands; only 37.5% of surveyed households had access to credit sources. Regarding the cropping pattern, 82.5% of households practiced monocropping.

Farmers' perceptions of the status of land degradation

All the surveyed farm households possess some knowledge of land degradation problems, and 55% consider that land degradation exists. According to respondents, the major land degradation types in the area are soil erosion (33.4%), water degradation (33.4%) (aridification and lowering of ground water level) and vegetation degradation (32.9%) (reduced vegetation cover and proliferation of invasive species); while 2.1% considered salinization is also a problem, and 52% considered that the direct causes of land degradation are anthropogenic. The underlying causes of degradation perceived by the farmers were the growth of human and livestock populations. The results show that farmers were well aware of the direct and underlying causes of degradation. Moreover, they considered the severity of degradation in the area as low (6%), moderate (29.5%), high (8%) and very high (11.5%) (Figure 1).

Less than 25% of farmland area was perceived to be degraded according to more than half (56.36%) of the surveyed households. Similarly, 38.18% and 5.45% of respondents considered that 26–50% and 51–75% of their farmland area was degraded, no respondents thought there was >75% degradation. The farmers considered soil erosion differed between farmlands and non-farmlands. In farmlands, 50% thought there had been an increase in soil erosion, whereas 42% reported a decreasing trend of soil erosion, and 8% perceived no change in soil erosion. In non-farmlands, 56% of households reported increased soil erosion and the rest (44%) perceived no change in soil erosion. None of the farmers considered there had been a decrease of soil erosion on non-farmlands. The increased soil erosion on non-farmlands may be related to a lack of conservation measures used on non-farmlands (Figure 2).

Farm households were also asked about soil fertility on farmlands and non-farmlands. The survey showed that 44.5% households perceived an increase in soil fertility on their farmlands, while 49.5% thought that soil fertility was decreasing, and only 6% reported no change in soil fertility. In case of non-farmlands, 55.5% of households considered that soil fertility is decreasing, however 44.5% saw no change in soil fertility on non-farmlands. None of the farmers considered that soil fertility was increasing on

Table 1. Characteristics of independent variables selected for the regression model.

Description	Variable code	Variable type	Hypothesised relationship with land degradation
Household size	HHSIZE	Continuous	Positive
Age of household head	HHHAGE	Continuous	Negative
Number of educated males in the family	EDUMEMB	Continuous	Negative
Number of family members working on the farm	FAMLABR	Continuous	Negative
Landholding size	LHSIZE	Continuous	Positive
Livestock standard unit	LVSTKLSU	Continuous	Positive
Farm income (rupees per year)	FRMINCM	Continuous	Negative
Off-farm income (rupees per year)	OFRMINCM	Continuous	Positive
Non-farm income (rupees per year)	NONFINCM	Continuous	Positive
Frequency of visits by extension agents	EXTENVST	Continuous	Negative
Security of tenure	TENURSEC	Dummy, taking a value of 1 if the cultivated land is owned by the farmer, and 0 otherwise	Negative
Access to credit	CRDTACCES	Dummy, taking a value of 1 if farmers have access to credit, and 0 otherwise	Negative
Cropping pattern	CRPNGPTRN	Dummy, taking a value of 1 if the cropping pattern is monocropping, and 0 otherwise	Positive

Table 2. Summary of the major socio-economic characteristics of the respondents.

Variable	Category	Households (%)	Mean	Minimum	Maximum
Household size	0–5	5	–	–	–
	6–10	77			
	11–14	18			
Age of household head	–	–	57.23	39	68
No. educated males in family	Illiterate	63.43	–	–	–
	Primary	6.3			
	Secondary	25.99			
	College/University	3.75			
No. family workers on farm	–	–	3.45	1	5
Landholding (acres)	Marginal (0–25)	53.39	–	–	–
	Small (26–50)	28.18			
	Medium (51–75)	9.32			
	Large (76–150)	6.7			
	Very large (>150)	1.69			
Livestock standard unit (LSU)	–	–	16.15	1.76	35.35
Farm income (Pakistani Rs.)	–	–	2,051,905.0	50,000.0	10,040,000.0
Off-farm income (Pakistani Rs.)	–	–	191,082.4	10,800.0	300,000.0
Non-farm income (Pakistani Rs.)	–	–	212,045.5	96,000.0	550,000.0
Extension agent visits	Visited	15	–	–	–
	Not visited	85			
Security of tenure	Owned	57.5	–	–	–
	Rented	42.5			
Credit access	Yes	37.5	–	–	–
	No	62.5			
Cropping pattern	Monocropping	82.5	–	–	–
	Double cropping	17.5			

non-farmlands (Figure 3). The overall declining soil fertility in non-farmlands may be because these lands are under a free rangeland grazing system, where no specific conservation measures are practiced.

Socio-economic determinants of land degradation

Identification of the socio-economic characteristics of land degradation helps not only to better understand relationship between the socio-economic drivers and land degradation

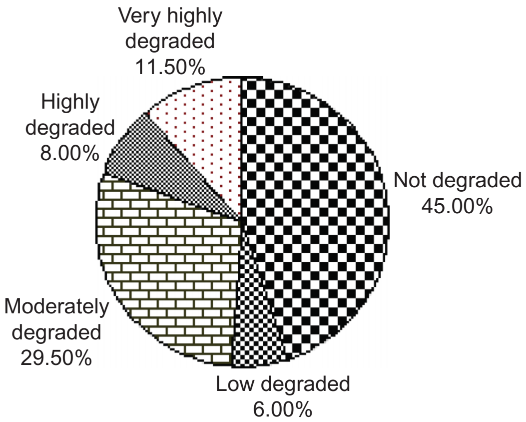

Figure 1. Farmers' perceptions of intensity of degradation in the area.

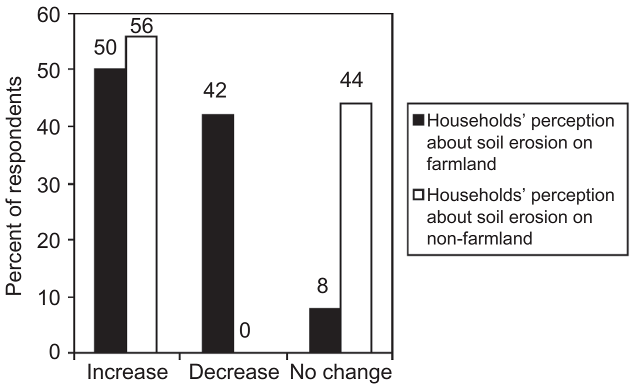

Figure 2. Farmers' perceptions on soil erosion trends in the study area.

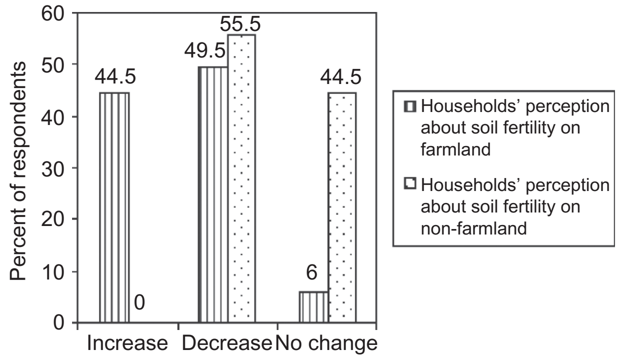

Figure 3. Farmers' perceptions of soil fertility trends in the study area.

but also helps to formulate better strategies for addressing the issues of land degradation. As described in the methods, 13 variables were analysed using logistic regression analysis to examine their relation with land degradation status. The overall measure of fitness of the model is given by the likelihood value (−2 log-likelihood, i.e. −2LL), which is opposite to that of R^2, because a well-fitting model will have a small value for −2LL (Hair et al. 1998). The −2LL value for data in the model is 39.65, indicating fitness of the model (Table 3). The fitness of the model was also be determined by the Cox and Snell ($R^2 = 0.692$) and the Nagelkerke ($R^2 = 0.926$) methods. The statistical significance of the parameters of land degradation included in the logistic regression model is shown in Table 3. Of the 13 variables hypothesised to affect land degradation, three were significant at 99% confidence level: total number of male educated members above primary level (EDUMEMB), frequency of visits by extension workers (FREQVSTS) and access to credit (CRDTACCES). Four other variables, household size (HHSIZE), security of tenure (TENURSEC), cropping pattern (CRPNGPTRN) and livestock population (LVSTKLSU), had 95% confidence.

The variable, number of male educated members in the family, was negatively associated with land degradation, indicating that a unit increase in education level of the farmers decreases the odds of degradation by a factor of 0.205. The possible explanation of this is that the majority of young males are educated only up to secondary level. However, the literacy ratio is still low because of a lack of adequate education facilities. Likewise, the variable, frequency of visits by extension workers, also had a significant negative relationship with land degradation. Although the frequency of visits by extension agents was less in the area, it had significant negative effect on land degradation because if one farmer adopts any conservation measure and achieves significant results, it is ultimately adopted by the

Table 3. Parameter estimates for the significant variables in the logistic regression model.

Explanatory variable	B	Wald	*P*	Odds ratio, Exp (B)
Constant	−1.123	0.166	0.684	0.325
HHSIZE	0.550	4.439	0.035*	1.733
EDUMEMB	−1.586	9.271	0.002**	0.205
FREQVSTS	−1.892	8.525	0.004**	0.151
TENURSEC	−3.337	4.983	0.026*	0.036
CRDTACCESS	−4.864	13.005	0.000**	0.008
CRPNGPTRN	2.621	3.956	0.047*	13.745
LVSTKLSU	0.113	4.254	0.039*	1.120

Notes: *, **Significant at 95% and 99% confidence, respectively; −2 Log-likelihood = 39.645; Chi-square = 235.611; Cox and Snell $R^2 = 0.692$; Nagelkerke $R^2 = 0.926$.

nearby farmer, etc. However farmers' organisations were lacking in the area, which could be more effective for adoption of conservation measures. The other variable with a significant negative effect on land degradation is access to agricultural credit. In the study area, areas where farmers had access to agricultural credit were more inclined to take conservation measures. Lack of access to agricultural credit hinders adoption of conservation measures and proper use of inputs, like chemical fertilisers and improved seeds.

It can be argued that household size can have a negative relation with land degradation because larger households have more labour and thus contribute to land conservation, resulting in decreased degradation. On the contrary, we observed that household size had a positive relationship with land degradation because the increased number of household members requires more agricultural land to meet their food requirement, and they even cultivate marginal land for this purpose without much emphasis on land conservation. The model shows that for a unit increase in the household size the odds of degradation increase by a factor of 1.733. The other variable, security of tenure, had negative effect on land degradation in the model. The possible explanation is that although rented lands were common in some areas, most ($>50\%$) surveyed households had full ownership of their land. Land ownership induces farmers to invest in soil conservation measures and hence plays an important role in controlling land degradation.

The variable, cropping pattern, had a strong positive relation with land degradation. Monocropping is widely prevalent in the area. In rainfed lands, the only crop cultivated is wheat and in irrigated lands apple orchards dominate, leaving soils deficient in certain key nutrients. Low crop yield of these major crops is evident, indicating poor soil health. The odds ratio was highest for this variable among all seven variables included in the model. Similarly, other variable that had significant and positive relations with land degradation was livestock population. As mentioned above, lack of regulated grazing and conservation measures, rangeland resources are openly used for grazing by the community and this situation can be explained from the theory of the 'tragedy of the commons'. The model showed that the odds of degradation increase by a factor of 1.120 for a unit increase in LVSTKLSU.

Conclusions and recommendations

The findings of this study have important policy implications for controlling land degradation in the study area. The study demonstrates that in areas with a paucity of data, farmers' perceptions can provide useful for the resolution of environmental problems. As far as farmers in the study area are concerned, they were well aware of the problems of land degradation and had sufficient knowledge on the types and causes of degradation. They perceived the status of soil erosion and soil infertility as be more serious on non-farmland, probably because no conservation measures were adopted for larger non-farmland areas and these areas were excessively used for grazing and fuelwood collection, with no individual accountability. Therefore, there is a need to take effective measures to protect farmlands as well as communal grazing lands from further degradation.

The study also revealed that education, extension agent visits and access to credit were major requirements for success against land degradation. Although knowledge on land degradation and use of traditional methods of conservation were important, getting formal education, technical training from extension workers and credit can support farmers in combating land degradation. The other factors affecting degradation were household size, security of tenure, cropping pattern and livestock population. There is a need to control human and livestock populations and devise appropriate cropping patterns for sustainable use of land and water resources. Land reforms by the government, if introduced to deal with the problem of land tenure, can also be effective for conservation of resources from further degradation. Efforts are also needed to involve and encourage the female population to take part in productive work and decision-making for the struggle against land degradation.

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