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Land Degradation – Its Extent and Determinants in Mountainous Regions of Himachal Pradesh[§]

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Abstract

The study has been undertaken with the objectives of finding the extent of land degradation and its determinants in the mountainous regions of Himachal Pradesh by dividing the state into four zones. Multistage random sampling technique has been adopted to select the sample farmers from each zone. Logit analysis has been carried out to find the probability of different factors affecting land degradation. The factors whose effect on land degradation has been reported are: total owned land, land fragmentation, family labour, non-farm income, farm income, migration, leasing-out of land and education level of members in a household. The study has suggested some measures to minimize land degradation and consequently increase production and income levels in this difficult terrain of the country.

Introduction

In the north-western Indian Himalayan region, particularly in the state of Himachal Pradesh, land degradation is a serious problem that threatens the sustainable agricultural development. In Himachal Pradesh, the net cultivated area is only 9.87 per cent of the total geographical area. The per capita availability of cultivated land is declining and of fallow /abundant land is increasing. This may increase land degradation and hence decrease the production and income levels of those who derive their livelihood from agriculture (Wiebe, 2003). There was a need to examine the extent of land degradation and its determinants in the state, particularly in the hilly/ mountainous areas. It needed a thorough investigation through household data analysis. Therefore, the present study was undertaken with the specific objectives of finding the existing land-use pattern; and the extent of land degradation and its determinants. It also aimed to suggest suitable policy measures for minimization of land degradation.

Methodology

Himachal Pradesh was subdivided into four agro-climatic zones as Zone I (sub-mountain low hills, below 650m), Zone II (mid-hill high humid, 650-1800m), Zone III (high-hills temperate wet, 1800-2200m) and Zone IV (high-hills temperate, 2200m and above) and the study was carried out in all these four zones. Multistage random sampling technique was adopted to select the sample of blocks, villages and ultimately the farmers in each zone. At the final stage, 50 farmers were selected from each zone, making a random sample of 200 farmers. The data were collected during the year 2005-06. LOGIT analysis was carried out to study the probability of factors affecting the land degradation.

LOGIT Analysis

Logistic regression or LOGIT analysis (Raina, 1991; Rao *et al.*, 2008) is a popular statistical modelling technique in which the probability of a dichotomous outcome is related to a set of potential explanatory variables. A dichotomous outcome Y {value '1' was

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assigned if land degradation was ≥ 20 per cent of the owned land and '0' otherwise.

One can usually assume that probability is related to a set of potential explanatory variables in the form of Equation (1)

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_n X_n + e \quad \ldots(1)$$

where, Y = 1 if degradation is ≥ 20 per cent, and 0 otherwise; β_0 is the intercept; β_1,……, β_n are the regression coefficients associated with each explanatory variable X_1, …….., X_n and e is the error-term.

Regression Y on Xs using OLS will lead to three problems. First, the error-term, e, obviously not normally distributed as we generally assume, and more importantly, estimated probabilities can lie outside the range (0, 1). Furthermore, the error variance is not constant across the levels of the Xs. However, one can assume that P follows a logistic distribution.

$$P = 1/ (1–\exp [–(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_n X_n)] \quad \ldots(2)$$

Rearranging terms, Equation (2) can be expressed as :

$$P/1–P = \exp [–(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_n X_n)] \quad \ldots(3)$$

where, P/1–P is the odds of the outcome such as land degradation. It is clear from the equation that the logarithm of the odds, or simply log odds, is a linear function of the explanatory variables, Xs as:

$$\log [P/(1–P)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_n X_n \quad \ldots(4)$$

Since P is assumed to follow a logistic distribution, maximum likelihood method can be used to estimate the coefficients β_1, …., β_n. Exp (β) represents the expected change in the odds of land degradation versus no degradation per unit in the explanatory variable, other things being equal. The logistic procedure in the SPSS package was used in the analysis for identifying the factors responsible for land degradation in Himachal Pradesh.

Although many factors were identified by reviewing the literature, only eight important factors were considered and these were: total owned land (TOL), number of fragments of land (FR), family labour (FL), non-farm income (NFI), farm income (FI), migration (MI), leased-out land (LOL) and highest education in the family (HED). Y was the dependent variable and was taken as the percentage of land degraded to the total owned land as reported by the farmers.

The probabilities were calculated as follows:

$$P/1–P = \text{Anti log } (b_i) \quad \ldots(5)$$

$$P = \text{Anti log } (b_i)/ (\text{Anti log } (b_i) + 1) \quad \ldots(6)$$

where, P is the probability of land degradation and b_i is the i^{th} regression co-efficient

Results and Discussion

Land Utilization Pattern

The total owned land was highest in Zone IV, followed by Zone III, Zone I and Zone II (Table 1). In Zone I, the operational holding was highest (0.877 ha/ farm, 83% unirrigated) in Zone I and minimum (0.247 ha/farm, 100% unirrigated) in Zone II. The share of wasteland was also highest in Zone II. Leasing-in/out of land was quite high in these zones (I&II) due to migration. In Zones III and IV, due to cultivation of high-value cash crops (vegetables and horticultural crops), the leasing-in/out of land was almost absent and wasteland was also less.

Extent of Land Degradation

Information regarding wasteland was collected for two different time periods, viz. 1995 and 2005-06 (Table 2). The wasteland was found maximum in Zone II (43% of total owned land), followed by in Zone I (21%), and Zones III and IV (8% each).

The increase in wasteland was highest in Zone II. Animal menace, annual weeds, nearby fallow land and decrease in family labour were some of the main reasons for this increase, besides migration to urban areas. The less wasteland in Zones III and IV was mainly due to production of cash crops and better irrigation facilities. Ramasamy *et al.* (2005) have also found that better irrigation facilities could reduce the extent of fallow lands at the farm level in Tamil Nadu.

Fragments of Owned Land

The study of fragmentation of land revealed that in Zones I and II (Table 3), 42-50 per cent farmers had maximum size of fragments between 3-5 bigha. The minimum size of fragment of more than 5 bigha was with 6 per cent farmers in Zone I and there was none in Zone II. In Zones III and IV, the proportion of

Table 1. Land utilization pattern

(ha/farm)

Particulars	Zone I	Zone II	Zone III	Zone IV
1. Total owned land	1.414	0.708	1.517	1.701
-Irrigated	0.152	-	0.022	1.371
-Unirrigated	1.262	0.708	1.494	0.33
2. Leased-in land	0.006	0.078	-	-
3. Leased-out land	0.099	0.081	0.014	-
4. Orchards	0.013	-	0.401	1.067
5. Grassland	0.232	0.159	0.416	0.182
6. Wasteland				
-Current fallow	0.022	0.033	0.014	0.003
-Fallow other than current fallow (Long-term fallow)	0.168	0.146	0.066	0.022
-Culturable waste	0.102	0.123	0.042	0.094
7. Operational holding	0.877	0.247	0.578	0.333
-Irrigated	0.146	-	0.022	0.333
-Unirrigated	0.731	0.247	0.556	-

Table 2. Extent of land degradation

(Per cent of farmers)

Particulars	Zone I	Zone II	Zone III	Zone IV
Wasteland (ha/farm)				
1995	0.20	0.12	0.11	0.15
2005-06	0.29	0.30	0.12	0.12
Increase in wasteland (ha/farm)	0.11	0.18	0.02	nil
Total farmers (No.)	50	50	50	50
Farmers with wasteland	92	94	42	34
Farmers with increased wasteland	60	70	14	6
Main reasons for wasteland				
-Weeds infestation	52	92	24	6
-Fragmentation	6	2	8	-
-Nearby fallow land	32	34	14	4
-Division of land	6	2	20	-
-Wild animal menace	76	88	18	-
-Decrease in family labour (migration, other)	28	34	8	-

farmers having bigger farm-size was high, viz. 62-74 per cent with more than 5 bigha, followed by farmers with 3-5 bigha. No farmer had maximum size of fragment below 1 bigha, whereas the minimum size of fragment was 1-3 bigha (38-50% farmers). The number of fragments of land per farm was only 2 in Zone III and 3 in Zone IV. Thus, the wasteland was less in these zones as larger size of fragments led to better land utilization.

Workers Distribution

The distribution of workers, presented in Table 4, showed that though the actual labour available for work was very low in all the zones, it was highest in Zone III (43-47% of total population), followed by Zone IV (34-45% of total population). It leads to less fallow land and higher farm income as sufficient labour was available for the cultivation of entire land in Zones III

Table 3. Fragments of owned land

(N= 50 in each zone) (Per cent of farmers)

Particulars	Zone I	Zone II	Zone III	Zone IV
Maximum size of fragment (bigha*)				
< 1	-	-	-	-
1-3	22	16	8	10
3-5	42	50	30	16
>5	36	34	62	74
Minimum size of fragment (bigha)				
< 1	14	2	4	-
1-3	64	76	38	50
3-5	16	22	24	26
>5	6	-	34	24
Number of fragments of land per farm	4.00	4.14	1.86	3.14

Note: *1 Bigha = 0.08 ha

Table 4. Zone-wise distribution of workers

(in per cent)

Particulars		Zone I	Zone II	Zone III	Zone IV
Total working population (No.)	M	114	83	85	79
	F	106	96	93	78
Working population as % of total population	M	53.28	60.58	59.03	57.12
	F	65.84	64.86	63.69	60.00
Actual work force available (No.)	M	62	51	68	47
	F	43	46	62	59
Actual work force available as % of total population	M	28.97	37.23	47.22	33.81
	F	26.71	31.08	42.47	45.38
Total population	M	100 (214)	100 (137)	100 (144)	100 (139)
	F	100 (161)	100 (148)	100 (146)	100 (130)

Note: Figures within the parentheses are total number on which percentages have been calculated.

and IV. The proportion of male and female workforce was almost same in all the zones, except Zone IV where the number of female farm workers was found more.

Migration Pattern

It was hypothesized that the migration was higher due to low farm productivity and small size of holding. The results, presented in Table 5, showed that the migration was highest in Zone II (64% of the total population), followed by Zone I, whereas in Zone IV very little migration was observed.

In all the zones, migration was more without family than with family, except in Zone III. Maximum migrations had occurred 5-10 years ago in all the zones. Lack of employment, erratic climate, animal menace and low farm income in the area were advocated as the main reasons for migration. For migrations with family, education of children was the added reasons for migration. The migration of farmers has led to higher land degradations due to leaving of the land fallow. The non-cultivation of land has caused spread of obnoxious weeds and thus degradation in the land

Table 5. Migration pattern and reasons of migration

(Per cent of farmers)

Particulars	Zone I		Zone II		Zone III		Zone IV	
	WF	WOF	WF	WOF	WF	WOF	WF	WOF
Farmers migrated (No.)	1	8	6	26	5	4	-	2
Reasons for migration								
Lack of employment	100	100	100	100	60.00	100	-	100
Education of children	100	37.50	83.33	-	100	-	-	-
Low farm income in area	100	-	83.33	61.54	-	25.00	-	-
Erratic climate and low returns	-	62.50	33.33	26.92	-	50.00	-	50.00
Others (animal menace, annual weeds, etc.)	100	-	50.00	46.15	-	-	-	-

Note: WF – With family; WOF – Without family

Table 6. Information about leasing-out of land

(Per cent of farmers)

Particulars	Zone I	Zone II	Zone III
Farmers leasing-out land	22.00	24.00	6.00
Area (ha/ farm)*	0.46	0.35	0.12
Reasons for leasing-out			
Far away land	54.55	25.00	-
Labour problem	36.36	58.33	66.67
Too much land	9.09	8.33	-
Less income from farming	36.36	41.67	100
Migration to other places	45.45	50.00	66.67
Education of children	-	-	66.67

Notes: The leasing-out of land was absent in Zone IV due to high farm-income in the area.

* Average has been calculated on the basis of total number of farmers who leased-out their land.

quality. The weeds have not only affected the uncultivated lands but the cultivated area also through spread of weeds via wind, birds, etc., resulting into land degradation and fall in total productivity.

Leasing-out of Land

The leasing-out of land on a farm affects land management and productivity for several reasons. This helps the researchers to understand the land tenural system besides its effect on land degradation. Table 6 summarizes the information regarding the leasing-out of land in the study area. The leasing-out of land was found higher in Zones I and II because the cultivators were not able to manage the land themselves. It has also been found that in Zone I, rental system was prevalent for leasing-out land, whereas in Zones II and III, share cropping was being practised. The land was mainly leased-out to other farmers/ villagers and relatives. Faraway lands, migration to other places, low income from farming and labour scarcity were found to be the major reasons for leasing-out the land

Sources of Household Income

The total household annual income was found highest in Zone IV (Rs 1.78 lakh), followed by Zone III (Rs 1.43 lakh), Zone II (Rs 1.12 lakh) and Zone I (Rs 1.08 lakh) (Table 7). A similar pattern was observed in the case of farm income. The farm income was higher in Zones III and IV than in Zones II and I, which was mainly due to cultivation of high-value cash crops.

The high farm income helps in reducing land degradation as it increases farm investment for land improvement. The non-farm income was very high in Zones II (95%) and I (88%) which was the major cause of land degradation in these areas, since agriculture has become the secondary source of income and thus low attention was being paid towards land. In these zones, the shares of service/ pension and business income were also found quite high, depicting more income from non-farm sources.

Education-wise Distribution of Households

The literacy was found quite high, almost 100 per cent in all the zones (Table 8). The proportion of graduates in all the zones (except Zone II) was maximum. The proportion of post-graduates was higher in Zones III and IV than in Zones I and II. The higher education had two-way effect. On one side, it may increase the household's opportunities for off-farm

Table 7. Sources of household income

(in per cent)

Particulars	Zone I Overall	Zone II Overall	Zone III Overall	Zone IV Overall
Farm income	11.61	5.42	43.02	74.93
Agriculture	5.70	2.21	0.00	2.70
Horticulture	0.09	0.00	19.48	59.71
Vegetables	0.00	0.00	20.06	9.99
Animal husbandry	5.79	3.17	3.48	2.52
Non-farm income	88.39	94.58	56.98	25.07
Service/ pension	63.76	82.47	45.19	16.88
Business	19.15	5.29	10.81	6.14
Daily Paid Labour	1.67	2.06	0.56	0.57
Others	3.81	4.77	0.42	1.48
Total income (Rs/annum)	**1,07,765**	**1,12,065**	**1,42,584**	**1,77,851**

Table 8. Education-wise distribution of households

(in per cent)

Education level	Zone I	Zone II	Zone III	Zone IV
Illiterate	0	2	0	0
Primary	2	0	0	0
Middle	0	0	4	6
Matriculation	20	28	22	28
Plus two	30	38	10	14
Graduate	36	24	46	36
Post-graduate	12	8	18	16

Note: Based on education of family members of more than 18 years age.

employment and ability to start up various non-farm activities, and on the other hand, it may increase access to credit, leading to purchase of physical capital and market-oriented inputs and overall better land management. The table shows that educational status had a negative relationship with land degradation.

LOGIT Analysis

The LOGIT analysis was carried out to identify the factors due to which households could move towards land degradation. The variables given in the methodology were considered and the results obtained are presented in Table 9. It has been found that there was 84 per cent probability in Zones I and II that with the increase in total owned land, the land degradation would increase. It was because the operational holdings in these areas were mostly rain-fed and there was high uncertainty in keeping the land under cultivation. As far as fragmentation of landholdings was concerned, the table revealed that in Zones I and III there was about 40 per cent probability of an inverse relationship with land degradation. Due to small holdings, the family labour was already surplus and any increase in it would cause land degradation in all the zones. In general, the non-farm income has shown 50 per cent probability of increasing land degradation in all the zones. In Zones I and II, III the farm income has led to a decrease in land degradation with the probability of only 10 per cent and 17 per cent, respectively, whereas in Zones III and IV, the probability was 50 per cent. The results have shown that there was 62 per cent probability that migration and land degradation would move in the same direction.

In all the zones, there was a higher probability that leasing-out of land would cause more land degradation. The higher education could cause more land

Table 9. LOGIT analysis

Factors	Regression coefficients				Probabilities			
	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV
Total owned land	1.661*	1.661	0.122	0.001	0.840	0.840	0.530	0.500
	(0.606)	(2.152)	(0.413)	(0.029)				
Fragmentation of land	-0.374	0.559	-0.500	0.379	0.408	0.636	0.378	0.594
	(0.499)	(0.671)	(0.597)	(0.301)				
Family labour	0.540	0.085*	0.475	-0.306*	0.632	0.521	0.617	0.424
	(0.601)	(0.038)	(0.297)	(0.130)				
Non-farm income	-0.139	0.076*	-0.017*	-0.246*	0.465	0.519	0.496	0.439
	(0.154)	(0.005)	(0.003)	(0.120)				
Farm income	-2.183*	-1.623*	-0.002	0.016*	0.101	0.165	0.500	0.504
	(0.778)	(0.570)	(0.018)	(0.004)				
Migration	-	0.468*	-	-	-	0.615	-	-
		(0.117)						
Leasing-out of land	1.264	-2.34	-6.288	-	0.558	0.088	0.002	-
	(1.529)	(1.548)	(34.537)					
Education level of the family member	1.130*	-0.033	-0.581*	0.858	0.756	0.492	0.359	0.702
	(0.518)	(0.018)	(0.215)	(0.448)				

Notes: Figures within the parentheses are standard error.

* Indicates significance at 5 per cent level.

degradation because the educated ones, in general, did not opt for agriculture for better off-farm employment. The land is kept fallow, leading to more land degradation.

Conclusions

The study has concluded that amongst the four agro-ecological zones, the cultivation of high-value crops (vegetables and horticultural crops) is being practised in Zones III and IV only, due to irrigation facilities. The leasing-out of land as well as wasteland have been found almost absent in these two zones. The wasteland has been found maximum in Zone II, followed by Zone I. The fragmentation of land has also been observed higher in Zones I and II. The rural-urban migration has been noted highest in Zone II (64%), followed by Zone I. As a consequence, farm income as well as total income has been found higher in Zones IV and III than in Zones I and II. The literacy level has been found almost 100 per cent in all the zones with a significant proportion of graduates and postgraduates. But, higher education has shown two-way effect. In Zones I and II, it has diverted the farmers, particularly the younger generation, towards better non-farm employment, causing higher land degradation in these zones. On the other side, it has induced better access to credit, use of modern farm implements and high-yielding varieties of seeds and diversification towards vegetables and horticultural crops. As a result, the farm income and total income have been much higher in Zones III and IV than in Zones I and II. The logit analyses has revealed that factors like increase in total owned land, extent of land fragmentation, family labour, migration and decreasing farm income have higher probabilities of increasing land degradation in the state. The study has suggested that to minimize land degradation in this difficult area, better irrigation facilities should be developed. Also, the problems like spread of weeds, animal menace, stray/wild cattle, and access to credit of smallholders should be addressed for a decrease in land degradation and increase in rural employment and farm income in the state.

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References

Raina, K.K. (1991) Economic analysis of tribal agriculture in Lahaul valley of Himachal Pradesh. *Ph.D. Thesis* (unpublished), Department of Agricultural Economics, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur.

Ramasamy, C., Balasubramaniam, R. and Shivkumar, S. D. (2005) Dynamics of land use pattern with special reference to fallow lands – An empirical investigation in Tamil Nadu. *Indian Journal of Agricultural Economics*, **60** (4): 97-107.

Rama Rao, C.A., Srinivasa Rao, M., Naraiah, P., Malathi, B. and Reddy, Y.V.R. (2008) An economic analysis of adoption of integrated pest management in groundnut. *Indian Journal of Agricultural Economics*, **63** (1): 629-643.

Wiebe, Keith (2003) Linking land quality, agricultural productivity and food security. In *Agricultural Economic Report No. 823*, Resource Economics Division, Economic Research Service, US Department of Agriculture, Washington, DC, USA.