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Economics of Soil Conservation Structures in the Nilgiris

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I

INTRODUCTION

Soil conservation is an important economic activity which requires considerable investment. It has been included as one of the important programmes in successive agricultural development programmes. During the past fifty years, public sector investment on soil conservation has been made in a big way. It increased from Rs. 1.80 crores during the First Five Year Plan to Rs. 800 crores during the Eighth Five Year Plan (Government of India, 1992, 1994). In addition, soil conservation programmes are also an integral part in Drought Prone Area Programme, Command Area Development Programme, Intensive Tree Development Programme, River Valley Projects, Hill Area Development Programmes, etc. Private investment, in terms of farmers' own resource allocation, in soil erosion prone areas is also sizeable. Despite the huge investment made on soil conservation by both public and private sectors, the results achieved are not very impressive (Anonymous, 1993).

Soil Erosion Studies

Soil erosion is a serious problem in India and it has to be controlled if the avowed aim of sustainable agriculture is to be achieved. Besides macro level estimates, a number of micro level studies have brought out the seriousness of this problem. At the macro level, it is estimated that out of the total geographical area of 329 million hectares (mha) in India, about 167 mha (about 51 per cent) are either affected by some or other form of degradation (either water and wind erosion or remain as cultivable waste lands). Of the estimated 167 mha of total problem area, about 127 mha are subject to serious soil erosion and 40 mha are degraded in the form of gullies and ravines (Singh and Venkataramanan, 1990). At the farm level, it is estimated that about 16.40 tonnes/ha of soil is lost annually due to agriculture and associated activities alone and of this about 29 per cent is carried away by rivers into the sea (Kumar, 1991). Contour ridges and contour cultivation can check soil loss and run-off to the extent of 28.3 and 12.2 per cent respectively (Patil and Bangal, 1974). These studies confirm that soil erosion results in the loss of most important natural resource and any negligence to control it will enlarge investment on soil conservation measures.

Why this Study in the Nilgiris

The study was taken up in the Nilgiris district of Tamil Nadu.[1] The high amount of intense rainfall with their high erosivity of soils coupled with moderate to very steep slopes makes this hilly region prone to severe erosion. The area prone for soil erosion is 68,100 ha in the

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district. The soil loss in the Nilgiris is reported to exceed 40 tonnes/ha/year (Anonymous, 1993). The prevalence of conducive agro-climatic environment in the Nilgiris favours extensive cultivation of horticultural crops even in undulating topography. In spite of substantial efforts and huge investments made on soil conservation, limited success has been achieved.

Raghunath *et al.* (1967), based on a series of experiments, reported that deep laterite soils of the Nilgiris were subjected to severe soil erosion and contour cultivation on slopes as high as 33 per cent, reduced run-off by 44 per cent and soil loss by 62 per cent. Das and Raghunath (1967) in an another study found that bench terracing reduced run-off by 50 per cent and soil loss by 98 per cent in the fields under potato cultivation. Besides, a gross increase of 27 per cent in the yield of potato due to bench terracing was reported.

Soil conservation activities are carried out in the Nilgiris as a protective action and the soil conservation practices like contour bunding, land levelling, gully control, stonewalling, bench terracing, contour stonewalling, staggered trenching, etc., have been executed in isolation both by the farmers and the government departments. Lack of adequate credit, risk aversion, lack of education on soil conservation technologies smaller farm size, high erosion potential, etc., were the major impediments discouraging the farmers' investment decisions. Consequently, construction and maintenance of soil conservation structures in the Nilgiris are given priority only by a section of the farmers to protect the soil resource.

Juxtaposed with this situation, the farmers maintaining conservation structures were able to get higher output and thereby realised enhanced farm returns. It was also observed that the decision to adopt or not to adopt conservation practices was highly determined by the farmers' socio-economic status and their orientation towards a particular technology (Gunatilake and Abeygunawardena, 1993).

The programmes designed to meet the on-farm requirement of soil conservation have not borne the desired results and in some cases the intended benefits have not reached the target groups. The reasons attributed for the non-adoption of conservation technologies were mainly due to the insufficient credit flow and in some cases the advancement of credit by institutions was not commensurate with the actual requirements of the investment. The problem of soil erosion to a serious degree, public investment programmes and associated issues, and poor adoption of soil conservation technologies, and all other issues relating to soil conservation, unambiguously, warranted a study to understand the problems so that right kind of measures can be initiated to solve the problems.

II

OBJECTIVES

In the present study, three major issues were considered viz., (i) analysis of investment on soil conservation measures, (ii) determinants of land value and (iii) adoption analysis of soil conservation technologies. The three aspects are closely related. The results of investment analysis provide evidence on the profitability of making investment on soil conservation technologies. This is a pre-requisite for the farmers to select the right kind of investment. Then investment on soil conservation is expected to increase the land value because conservation not only improves soil health but also increases productivity. Rise in land values is an incentive to the farmers who can invest further on farm improvements.

Despite the benefits due to investment on soil conservation technologies, there are still sizeable number of farmers who are not serious to invest on soil conservation. Hence, analysing soil conservation technology adoption is important to redesign public interventions and to encourage soil conservation. Thus the three issues are integrated in the analytical framework.

In order to achieve precision in the analysis, the hypotheses were formulated. They were: soil erosive farm practices lead to a decline in crop productivity and thus decrease the farm returns; the conservation structures enhanced the net benefit and the land value is highly influenced by the qualitative attributes of land (soil); and soil conservation investment is determined by socio-economic, physical and institutional parameters. In view of what have been discussed above, a study was made in the Nilgiris district with the following specific objectives: (a) to assess the extent and nature of soil conservation practices adopted by the farmers; (b) to evaluate the financial gains of investment on different soil conservation technologies; (c) to study the changes in farm land value as a result of investment on soil conservation technologies; and (d) to determine the factors (viz., personal, physical, institutional and socio-economic) influencing farmers' decision to adopt the conservation measures.

III

METHODOLOGY

Sampling Design

There are two major catchments in the Nilgiris, viz., Kundah and Lower Bhavani. The River Valley Project (RVP) wing of the Department of Agricultural Engineering with the assistance of the National Bureau of Soil Survey and Land Use Planning (NBSS and LUP) has delineated 176 sub-watersheds in the two major catchments which are further divided into five categories as very high priority, high priority, medium priority, low priority and very low priority based on Silt Yield Index.[2]

For the present investigation, multi-stage sampling framework was followed. In the first stage, sub-watershed category which needs very high priority (with high erosion) was considered. This category of sub-watersheds shows highest Silt Yield Index. There are about 42 sub-watersheds which lie under this category. In the second stage also, two sub-watersheds were selected randomly. The selected sub-watersheds are Jagathala and Kattery. Incidentally, these two sub-watersheds have silt monitoring stations to record rainfall, soil loss, silt transportation rate, etc. In the third stage, six villages were randomly selected in each sub-watershed. This was followed by selection of ten farms from each of the 12 sample villages thus making a total sample of 120 farmers. Of them, 50 per cent representing the adopters of soil conservation technologies and the remaining 50 per cent representing the non-adopters were randomly selected from the two different populations of adopters and non-adopters prepared with the help of village level government officers. For this study the farmers who had practised either one of the four soil conservation technologies, viz., staggered trench, stonewall, contour bund, and waterway were treated as adopters. The purpose of dividing the samples into two categories was to precisely assess the impact of soil conservation technologies.

The data for the present study pertained to the year 1994-95. Potato, carrot, cabbage and tea were the major crops cultivated in the selected sub-watersheds; therefore, these four crops were considered for various economic analyses. The conservation technologies considered were construction of stonewall, contour bund, staggered trench and waterway. The data on the cost of production of crops, investment and maintenance of soil conservation structures, factor prices, output and other required information were collected both from primary and secondary sources.

Analytical Framework

1. *Investment Analysis*

For long-term projects such as soil conservation structures that will last for several years and have differently shaped future costs and benefits streams, the use of discounted techniques will help to make appropriate choice of investment projects. Discounted methods have been widely used for long-term conservation projects. Various authors have computed net present value (NPV), benefit-cost ratio (BCR) and internal rate of return (IRR) to assess the feasibility of various soil conservation measures by considering the life of project as 25 years, at different discount rates (Tejwani and Babu, 1982; Babu *et al.*, 1985; Dhyani *et al.*, 1993). The present study also computed NPV, BCR and IRR to assess the financial feasibility of soil conservation structures.[3]

2. *Econometric Application*

(a) *Hedonic model*

A hedonic model was employed to study the influence of characteristics of farm land on its value.[4] Miranowski (1984), Bartic (1987), and Palmquist (1989) in their studies have demonstrated the application of hedonic techniques to value farm lands, farm land sales and land improvements respectively. One of the objectives of the present study is to examine the changes in farm land values due to several soil quality characteristics. Therefore, hedonic model was estimated.[5] The model is:

LNDPR = f {SODEP, SOILWET, LOCAT, FSIZE, PCROP, SOILQUL, POPCHGE, POPDEN93, SOILHU, SOILQLD, POPSOIL, SOWCROP}

where
- LNDPR = Value of land per hectare (lakh rupees),
- SODEP = Soil depth (cm),
- SOILWET = Dummy = Soil wetness (1 if poorly (or) very poorly drained; 0 otherwise),
- LOCAT = Dummy = Location of land in relation to community housing,
- FSIZE = Farm size (ha),
- PCROP = Per cent of crop land,
- SOILQUL = Quality of soil rating (poor = 1, average = 2; good = 3),
- POPCHGE = Percentage population change in the villages of watershed between 1981-91,
- POPDEN 93 = Population density in 1993 (persons per ha),
- SOILHU = Dummy = presence of humus in soil (1 if present; 0 otherwise),
- SOILQLD = Dummy = poor soil quality (1 if present; 0 otherwise); an alternative definition of SOILQUL,
- POPSOIL = Interaction term POPDEN 90* SOILQUL, and
- SOWCROP = Interaction term SOILWET* PCROP.

Several quality characteristics determine the value of land. Soil depth, soil fertility, soil wetness, soil with rich humus content and degree of erosiveness are the quality variables considered in the model. Besides population pressure in the locality, location of land in relation to community housing and farm size are expected to exert significant influence on value of land. Since the economies of scale can be realised in larger farms and the farmers are keen to grow plantation crops in the Nilgiris, which in turn require larger farm area, the land in larger farms had higher value. The same logic applies to percentage of crop land in a farm. In view of this, farm size and crop area were considered in the hedonic model. Three versions of hedonic model were estimated. The rationale for running three versions was to capture the exact influence of the certain qualitative variables, viz., soil quality and their interaction effects, either separately or in combination with the rest of the variables included in the model.

(b) *Adoption model*

To understand the role of physical, personal, institutional and socio-economic factors individually and collectively in influencing the adoption of number of soil conservation practices, a linear adoption model incorporating the aforesaid variables was estimated. The model is:

SCTADP = f {ERPTL, SLDPTH, EDN, CNSRAT, AGE, FRDEP, FRSIZE, PCROP, RSKAV, NFIN, SUBDY, DEBT}

where SCTADP = Number of soil conservation practices - dependent variable,
ERPTL = Erosion potential (High-3; Medium-2; Low-1),
SLDPTH = Soil depth (cm),
EDN = Education (Illiterate-0); Primary-1; Secondary-2; Collegiate-3),
CNSRAT = Conservation attitude[6] (conservation attitude index was constructed with information on farmer's predisposition towards soil conservation),
AGE = Chronological age of the survey respondents,
FRDEP = Number of family dependents on the available land area,
FRSIZE = Farm size (ha),
PCROP = Percentage of crop land,
RSKAV = Risk aversion (coefficient of variation in net farm income of the farmers for the four representative crops considered in the study for seven years from 1990 was used as proxy),
NFIN = Net farm income (thousand rupees/ha),
SUBDY = Institutional subsidy[7] (thousand rupees/ha), and
DEBT = Debt level (very much concerned-2; somewhat concerned-1; not concerned-0).

The soil characteristics which are expected to influence the adoption of soil conservation technologies are erosion potential and soil depth. The farmers in high erosion prone sites will be the front runners in adopting soil conservation technologies. As regards soil depth, the farmers who possess lands with higher soil depth may not be interested to invest on soil conservation as their crop productivity may not be affected in the short run. Education, age and attitudes on risk and soil conservation are the personal and/or social variables which are expected to determine the technology adoption. The economic variables which are expected to influence adoption are farm size, share of crop land in the total land resource, net farm income, subsidies and debt level of farmers.

IV

RESULTS AND DISCUSSION

1. *Characteristics of Farms*

The cropping pattern on the sample farms exhibited the dominance of horticultural crops (Table 1). There was a shift in the cropping pattern in favour of growing more of tea at the cost of vegetable crops.

TABLE 1. CROPPING PATTERN IN SELECTED HOUSEHOLDS IN THE NILGIRIS DISTRICT BETWEEN 1985 AND 1995

(per cent)

Crop (1)	1985 (2)	1995 (3)
Potato	27.69	20.35
Carrot	11.43	8.26
Cabbage	3.92	2.31
Tea	50.95	63.42
Others*	6.01	5.66
Total	100.00	100.00

*Garlic, radish, bean, pea, etc.

Of the total cropped area, non-food crops constituted 96.67 per cent (Table 2). On the sample farms only 5.83 per cent of the farmers irrigated the crops with well water during

TABLE 2. SELECT CHARACTERISTICS, PRODUCTIVITY DECLINE AND ADOPTION OF SOIL CONSERVATION TECHNOLOGIES

Description	Figures
Average size of the farm (ha)	1.54
Total cropped area (ha)	184.95
Non-food crops (per cent)	96.67
Irrigated crops (per cent)	5.83
Productivity decline (per cent)	
Potato	16.72
Carrot	15.21
Cabbage	12.97
Tea	8.16
Adoption (per cent farmers)	
Contour bund	49.17
Staggered trench	23.33
Waterway	18.33
Stonewall	9.17

*Pertains to adopter category only.

summer months to supplement natural showers. In the selected sub-watersheds, an average soil loss of 5.88 tonnes/ha was noticed. A productivity decline of 16.72 per cent, 15.21 per cent, 12.97 per cent and 8.16 per cent was reported for potato, carrot, cabbage and tea crops respectively.[8] It was found that the yield decline was exclusively due to soil erosion. Care was taken to exclude losses in yield due to other factors in order to capture yield loss due to soil loss alone.

2. *Soil Conservation Technologies*

Terracing was the most commonly adopted soil conservation practice. About 96 per cent of the farmers adopted this soil conservation technology. Contour bunding was adopted by 49.17 per cent of the farmers and stonewall by 9.17 per cent of them. Even though the initial cost for the construction of stonewall remained high, the farmers (mainly medium and large) preferred stonewall. Besides the technical feasibility and economic viability, its durability and erosion controllability confirmed the superiority of the stonewall. Non-availability of stones and transportation to interior areas have restricted the construction activity to certain extent. Despite their short-term sustenance and frequent treatments, the farmers preferred contour bunding and staggered trenching because of low initial investment and local technical know-how. For the purpose of comparing the conservation structures, a uniform time horizon of five years was considered for calculating NPV, BCR and IRR. It was assumed that prices remain constant during the period of analysis.

(a) *NPVs:* The NPVs of potato for different conservation technologies are presented in Table 3. In this analysis, the NPVs reflect the impact of adoption of different conservation technologies. Among the various soil conservation technologies considered, stonewall gave the maximum NPV of Rs. 21,919, followed by contour bunding with Rs. 10,788, waterway with Rs. 10,467 and staggered trenching with Rs. 6,734 at 10 per cent discount rate. The foregoing results indicated the superiority of the stonewall.

The NPVs for carrot under different soil conservation technologies also showed similar pattern as that of potato but marginally lower than for potato, indicating the significant impact of conservation structure on both potato and carrot. The NPVs for cabbage have shown the same pattern as observed for potato and carrot but the effect was found to be little less than for the other two crops. The tea crop exhibited a different situation. Even though stonewall was found to be the dominating soil conservation technology with high NPV (Rs. 13,918), it was followed by waterway (Rs. 8,482), staggered trenching (Rs. 7,315) and contour bunding (Rs. 4,639). Since tea crop is cultivated even in undulating terrains, the contour bunding might not have been effective in controlling soil erosion due to very high velocity of run-off water. Wherever tea crop was cultivated, the efficacy of waterway has been more pronounced than contour bunding and staggered trenching. On the sample farms, frequent silting of trenches and breaching of contour bunds were the common occurrences especially in tea gardens. Overall, the high NPVs for different soil conservation technologies suggest the profitability of conservation farming. This is an important information to be passed on to the farmers and policy makers for allocating sufficient resources for soil conservation programmes.

(b) *BCR and IRR:* The BCR provides an easy way to compare the relative profitability of different conservation investment opportunities and thus spell out the economic solution to the investment alternatives. For an investment to be economically viable, the BCR should be more than unity. The results of the BCRs for potato, carrot, cabbage and tea at 10 per cent discount rate are presented again in Table 3. As for potato, the stonewall gave the highest BCR value of 2.93. For carrot and cabbage the BCRs did behave similar to that of potato, but the ratios were lower for tea. Next to stonewall, the contour bunding gave the highest BCR value, followed by waterway and staggered trenching. The superiority of contour bunding might be due to the moisture conserving capacity of the technique, which contributed for higher crop productivity. This argument was supported by may of the survey respondents.

TABLE 3. NPVs, BCRs AND IRR FOR VARIOUS SOIL CONSERVATION TECHNOLOGIES

Soil conservation technology	Discount rate at 10 per cent			
(1)	Potato (2)	Carrot (3)	Cabbage (4)	Tea (5)
Contour bund				
NPV (Rs.)	10,788	9,942	8,986	4,639
BCR	2.21	2.14	2.01	1.07
IRR (per cent)	29.72	28.16	26.39	17.14
Staggered trench				
NPV (Rs.)	6,734	6,332	6,149	7,315
BCR	1.54	1.39	1.36	1.64
IRR (per cent)	22.14	20.97	19.16	13.22
Stonewall				
NPV (Rs.)	21,919	20,698	18,375	13,918
BCR	2.93	2.86	2.88	1.76
IRR (per cent)	40.07	38.49	34.64	24.12
Waterway				
NPV (Rs.)	10,467	9,933	8,685	8,482
BCR	1.76	1.63	1.50	1.34
IRR (per cent)	26.83	25.02	23.39	13.25

The IRR was the discount rate at which the NPV becomes zero (Table 3). The stonewall gave the maximum IRR value for all crops, followed by contour bunding, waterway and staggered trenching. The IRR crystallises the superiority of the stonewall in terms of economic viability. The overall results on feasibility analysis for various soil conservation technologies across the selected crops are encouraging and advocate the advantages of adopting conservation practices to enhance farm income. Among technologies, stonewall appeared most profitable, followed by contour bunding for all the four crops.

3. *Hedonic Model Results*

Table 4 suggests that all the variables did bear the expected signs in all three model versions. Soil depth (SODEP), soil wetness (SOILWET), percentage of crop land (PCROP) and soil quality (SOILQUL) emerged significant. The shifter variables, viz., farm size, population change, population density and the interaction term between population density and soil quality did not have any significant influence on land value. In model version II, the independent variable, soil quality was replaced with two dummies, SOILHU to capture the presence of humus in the soil and other SOILQLD to represent poor/good quality soil in the place of graded rating of SOILQUL variable. In this version, the R^2 measure was not significantly affected and the magnitudes and significance of the other explanatory variables were also essentially unchanged. The analysis indicated the significance of soil quality on land value in whatever way it is represented. The poor quality soil had negatively influenced the land value. The model results were in conformity with the expected outcome of a similar model employed elsewhere (Palmquist, 1989).

TABLE 4. RESULTS OF HEDONIC MODEL

Variable (1)	Model version I (2)		Model version II (3)		Model version III (4)	
SODEP	0.0170**	(2.931)	0.0040**	(2.498)	0.1590**	(2.589)
SOILWET	-0.1172**	(-2.771)	-0.0459*		-0.1773*	(-1.743)
LOCATE	0.5016	(0.561)	0.0512	(-2.649)	0.0365	(0.753)
FSIZE	0.0064	(0.289)	0.0029	(0.932)	0.0061	(0.270)
PCROP	0.0089**	(2.419)	0.0042**	(0.421)	0.0097*	(2.172)
SOILQUL	0.2130**	(2.464)		(3.502)	0.1983**	(2.490)
POPCHGE	0.0590	(0.012)	0.0123		0.0581	(1.561)
POPDEN 90	0.1510	(0.242)	0.0675	(1.095)	0.0910	(0.126)
SOILHU			0.0554**	(0.260)		
SOILQLD			-0.0068**	(2.388)		
POPSOIL	-0.2610	(-1.017)	-0.1105	(-2.345)	0.3096	(1.136)
SOWCROP				(-1.225)	-0.0091	(-0.529)
Intercept	0.8970		0.8941		0.8750	
R^2	0.8910		0.8320		0.8209	

* Significant at 5 per cent level. ** Significant at 1 per cent level. Figures in parentheses are 't' values.

The results shown in model version III reflected the addition of an interaction term between soil wetness and land use. The inclusion of this interaction term had little statistical significance. The results for the other variables were scarcely affected by the addition of the interaction term although not surprisingly the 't' ratio was reduced for soil wetness when that variable entered the model in two forms. The newly introduced variable SOWCROP also did not have any significant impact on the value of farm land.

The information obtained from the model results affirms that the soil/land quality characteristics are critical variables in determining the land value. This provides ample evidence that the farmers must invest on soil conservation technologies in order to sustain and enhance the land productivity and its value. Since the study region has a slopy undulating terrain, soil depth determines the land value to a great extent. As such location of land has no significant influence on farm land. So also no major changes were observed in the population density in the last one decade and hence its impact on land value was not realised.

The farm land value which reflects the productive capacity of land emerges as a critical variable in agricultural production. Therefore, understanding the process of determination and role of farm land values should command high research priority. The empirical results provided qualified support for the proposed hypothesis that the farm land values rely largely on qualitative characteristics. Hence, one of the recommendations affirmed by this study is that considerable attention has to be devoted to analyse the consequences of soil characteristics and devise means to minimise the damage to farm land values. Along with regulatory controls like legislative means to check over-exploitation of land resource, strengthening of village institutions and providing orientation training programmes to the farmers in land management will be highly rewarding. The results obtained from the hedonic model clearly demonstrated the influence of soil depth, soil wetness, percentage of crop lands, soil quality, etc., on farm land values and the need to conserve the land resource.

4. *Investment Decision Behaviour*

The farmers viewed soil conservation in different ways. The long gestation period of the conservation projects and also their low-paced payback constrained the adoption decision. Further, there were certain other attributes which hindered the adoption decision of soil conservation technology by the hill farmers. As one of the objectives was to study the impact of physical, personal, institutional and socio-economic factors on adoption of conservation practices, it was decided to estimate an adoption model to quantify the influence of these factors. The model results are presented in Table 5.

TABLE 5. FACTORS INFLUENCING ADOPTION OF SOIL CONSERVATION TECHNOLOGIES - RESULTS OF ADOPTION MODEL

Variable (1)	Partial regression coefficient (2)	't' value (3)
EPTL	0.1226	2.177*
SODEP	-0.0164	-3.200**
EDN	0.0287	1.902*
CNSRAT	0.6961	2.646**
AGE	-0.0093	-2.022*
FRDEP	-0.0320	-0.951
FRSIZE	0.1716	1.641
PCROP	0.0273	1.849*
RSKAV	-0.0291	-3.155**
NFIN	0.1183	0.613
SUBDY	0.4085	4.227**
DEBT	-0.0852	-1.564
Constant	-2.7057	-8.296

* Significant at 5 per cent level. ** Significant at 1 per cent level. $R^2 = 0.8161$.

The coefficients of variables have largely the expected signs. The choice variables, viz., erosion potential, percentage of crop lands and educational level were significant and positive; while age of the farmer has a negative influence on adoption of soil conservation practices. Conservation attitude, and institutional subsidy positively influenced the adoption of soil conservation technologies. Risk aversion and soil depth have negative impact on adoption of soil conservation practices. The coefficient of soil depth suggests that a unit decrease in soil depth will increase the number of soil conservation practices by 0.0164 unit. Similarly, one unit increase in the percentage of crop land increases the conservation practices by 0.0273 unit. So also a unit change in institutional subsidy will increase the adoption of conservation practices by 0.4085 unit. The above results clearly confirm that soil depth, cultivated area and subsidy are critical variables for promoting soil conservation programme.

V

CONCLUSIONS AND POLICY IMPLICATIONS

The present investigation was undertaken with a view to analysing the critical issues relating to soil conservation in a hilly district, the Nilgiris. Among soil conservation technologies, about half of the farmers adopted contour bunding. The next important technology adopted by the farmers was staggered trenching, followed by construction of waterway and stonewall. In order to assess the returns to investment on soil conservation technologies, financial measures such as NPV, BCR and IRR were computed for these technologies. Among them, stonewall was found to be more profitable, followed by contour bunding, waterway and staggered trench for potato crop. A similar pattern was observed for carrot and cabbage but with a lesser magnitute. For tea crop, the waterway was the second important technology in terms of returns, followed by staggered trenching and contour bunding. Evidently, the response of potato, carrot and cabbage to soil conservation technologies had been comparatively better. The BCRs and IRRs showed similar results as that of NPVs in terms of ranking of soil conservation technologies for different crops. The hedonic model results clearly revealed that soil quality characteristics rather than physical and socio-economic variables dominated in determining the land value. This fact underscores the need for adopting soil conservation technologies which will help to sustain soil quality.

To have a better understanding on behaviour of farmers in adopting soil conservation technologies, an econometric model relating to the adoption of conservation practices was estimated. Erosion potential, soil depth, farmer's education, his conservation attitude and age, crop area, risk aversion and institutional subsidy significantly influenced the adoption decision of soil conservation technologies, whereas net farm income, farm dependents, size of holdings and debt levels did not exhibit any influence on the adoption of conservation practices. The study brought forth a number of policy implications. The most important policy options which require serious considerations are as follows:

Investment on soil conservation measures is beneficial; and contour bunding and stonewall were found to be the superior technologies in terms of economic returns. This is an important information to be passed on to the farmers through extension departments, mass media and non-governmental organisations.

Risk aversion negatively affected the investment on soil conservation measures. Introduction of appropriate insurance policy to minimise the effect of risk and uncertainty on soil conservation structures, and crop production will provide a conducive environment for more investment in soil conservation measures.

As the soil characteristics, viz., soil quality, soil depth, soil wetness, etc., are significantly influencing the farm land values, the outcome of the research findings can be used in deciding the level of subsidies (based on the extent of soil erosion damage and changes in the soil characteristics) to be extended by the government for conservation projects to make the farmers convinced about the conservation farming.

Promulgating legislative measures and regulatory controls to check the over- exploitation and misuse of land resource will ease the problem of pressure on land, besides protecting the original and indestructive properties of the soil.

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NOTES

1. The Nilgiris district is a hilly district with a geographical area of 2,54,300 hectares. Economically important crops of tea, potato, cabbage, cauliflower, etc., are grown in more than 90 per cent of the area, which are largely grown in hill slopes. Since the soil erosion is severe and substantial investment has been made on soil conservation in the Nilgiris, the district emerged more appropriate to study the economics of soil conservation.

2. Silt Yield Index = $\frac{(Aei \times Wt \times DR) \times 100}{Aw}$

where Aei = Area of the erosion intensity unit,
Wt = Relative weight assigned to the Aei,
DR = Adjusted delivery ratio, and
Aw = Area of the sub-watershed.

3. For a detailed discussion on investment analysis and concepts, viz., NPV, BCR, IRR, etc., refer Gittinger (1972).

4. In the study, 'land value' alone was considered. The value of a unit of land was defined as the market rate of the unit perceived by the farmers, whose perceptions are based on land sales which have taken place in the village or locality, most recently.

5. The functional form of the hedonic equation was selected empirically by considering the residual sum of squares. Among the most common functional forms (linear, semi-log, log linear and inverse semi-log), the linear form was found to be preferable to run the hedonic equation analysis for the present investigation.

6. To measure the conservation attitude of the farmers, the "Likert Method" used by Pillai and Nair (1978) was applied and 10 statements having the maximum 't' values were selected and scales constructed.

7. Subsidy extended by the Government through bank loans for soil conservation activities (the subsidy varies based on categories, viz., small, medium, scheduled caste/scheduled tribe, etc.).

8. The estiamtes of productivity decline were obtained from Department of Agricultural Engineering (River Valley Project), Coonor, the Nilgiris District, Tamil Nadu.

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