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Economics and Adoption Behaviour of Farmers in Soil Conservation Technologies in Hilly Zone of South India

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Abstract

The paper has examined the nature of conservation technologies adopted by the farmers and has identified the factors affecting the investment on these technologies by selecting 50 farmers from each priority category of five watersheds (very high, high, medium, low and very low). The technical feasibility and economic viability of different conservation technologies have been studied using NPV, BCR and IRR. The conservation structures were constructed at two levels, viz. farm and community. Farm level adoption of conservation structures like staggered trench has accounted for 72 per cent. Carrot, potato and beans and perennial crops like tea have shown positive additional net returns for adopters compared with non-adopters of conservation technologies. In tea plantation, stone wall had the highest NPV, and in carrot, bench terrace had the highest IRR. The BCR, NPV and IRR for both annual and perennial crops have been found encouraging. Multinomial logit model has been used for identification of factors influencing the choice for soil conservation technologies by the farmers. The study has found that bench terrace was being adopted for annual crops and the variables, number of land parcels, educational level and on-farm income, significantly influence the adoption rate.

Key words: Soil conservation technologies, tea, carrot, potato, beans, NPV, BCR, IRR, multinomial logit model

JEL Classification: Q12, Q16

Introduction

In India, hill areas have serious problems of landslides, torrents, slips and encroachments. About 5334 Mt (16.5 t/ha) of soil is eroded annually and 5.37 - 8.40 Mt of soil nutrients are lost through water erosion (Sharma and Verma, 2010). In Tamil Nadu, land degraded by water erosion alone is estimated at 4.92 Mha and 41 per cent of the total geographical area of the state is affected by various forms of soil erosion. The resource allocation to soil conservation programmes has increased phenomenally over various plan periods in India. In Tamil Nadu, both central and state governments allocate funds for conservation programmes. Soil and water conservation activities in the Nilgiris are carried out by institutions as well as farmers, but they are not sufficient.

Despite launching of several programmes and heavy investments on technical and engineering structures, the data on costs and benefits of various conservation technologies are limited, incomplete and insufficient. Hence, the present study was carried out to (i) examine the nature of conservation technologies adopted by the farmers in the hilly terrains, (ii) identify the factors affecting the investment on soil

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conservation, and (iii) suggest policy implications to protect soil resource through institutional intervention.

Data and Methodology

For the present study, Lower Bhavani catchment located in the district of Nilgiris was purposively chosen. Five priority watersheds (very high, high, medium, low and very low priority watersheds) were identified based on the implementation of compliance programmes of Government of Tamil Nadu. Then, 50 sample respondents were identified for survey in each of the five categories of watersheds, making the total sample size of 250 farmers. The ANOVA on the investment among the five categories of watersheds did not show any significant differences. So, the sample farmers were post-stratified as (i) marginal (< 1 ha), (ii) small (1-2 ha), (iii) medium (2-4 ha), and (iv) large (> 4 ha) farmers based on their farm-size.

The personal characteristics of sample farmers like age, education, experience and average family size and general characteristics of the farms like size of holdings and cropping pattern were analysed through simple percentage analysis. The conventionally employed discounted methods of analysis, viz. net present value (NPV), benefit cost ratio (BCR) and internal rate of return (IRR) were used to study the economic feasibility different conservation technologies like staggered trench, stone wall, waterways and bench terrace that are commonly adopted by the farmers.

A multinomial logit model was employed to identify the choice of conservation technologies (Teklewold and Kohlin, 2011). The model was specified as:

$$Y_{ij} = \alpha + \beta X_i + u_i$$

where, Y_{ij} is the conservation structure j for i[th] farm, X_i represents the factors influencing the choice of a particular type of soil conservation structure, u_i is the random-error term, and α and β are parameters to be estimated. The dependent variable Y_{ij} is a set of neutrally exclusive binary variables defined in Table 1.

The constraints in the adoption of soil conservation technologies were analyzed based on Garret's scoring technique.

Results and Discussion

The average farm size of marginal farmers was 0.5 ha and they constituted about 58 per cent of the sample size. Medium and large farmers were less in number and their average landholding size was 4.40 ha against the average landholding of 3.18 ha for the entire sample.

Table 1. Definition of explanatory variables X_i

Variable		Value
NONE	-	0, if no conservation structure was adopted)
STAGRTRNECH	-	1, if staggered trench was adopted
STONWAL	-	2, if stone wall was adopted
WATRWAY	-	3, if water ways was adopted
BENTERCE	-	4, if bench terrace was adopted
AGE	-	Age (in years)
EDU	-	Education (No. of years)
FMLYSZ	-	Family size (No.)
EXP	-	Experience in farming (No. of years)
FRMSIZ	-	Farm size (ha)
ONINC	-	Annual net farm income (₹ /ha)
PERICRPAREA	-	Perennial cropped area (ha)
OWNLAN	-	Land ownerships (1 if owned; 0 otherwise)
INTSUB	-	Institutional subsidy to soil and water conservation technologies (₹ / ha)
STEPSLP	-	Steep slope (1 if plot has steep slope; 0 otherwise)
SOLTYP	-	Soil type (1 if laterite; 0 otherwise)
HIRFERSO	-	Highly fertility of soil (1 if highly fertile; 0 otherwise)
LNHOLD	-	Landholding trends (1 if decline; 0 otherwise)
NOPARL	-	Number of parcels of farm land

Adoption of Soil Conservation Structures

The conservation structures are constructed at two levels, viz. (i) farm level, and (ii) community level. In the sample farms, for perennial crops like tea, staggered trenches, stone wall and waterways were predominantly adopted, while for annual crops like vegetables, bench terrace was the commonly adopted technology by the farmers.

(a) At Farm Level

The conservation structures adopted by the farmers showed that there had been different combinations of soil conservation technologies at the farm level. The

Table 2. Farm level adoption of soil conservation structures in Nilgiris district

Conservation structure	Marginal farmers		Small farmers		Medium & large farmers		All farmers	
	No.	%	No.	%	No.	%	No.	%
Staggered trench	136	97.14	77	69.37	27	34.18	240	72.73
Staggered trench + stone wall	4	2.86	23	20.72	23	29.11	50	15.15
Staggered trench + stone wall + water ways	-	-	4	3.60	8	10.13	12	3.64
Bench terrace	-	-	4	3.60	12	15.19	16	4.85
Staggered trench + Bench terrace	-	-	3	21.07	3	3.80	6	1.82
Staggered trench + Bench terrace + stone wall	-	-	0	0.00	5	6.33	5	1.52
Staggered trench + Bench terrace + stone wall + water ways	-	-	0	0.00	1	1.27	1	0.30
Total	140	100.00	111	100.00	79	100.00	330	100.00

data presented in Table 2 reveal that across sample farmers, about 73 per cent adopted staggered trench, about 15 per cent adopted both staggered trench and stone wall and 4.85 per cent adapted bench terrace. Bench terrace was mostly followed by farmers growing annual crops like carrot, cabbage, beans, etc.

(b) At Community Level

The community level conservation structures like loose boulder check, gabion check and stream training work were constructed by the institutions in the farms as well on the community lands for reducing soil erosion and conservation of rain water. Loose boulders checks and gabion checks in the tea plantations were reported to increase moisture conservation and enhanced productivity of tea leaf. On the other hand, loss of soil was reduced due to gully formation in the high slope lands. Stream training work was erected for arresting the gullies by constructing a stone wall or masonry work on the either sides of streams. The details about community level conservation technologies are given in Table 3.

Investment at Individual and Institutional Levels on Conservation Technologies

From Table 4, it could be noted that about 78 per cent of sample farmers used own funds for adoption of staggered trench. In the case of stone wall, it was 62 per cent and for waterways it was only about 25 per cent. Institutions provided subsidy either fully or partially for establishing a conservation structure at the farm level. Table 5 presents crop-wise adoption of soil conservation technologies by the farmers. It is concluded that only community level conservation technologies were exclusively provided by the government and NGOs.

Cost on Conservation and Maintenance of Soil and Water Conservation Technologies

The costs on different conservation structures and maintenance are presented in Table 5. After adoption of a conservation technology, maintenance is an important component for the sustainability of long-term benefits. It was observed that staggered trench involved

Table 3. Community level conservation technologies adopted in Nilgiris district

Type of conservation structure	Marginal farmers		Small farmers		Medium & large farmers		All farmers	
	No.	%	No.	%	No.	%	No.	%
Loose boulder check	5	38.46	6	42.86	11	68.75	22	51.16
Gabion check	1	7.69	2	14.28	2	12.50	5	11.63
Stream training work	7	53.85	6	42.86	3	18.75	16	37.21
Total conservation structures	13	100.00	14	100.00	16	100.00	43	100.00

Table 4. Investment at individual and institutional levels on conservation technologies in Nilgiris district

Crop	Conservation technology	Adoption			
		Individuallevel	Institution level	Both levels	Total
Tea	Staggered trench	186 (77.50)	48 (20.00)	6 (2.50)	240
	Stone wall	31 (62.00)	15 (30.00)	4 (8.00)	50
	Water way	3 (25.00)	7 (58.33)	2 (16.67)	12
	Loose boulder check	0	19 (86.36)	3 (13.64)	22
	Gabion check	0	5	-	5
Vegetables	Bench terrace	12 (42.86)	7 (25.00)	9 (32.15)	28
	Stream training work	0	16 (13.68)	0	16

Note: The values within the parentheses are percentage of row's total

Table 5. Cost on construction and maintenance of various conservation technologies

(₹)

Conservation technology	Cost on establishment	Annual maintenance cost
Staggered trench	11,032	5245
Stone wall	2,47,675	16788
Waterway	1,27,891	13,654
Bench terrace	2,96,424	14865

Table 6. Financial analysis of soil conservation technologies adopted in tea crop

Discounted measure	Conservation technology		
	Staggered trench	Stone wall	Water way
NPV (₹)	19237	74335	45454
BCR	1.03	1.08	1.15
IRR (%)	14.99	15.58	15.31

least cost, followed by water ways. The conservation structure commonly adopted in tea plantations was staggered, followed by stone wall. The stone wall was adopted by the farmers only to construct the water ways in their farms.

Soil Conservation Technologies – Economic Analysis

The economic analysis was carried out to assess the returns from investment on soil conservation technologies using financial measures such as a NPV, BCR and IRR. The results of analysis are reported crop-wise for different conservation technologies in Table 6 for tea and in Table 7 for annual crops.

A perusal of Tables 6 and 7 reveals that the BCR ranged from 1.03 for staggered trenches in tea plantation to 1.40 in bench terrace for carrot, indicating the economic viability of technologies. The BCR for bench terrace varied from 1.12 for beans to 1.40 for carrots. The BCR for tea plantation was more than unity

Table 7. Financial analyses of soil conservation technology adopted in annual crops

Discounted measure	Bench terrace			
	Carrot	Potato	Cabbage	Beans
NPV (₹)	57101	42008	34603	32538
BCR	1.40	1.20	1.22	1.12
IRR (%)	34.81	32.29	28.47	22.46

Table 8. Multinomial logit model for identification of factors influencing the choice of conservation technologies adoption

Variables	Staggered trench		Stone wall		Water way		Bench terrace	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Constant	2.8251	2.2737	-10.0854**	3.9606	-20.0526***	4.6697	-19.7661***	4.8491
AGE	- 0.0386*	0.0222	-0.0910***	0.0322	-0.1825***	0.0453	-0.1348***	0.4304
EDU	0.3025***	0.0680	0.4971***	0.1125	0.4968***	0.1306	0.6594***	0.1354
EXP	- 0.2055***	0.0446	-0.1592**	0.0776	0.2047**	0.0968	0.1650*	0.1003
FRMSIZ	1.7061***	0.5497	1.4090**	0.5730	0.7466	0.5909	1.0885*	0.5941
FMLYSZ	- 0.3627**	0.1481	0.1801	0.2258	0.3713	0.2623	0.3899	0.2779
INTSUB	-0.00000007	0.00001	0.3106**	0.000001	0.000004	0.00001	0.000001	0.0000001
ONINC	- 0.00001	0.00000006	-0.1460	0.000009	0.000001*	0.0000009	0.000003***	0.000009
PERICRPAREA	2.0243***	0.5817	3.0456**	1.4029	3.1168**	1.3497	1.1859	1.2957
NOPARL	0.6489	0.3637	1.2876***	0.4468	3.1998***	0.5215	1.9005***	0.5151
OWNLAN	-0.0114	0.5765	3.3871***	1.2581	2.3445*	1.2503	1.2893	1.1938
SOLTYP	0.3873**	0.1942	0.9194*	0.5379	-0.3059	1.0246	-1.6250	0.9926
HIRFERSO	-6.2243**	1.3670	-0.2363	1.2933	-0.2758	1.4355	0.3478	1.4997
STEPSLP	1.5945***	0.6075	3.2221***	0.8381	-1.9535*	1.0843	-0.4014	1.0840
LNHOLD	-0.4995	0.8628	-0.8262	1.1706	-1.7125	1.2703	-1.5403	1.3350
log likelihood function	249.7129							
Restricted log likelihood	872.4745							
Chi squared	1245.523***							

Note : * p< 0.1,**p<.05,***p<0.01

Table 9. Marginal effect for identification of factors influencing the choice of conservation technologies adoption

Variables	None		Staggered trench		Stone wall		Water way		Bench terrace	
	Coefficient	standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Constant	-0.3173	0.0577	1.3224***	0.4470	-1.0986***	0.4184	-0.1132***	0.0788	-0.0788	0.0595
AGE	0.0010	0.0007	0.0045*	0.0024	-0.0045**	0.0023	-0.0007**	0.0004	-0.0003	0.0002
EDU	-0.0076*	0.0042	-0.0119	0.0103	0.0174*	0.0094	0.0020*	0.0008	0.0012	0.0010
EXP	0.0046	0.0028	-0.0110	0.0073	0.0030	0.0062	-0.0046	0.0014	0.0013	0.0010
FRMSIZ	-0.3959**	0.0176	0.6746**	0.0271	-0.0211	0.0190	0.0035	0.0032	-0.0020	0.0018
FMLYSZ	0.0071	0.0051	-0.0590	0.0229	0.4581**	0.0211	0.9102**	0.0027	0.0025	0.0020
INTSUB	-0.000000005	0.00000003	-0.2753	0.000001	0.2766***	0.0000001	0.000001***	0.000000005	0.00000003	0.00000004
ONINC	0.00000002	0.0000001	-0.1531	0.000001	-0.4218	0.00000006	0.0000005	0.00000001	0.0000001	0.0000001
PERICRPAREA	-0.0504	0.0329	-0.045	0.1211	0.0935	0.1115	0.0551	0.0067	-0.0033	0.0054
NOPARL	-0.0173	0.0116	-0.0557	0.3761	0.5543*	0.0333	0.1318**	0.0089	0.0044	0.0038
OWNLAN	-0.0081	0.0146	-0.3005**	0.1281	0.2944**	0.1255	0.1065**	0.0095	0.0035	0.0050
SOLTYP	-0.0101	0.0757	-0.0267	0.0463	0.0483	0.0441	-0.0038	0.0060	-0.0076	0.0066
HIRFERSO	0.1322	0.0820	-0.6831***	0.2411	0.5018**	0.1998	0.2737**	0.0199	0.0216	0.0166
STEPSLP	-0.4100	0.2521	-0.080	0.0644	0.1481	0.0653	-0.1929	0.1317	-0.0078	0.0006
LNHOLD	0.01286	0.2121	0.258	0.0750	-0.0286	0.0697	-0.0062	0.0054	-0.0037	0.0044

Note : * p< 0.1,**p<.05,***p<0.01

Table 10. Constraints in adoption of soil conservation technologies in Nilgiris district

Constraints	Garret's score	Rank
High cost of conservation compliance technologies	81.62	1
Non-availability of subsidy timely	72.16	2
High cost of credit	63.65	3
Lack of long-lasting soil conservation technologies	55.12	4
Poor and unsustainable farm income	50.07	5
Low price for farm produce	45.85	6
Lack of technical support from institutions	37.04	7
Insecure land tenure	33.04	8

for all the conservation structures, which indicates a positive impact of soil conservation technologies. The NPV of crops also reflected a significant impact of implementation of different conservation technologies.

Among the soil conservation technologies adopted, stone wall had the highest NPV in tea plantation (₹ 74335), followed by carrot (₹ 57101). The staggered trench had shown a lower NPV (₹ 19237) in tea plantation among all conservation structures. The bench terrace had the highest IRR (34%) for carrot, followed by potato (29%). The BCR, NPV and IRR values for both annual and perennial crops have been found quite encouraging. The overall results on the feasibility analysis have shown that practices followed by most of the farmers had paid dividends and these technologies could be popularized to other areas for extending the benefits of the soil conservation compliance activities.

Multinomial Logit Model

The multinomial logit model was used to identify the factors influencing the choice for adoption of a technology by the farmers. The Chi-square test statistic for the estimated multinomial logit model was 1245. The null hypothesis that the non-intercept co-efficient were jointly zero has been rejected at the 0.0001 probability level. This means that the empirical multinomial logit model was highly significant in explaining the choice of soil conservation practices by the respondents. Clustering of the data allowed the choice of technologies like none, staggered trench, stone wall and bench terrace, which were the dependent variables. The estimated co-efficient and results of multinomial logit model are presented in Table 8 and the marginal effects of coefficients are presented in Table 9.

The multinomial logit model used for identification of the factors influencing the choice of adoption of soil conservation technologies allowed the selection of technologies like none, staggered trench, stone wall and bench terrace, as the dependent variables. The results revealed that the staggered trench had direct impact on productivity. In tea plantation, staggered trench adoption was influenced by the area under crops, farm size, education level and land slope. The adoption of stone wall technology was positively influenced by owned land size, number of land parcels, education level, etc. For water ways, number of land parcels, educational level and area under plantation crops influenced the adoption. Bench terrace was adopted for annual crops and the variables, viz. number of land parcels, educational level and on-farm income significantly influenced the adoption rate.

Constraints in adoption of soil conservation technologies

The ranking of constraints experienced by the crop farmers is presented in Table 10. Among problems, high cost of conservation technologies was the prime constraint hampering the adoption decisions of farmers, followed by non-availability of subsidy, high cost of credit and lack of long-lasting conservation technologies. The poor technological support and lack of security of tenants were the less perceived problems of the hilly farmers.

Conclusions and Policy Implications

The study has revealed that among the various conservation technologies, staggered trench, stone wall and water ways are the promising measures for the perennial crops like tea. Bench terrace has been found to be economically and environmentally sustainable in conserving soil and enhancing crop yield and hence, this technology could be popularized in areas where annual crops like carrot, cabbage, cauliflower and potato are cultivated to get more yield and reduce soil erosion. The government should formulate strategies and programmes to extend technological and financial interventions in areas where perennial crops are grown. Farmers' decision to invest in soil conservation structures mainly depend on subsides, and therefore should be supported adequately since unabated soil erosion would involve increased marginal user costs. The government should facilitate easy access of farmers to loans to undertake conservation technologies, since many of them are technologically and financially feasible and environmentally sustainable.

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