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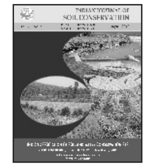

Soil erosion control measures impact on productivity of tea leaves and economics of tea plantation in South India

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ABSTRACT

Effective Soil and Water Conservation (SWC) measures are needed to control water induced soil erosion for not only sustained agricultural production but also for ecological balance of hills in southern India. Land degradation due to soil erosion is a serious problem in the region due to low adoption rate of recommended SWC measures owing to high initial investment cost and no eventual benefits in short term. The research study assessed the costs and benefits of three SWC measures in new tea plantation. Financial Cost Benefit Analysis (FCBA) was done considering the long term impacts of SWC measures in tea plantation. The result shows that it takes at least 6 years to recover the initial investment towards planting of tea clones without SWC and only 4 years with SWC measures. However, all the three SWC measures are attractive for the farmers and gave higher financial returns in terms of benefit cost ratio (BCR), net present value (NPV) and internal rate of return (IRR). Among the SWC measures, growing economically important cover crop like French bean (*Phaseolus vulgaris*) alongwith contour staggered trenches (CST) in new tea plantation was observed to be effective SWC measure, more attractive for the farmers and economically efficient to small and marginal farmers since cover crop provides returns in the initial year of tea planting. Financial efficiency of only SWC measures indicated that investment made on SWC measures was able to recover within 3 years in case of CST and in the same year for cover crop. It was also observed that these SWC measures can generate considerable employment opportunity for the family members. The result of the sensitivity analysis showed profitability of these SWC measures even under adverse situations. It is concluded that high investment costs on tea planting and SWC measures coupled with initial low returns are major hindrances to farmers in the southern hills of India. Small scale credit schemes at reasonable interest rate by any financial institution or tea processing factories, group or joint farming for sharing their labours, annual phasing out the tea planting depending on investment capacity are the some of the suggested mechanisms to overcome the problem of high initial investment cost to adopt SWC measures for preventing environmental degradation in the hilly region.

Key words:
Cost and benefits,
Nutrients,
Soil and water conservation measures,
Southern hills of India,
Tea plantation

1. INTRODUCTION

Soil erosion due to biotic and abiotic stresses has a debilitating effect on productivity of crops thus influencing socio-economic status of farming community. Soil conservation has ability to ensure energy and food security for growing population by adapting and building resilience to climatic change scenarios (Young and Crawford, 2004). Globally, around 3506 M ha (23.5% of the total geographical area) are degraded and currently degraded area is supporting nearly 1.5 billion (23.9%) rural population (Bai *et al.,* 2008). The degraded land reduced global food production up to 12% and is likely to increase world food price even upto 30% (Ephraim Nkonya *et al.,* 2016). Presently, more than a billion population is living in areas where decline in productivity due to land degradation is affecting socio-economic condition and food production (Nellemann *et al.,* 2009). Further, Den Biggelaar *et al.* (2004) reported that the yield loss ranges between 0.49 and 1.44 kg $ha^{-1}Mg^{-1}$ of soil loss for grain and legumes, and 0.69 and 127 kg $ha^{-1}Mg^{-1}$ of soil loss for root crops. In India, a total of 121 M ha productive land is degraded, mainly due to water erosion (83 M ha) and causes a loss of 8 Mt of major nutrients (Maji, 2007; Prasad and Biswas, 2000) resulting in decline of crop yields upto 60% (Sharda *et al.,* 2010; Bhattacharyya *et al.,* 2007). To manage the soil resources in India, the tolerable soil loss limits have been estimated between 2.5 to 12.5 t ha^{-1} depending upon soil quality and depth (Mandal *et al.,* 2009). In ecosystem services studies and policy level decisions, soil is as an overlooked natural resource (Hewitt *et al.,* 2015).

SWC measures need to be adopted to control soil erosion, prevent further land degradation and to maintain agricultural productivity (De Graaff *et al.,* 2008; Tenge *et al.,* 2005). Abonesh Tesfaye *et al.* (2016) reported that many soil conservation measures in watersheds significantly increased productivity of crops, which contributed greatly to food security. Presently, soil erosion remains a serious problem and adoptions of conservation practices by farmers are limited in spite of rapidly growing knowledge about effect of soil erosion (Kerr, 1998). The farmers cannot distinguish between losses due to soil erosion and impact of recommended SWC measures; this is an important reason for low adoption of SWC measures in crop production (Tenge *et al.,* 2004). The low adoption is also due to SWC measures competing with other limited resources, and profit are not directly visualized in a short time (Posthumus and de Graaff, 2004).

At present, tea is cultivated in more than 45 countries between latitudinal range of 45^0 N and 34^0 S (Barua, 2008), covering 3.94 M ha area globally. In India, tea is grown in an area of 0.58 M ha and accounts for 14.7% of world tea cultivated area (Basu *et al.,* 2010). Tea is grown in more than 70% of total cultivable land and dominated by small tea growers in the Nilgiris. The average annual growth rate of area under tea is 2% in the Nilgiris district as against 1.12% in southern India during the current decade. Mainly there are three tea growing regions in India, namely Darjeeling (North-Eastern India), Assam (North-East India) and Nilgiris (South India) which provide employment opportunity to more than 1.25 million population. About 60% of the cultivable land is under slope group of 16 to 35% (Madhu *et al.,* 2010; Tripathi and Sikka, 1999) and has resulted in high soil erosion rates in the Nilgiris. During initial years of tea planting, soil loss ranges from 28 to 40 t $ha^{-1}yr^{-1}$ in absence of any vegetative canopy and suitable soil conservation measures, which leads to declining productivity of land and reduction in storage capacity of water bodies (Madhu and Tripathi, 1997).

The question is whether benefits of a given SWC measure is worth the expenditure, and thus it becomes vital to understand the financial costs and benefits linked with adopting SWC measures. It's therefore very important to value both economic and environmental benefits of agricultural practices in order to show real costs and benefits of SWC practices (Ninan, 2007). However, the intangible benefits of SWC are not directly noticeable, and may differ among diverse groups of farmers, and may take more time for realization (Posthumus and De Graaff 2005; Tenge *et al*., 2005). The Nilgiris is a fragile eco-system and one of the 25 biodiversity hotspots in the world subjected to high degree of soil erosion due to cultivation on steep slopes without any soil conservation measures. Despite this, regional scale studies evaluating impacts of SWC measures on crop productivity remain relatively scarce. The objectives of this paper are to assess impact of soil conservation measures on yield of green tea leaves and soil nutrients loss, and financial viability of different SWC measures *viz*., CST, cover crop and combination of both in new tea plantation, especially for the small tea growing farmers in the Nilgiris region.

2. MATERIALS AND METHODS

Study Area

The Nilgiris is located in Southern high hills consisting of great plateau, up heaved at the Eastern and Western *Ghats* and running southward at a converging angle (Chand *et al*., 2009). It's elongated in the east-west direction and is located between 10°38' and 11°49'N latitudes and 76°10' and 77°15'E longitudes. The topography is rolling, steep and elevation ranges from 900 to 2636 m above mean sea level (amsl) with an average annual rainfall of 1921 mm. The economy of Nilgiris depends upon agriculture which occupies about 45% of the total geographical area of the Nilgiris. Agriculture is primarily horticultural crops based, which include vegetables, flowers and plantation crops like tea, coffee and spices.

Experimental Site Characteristics

The study was conducted from 1995 to 2003 at the Research Farm of ICAR-Indian Institute Soil and Water Conservation (IISWC), Research Centre, Udhagamandalam, Tamil Nadu, India. Experimental site is located at an elevation of 2217 m amsl, at 70°41' longitude and 11°24' latitude. High rainfall erosivity is observed during the months of September and October followed by April to July. Mean evaporation is 3.2 mm day^{-1} with a maximum evaporation of 4.7 mm day^{-1} (March) and a minimum of 2.3 mm day^{-1} (August). Mean annual potential evaporation is 988 mm. Average reference crop evapo-transpiration (ET_0) is 3.16 mm day^{-1} (Allen *et al*., 1998). The soil is very deep, well drained, granular silty clay loam (Sand: 17.04%; Silt: 44.97% and Clay: 37.99%). The soil is medium in available nitrogen (486 kg ha^{-1}), low in available phosphorous (8.5 kg ha^{-1}) and high in available potassium (423 kg ha^{-1}). The initial organic carbon content of the soil was very high (3.51%). The general land slope of the study site is 25% (Madhu *et al*., 2010).

Tea Planting and Conservation Measures

One year old B-6 tea clones were planted in pits of 0.15 to 0.20 m diameter and 0.45 m depth along contours. Double hedge contour staggered planting method was followed to plant tea clones. The spacing of 1.35 m between paired rows, 0.65 m between the rows and 0.75 m between plant to plant in a row was followed (Fig. 1). During the first year of planting, frost cover was provided to each tea plants using *Cystisus scoparius* which is common local weed used by the farming community. Standard management practices were followed for the tea crop.

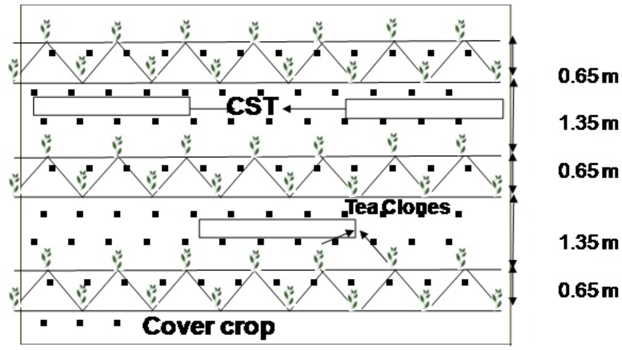

Fig. 1. Planting layout of tea with SWC measures

CST, cover crop of French bean (*Phaseolus vulgaris*) and combination of both were the three SWC measures studied. These measures were compared with tea plantation without conservation measure (Control). The trenches (2.0 m length, 0.45 m width and 0.3 m depth) were excavated in between the paired rows of tea with a density of 1250 trenches per ha. Desilting was done (100%) every year before the onset of monsoon. Cover crop of French bean (*Phaseolus vulgaris*) was grown during the first three years of tea planting. Cover crop residue was used as mulch after the harvest of tender pods of beans. The cover crop was established to full canopy by about 40 to 45 days after sowing. The experiment was laid out in a randomized block design. There were four treatments with five replications and eight year data was used for analysis.

Rainfall, Runoff and Soil Loss Data Monitoring

A standard rain gauge and a siphon type recording rain gauge were used to measure the amount and intensity of rainfall. Runoff was monitored from the four treatments in one replication using multislot deviser connected with tanks and barrel. The tanks and barrels were covered with lid made out of GI sheet to prevent collection of precipitation and to stop evaporation of the collected runoff water. Each plot was of 54 m^2 area and GI sheets (30 cm height) were installed around the runoff plots to divert the runoff water from each plot to tanks through multislot deviser. Depth of runoff water collected in the tanks and barrel was measured by wooden scale. Total volume of runoff was calculated using depth of measured runoff water storage and dimensions of tanks and barrel. Sample volume of 1000 ml runoff water was collected from each runoff tank after stirring to determine the silt content in the runoff water. Runoff and soil loss were measured and calculated daily during the rainfall events. All the runoff water collection units were empted immediately after sampling and depth measurement of runoff water storage. Rainfall events wise analysis was done and expressed in mm and tons per ha per year for runoff and soil loss, respectively.

Yield of Tea and Cover Crop

Plot wise green tea leaves were harvested as per standard schedule and practice. Yield data was expressed in tons per ha per year. The tender pods of beans were harvested from cover crop as per the standard schedule and practices.

Identification of Costs and Benefits

Investment costs included labour, cost of planting materials, cost of fertilizers; maintenance cost of tea plantation included tipping, pruning, weeding etc.; harvesting cost of tea leaves was accounted for tea plantation. Costs on SWC measures included labour cost for digging CST and its maintenance by desilting. Cost of raising cover crop included labour, seeds, fertilizers, maintenance, harvesting of tender pods, uprooting and mulching of cover crop residues as the major important cost components.

The benefits of SWC measures on retention of soil, nutrient and water were considered to be reflected in an increase in yield of green tea leaves. All the costs and benefits were quantified treatments-wise to their measurable parameters. The change of productivity approach was used to establish the benefits of SWC in tea plantation (Barbier and Bishop, 1995; Pimentel *et al*., 1995). Benefits only from SWC measures were calculated by subtracting total benefits in each SWC from the total benefits derived from the tea field without SWC measures.

Valuation of Costs and Benefits

All the costs were converted into monetary values using their respective quantitative terms of each year and market-prices. Actual labour used for individual operations were accounted as per the SWC measure and converted into per hectare basis. However, the opportunity cost of labour varied depending on season, possibilities for off-farm employment, and availability and source of labour (Enters, 1998; Gittinger, 2004). Prevailing price was used for all the cost components. Total costs for the respective SWC measure was arrived by summation of all the components of costs.

All the benefits were converted into monetary values by multiplying the benefits in quantitative terms by their corresponding market price. All the benefits were added to obtain the total production value. Year wise total cost and returns from tea plantation without SWC measures was subtracted from total cost and returns of corresponding SWC measures in order to obtain the total additional cost on SWC measures and additional benefits derived due to SWC measures. Multiple regression analyses were done between total returns and different components of cost to know the factors affecting cost and benefits. Results were interpreted at 1 and 5% levels of significance.

Cost Benefit Analysis

Efficiency of the respective SWC measures was evaluated using the FCBA method (Enters, 1998; Gittinger, 2004). Three interest rates were used to represent the variability in inputs rates when farmers borrow capital for new tea plantation with SWC measures. Separate analysis was done only for SWC measures if farmers borrow capital for implementing only SWC measures after tea planting.

Efficiency criteria in the FCBA - BCR, NPV, IRR and pay back period (PBP) - were calculated and interpreted (De Graaff *et al*., 2001). Ratio of discounted gross returns to the discounted total cost over the project period estimates BCR. NPV is the sum of differences between net present benefits and net present cost over the project period. IRR is the average earning power of the money used in the project over the project period. PBP is the year in which all the investment is recovered. Conservation measures with more than one BCR, positive NPV, IRR greater than the respective discount rate and lesser the PBP were considered to be profitable and financially viable from point view of farmers and also to financing institutions.

In FCBA, the project duration of 25 years was considered as by this time, long term impacts of SWC measures were realized.

Sensitivity Analysis

Sensitivity analysis was carried out under three scenarios to understand the risk bearing ability and economic viability of each SWC measure to withstand changes in both physical and socio-economic conditions. Decreased yield of tea leaves by 20% due to drought etc., increased cost of protection by 20% due to rise in input and labour cost, and combination of both are the three scenarios, considered. These variables were subjected to sensitivity analysis because of their greatest impact on the costs and returns.

3. RESULTS AND DISCUSSION

Soil Erosion

Average soil loss was minimum in CST (0.93 t $ha^{-1}yr^{-1}$) followed by CST+cover crop (1.02 t $ha^{-1}yr^{-1}$) and cover crop (1.95 t $ha^{-1}yr^{-1}$) as against 2.84 t $ha^{-1}yr^{-1}$ without conservation measure. Soil disturbance in cultivation of cover crop caused slightly higher soil loss as compared to CST. Soil loss was reduced by 68, 25 and 64% due to SWC measures of CST, cover crop and CST+cover crop, respectively over control. However, soil loss was below the critical limit (4.5-11 t $ha^{-1}yr^{-1}$) from all the treatments during the study period, except during the first year, and it followed a declining trend with the development of tea canopy.

The average minimum runoff (51.8 mm) was observed in CST + cover crop followed by CST (55.9 mm), and cover crop (75.3 mm) as against maximum in control (104.9 mm). SWC measures reduced runoff by 47, 29 and 51% in CST, cover crop and CST + cover crop, respectively as compared to control. All the three SWC measures were effective in conserving rainwater on sloping land. In the CST + cover crop treatment, the canopy of cover crop intercepts rain drops thus helping soil erosion control, whereas CST stores the runoff water collected from the micro catchment and allows collected rainwater to infiltrate more (Madhu *et al.*, 2001). These two mechanisms such as canopy interception and rainwater storage help *in-situ* moisture and nutrient conservation (Madhu *et al.*, 2016; Adhikary *et al.*, 2016).

Crop Yields

Yield of green tea leaves

An Average increase in yield of tea leaves with SWC measures over control was 11, 24 and 23% in CST, cover crop and CST + cover crop, respectively (Fig. 2). Yield of tea leaves increased by 39, 34 and 38% in CST, cover crop, CST + cover crop over control during the post monsoon period as against only 2, 12 and 9% increase in yield for the remaining period of the year (Lean season). The result reveals that growth and yield of tea did not differ significantly between the treatments during the monsoon period but conservation treatments played a significant role by contributing conserved rainwater for efficient utilization during lean period. Higher yield of tea leaves in SWC measures was mainly attributed to better growth and development of tea bushes and tea canopy during the initial years through increased availability of conserved rain water in soil profile as soil moisture along with nutrients, coupled with favourable weather condition, particularly during post monsoon period. Therefore, adequate water in soil coupled with suitable air temperature becomes congenial for plant growth, which results in increased growth rate and higher yield. Runoff during intense rainfall can be greatly reduced by a good mulch cover, canopy cover, and conservation measures. Thus, land management practices affect water and nutrient status in the soil, and increase plant growth and yield (Ali and Talukder, 2008; Falkenmark and Rockström, 2004; Unger and Stewart, 1983).

Tender Pod Yield of Cover Crop

Cover crop as a conservation measure was taken successfully for the first two years of tea planting, and from third year onwards, only the residual effect was studied. Tender pods yield of cover crop of beans was higher during initial two years of tea planting due to better growth of cover crop of beans and poor canopy cover of tea. During the third year, growth of cover crop was poor and yield reduced drastically due to increased tea canopy cover in all the treatments. CST + cover crop recorded lower yield of beans as compared to cover crop due to reduced plant population with CST. The variation in light intensity due to tea canopy caused day and night temperature variation, which had indeterminate effect on growth and development of cover crop resulting into poor growth and low yield. Residual effect of cover crop

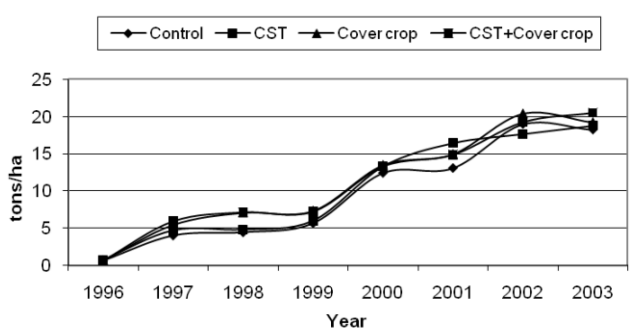

Fig. 2. Influence of SWC measures on yield of tea leaves

and in combination with CST continued to give higher yield of tea leaves even after third year to eighth year as compared to CST.

Soil Moisture Content

It was observed that all the SWC measures were effective in conserving rain water and increased soil moisture content in the profile compared to the tea plantation without SWC measure (Fig. 3). On an average, SWC measures conserved 13 to 18% higher soil moisture than the tea plantation without SWC measure. This shows that during drought like situation and post monsoon season, yield of green tea leaves is expected to be higher with SWC measures, thus these measures contributed towards higher yield.

Nutrients Conserved Due to Soil Conservation Measures

During the study, the nutrient loss was observed to be directly proportional to runoff and soil loss. Major nutrients *viz*., nitrogen, phosphorus and potassium were assessed during the study period and data revealed that the average total major nutrients loss was maximum under control (20.33 kg $ha^{-1}yr^{-1}$) and followed by cover crop (14.62 kg $ha^{-1}yr^{-1}$), CST + cover crop (8.78 kg $ha^{-1}yr^{-1}$) and minimum was in CST (8.51 kg $ha^{-1}yr^{-1}$) (Fig. 4). In other words, nutrients conservation was greater in CST (11.82 kg $ha^{-1}yr^{-1}$) followed by CST + cover crop (11.55 kg $ha^{-1}yr^{-1}$) and cover crop alone (5.71 kg $ha^{-1}yr^{-1}$) over control. Low nutrients conservation efficiency of cover crop and CST + cover crop was attributed to high soil nutrients concentration in soil due to added fertilizer to cover crop. These lost nutrients may pollute water bodies causing eutrophication, reduction in water storage capacity, etc., as off site effect of soil erosion (Telles *et al.*, 2013). The main onsite impact of soil erosion is decrease in crop yield and value of land, loss of soil

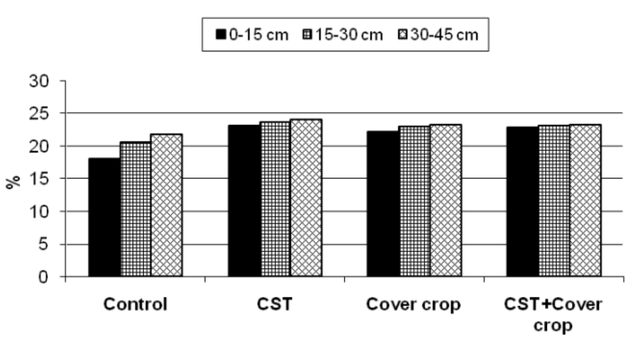

Fig. 3. Average soil moisture content under SWC measures in tea plantation

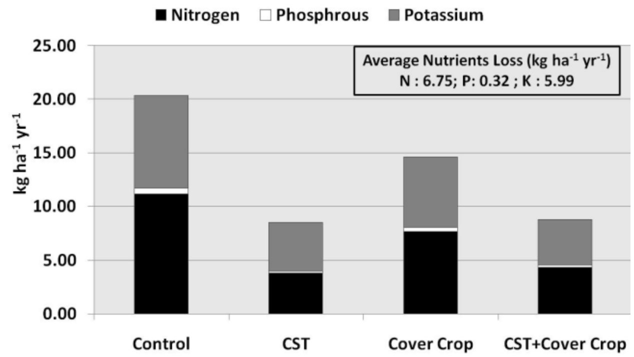

Fig. 4. Average nutrients loss due to soil erosion under SWC measures in tea plantation

biological activity and soil nutrients (Telles *et al.*, 2013). Continuous cover crops can reduce on-farm erosion nutrient leaching and build soil organic matter which improves water balance, leading to higher yields (Olson *et al.*, 2010). Tea plants continuously mine the nutrients from soil since young leaves are plucked regularly (Dang, 2005) and average harvest of 3000 kg ha^{-1} tea removes around 150 kg N and 60 kg K_2O $ha^{-1}yr^{-1}$ from soil (Ananthacumaraswamy *et al.*, 2003). Furthermore, continuous uptake of nutrients by tea plants coupled with continuous removal of produce leads to an overall negative nutrient balance at the farm level (Giller *et al.*, 1997). Tea plantations with SWC measures conserve valuable nutrients and enhance the productivity by reducing environmental degradation.

Factors Affecting Costs and Benefits

The result of the multiple regression analysis is presented in Table 1. On cost side, cost involved towards maintenance, SWC measures control harvesting, fertilization and other labour cost were considered and on the other side total return was considered. Cost involved towards the planting and establishment of tea is considered to be more critical. Tea plantation without SWC measures showed negative relation with the total returns since the constant is negative indicating huge investment made during the initial year of tea plantation. However cost for harvesting green tea leaves had significantly positive relationship with the total returns and remaining cost components were positive but not significantly influencing the returns.

General maintenance cost of tea plantation with SWC measures was observed to have significantly negative relationship with total returns when SWC measures of cover crop and cover crop with CST are

Table: 1
Multiple regressions co-efficient for different SWC treatments in tea plantation

Cost	Control	Cover crop	CST	CST+Cover crop
Constant	-31804.54	49425.66*	290301.46**	33755.04
Maintenance	0.61	-0.94*	24.13**	-0.65
SWC	-	3.44**	-310.26**	3.70**
Harvesting	1.82*	2.79**	2.30**	2.67**
Fertilizer	1.84	4.55**	-15.72**	4.62**
Labour	11.61	-26.55**	-49.103**	-21.99**

*Significant at 1%; **Significant at 5%

implemented in tea plantation. This was attributed to additional cost involved towards the cultivation of cover crop. Cost for CST was negatively related where as cost towards taking cover crop alone and in combination with CST had positive contribution towards the total returns due to initial returns obtained from cover crop. In all the SWC measures, harvesting cost had positive contribution towards the total returns since total returns depend on yield of green tea leaves. Cost of fertilizer contributed positively towards the returns in all the SWC measures, except in case of CST alone. In all SWC measures, labour cost was negatively contributing towards the total returns due to cost involved in harvesting additional tea leaves.

Employment Generation

Total and additional number of man days (MDs) generated in tea plantation with SWC measures showed that a total of 2013 MDs (control) to 2526 MD of employment was generated over a period of 9 years under different treatments in tea plantation with maximum in CST + cover crop (2526 MDs) followed by cover crop (2342 MDs) and CST alone (2302 MDs). Average annual total MDs works out to 280, 260, 256 and 223 MDs for CST + cover crop, cover crop, CST and control, respectively. The additional total MDs generated due to SWC measures varied from 288 in CST to 513 for CST + cover crop for the same period. The average annual additional MDs of employment generated due to SWC measures was highest in case of CST and cover crop (57 MDs) followed by crop (37 MDs) and CST (32 MDs). This additional employment was generated by taking up SWC measures and harvesting of increased yield of tea leaves, particularly due to the impact of SWC measures. This has particularly helped small tea growers by generating employment opportunity to the family members so that they need not to go in search of employment.

Benefits

The tangible benefits from the three SWC measures in this study were identified to be an increase in yield of green tea leaves, additional monetary returns from cover crop and increase in family employment opportunity. Increased rainwater productivity, reduction in silting up of streams and there by greater reduction in damages/losses due to flooding, and increase in economic viability and returns of the multipurpose hydro projects due to reduced siltation rate, etc., reduction of water pollution due to agricultural chemicals, increased perenniality of streams, availability of water to down reaches, increase in soil fertility status are some of the intangible benefits of SWC measures, particularly in this region.

Financial Cost Benefit Analysis (FCBA)

Financial efficiency of tea plantation with SWC measures

The result of FCBA over 25 years of tea plantation with SWC measures is presented in Table 2. The results show that, CST, cover crop and combination of both were financially attractive at all the discounts rates in comparison to tea plantation without SWC measures. All the SWC measures gave higher financial returns in terms of BCR, NPV and IRR.

Growing of cover crop alone and with CST provided additional financial returns in the first and second year of tea plantation coupled with increased yield of tea leaves in the subsequent year due to effective rainwater conservation and reduced soil erosion. Therefore, higher financial returns were obtained from these treatments as compared with

Table: 2
Financial efficiency of tea plantation with SWC measures

Treatment	B:C Ratio Discount rate			NPV (₹ In lakhs) Discount rate			IRR (%)	PBP (Year)
	10%	15%	20%	10%	15%	20%		
Control	1.45	1.35	1.24	1.97	1.02	0.52	41.24	6
CST	1.49	1.38	1.27	2.25	1.17	0.60	42.09	5
Cover crop	1.57	1.49	1.41	2.71	1.59	0.98	49.72	4
CST+ Cover crop	1.51	1.43	1.34	2.45	1.42	0.84	47.4	4

Note: The period of analysis is 25 years

CST alone and without SWC measures. Cover crop is highly beneficial to small tea growing farmers whose capital investment capacity is low and cannot wait for long period to get returns since they have already invested for tea plantation. SWC measures with cover crop gave higher internal rates of return (47.40 to 49.72%) and were able to recover the total investment within 4 years as compared to CST alone and without SWC measure. The expected main benefit of implementing sustainable land management practices is higher and more stable crop yields, increased system resilience and, therefore, enhanced livelihoods and reduced production risk (Thomas, 2008). Conservation of soil helps in improving soil biodiversity which is a key determinant of sustainable land productivity and under pins a multitude of ecosystem functions and processes (MEA, 2005).

Financial Efficiency of SWC Measures in New Tea Plantation

If a farmer wants to take loan or if any financial institution is willing to give loan to take up only SWC measures in newly planted tea plantation, understanding the financial viability of only SWC measures is very much needed. Therefore, financial analysis was done for SWC measures in newly established tea plantation and result is presented in Table 3.

Growing of cover crop alone and with CST provided additional financial returns in the first and second year of tea plantation coupled with increase in yield of tea leaves in the subsequent year due to effective rainwater conservation and reduced soil erosion, which are the major reasons for higher financial returns from these treatments as compared to CST alone and without SWC measures (Table 2). The cover crop is highly beneficial to the small tea growing farmers whose capital investment capacity is low and cannot wait for long periods to get returns after they have already invested for tea plantation. SWC measures with cover crop gave a higher IRR of 73.31% compared to CST (48.69%) and CST with cover crop (70.61%). All the SWC measures were able to recover the total investment on SWC measure within 1 to 3 years.

Table: 3
Financial efficiency of only SWC measures in new tea plantation

Treatment	B:C Ratio Discount rate			NPV (₹ In lakhs) Discount rate			IRR (%)	PBP (Year)
	10%	15%	20%	10%	15%	20%		
CST	2.05	1.78	1.58	2.76	1.54	0.09	48.69	3
Cover crop	2.9	2.87	2.86	3.32	5.72	0.47	73.31	1
CST+ Cover crop	2.06	2.02	1.98	4.89	3.95	0.32	70.61	2

Note: The period of analysis is 25 years

Sensitivity Analysis

Sensitivity analysis of tea plantation with conservation measures and only for SWC measures were done and results are presented in Table 4. The result from the table revealed that all the SWC measures are economically viable at all the discount rates and at scenario I and II in which BCR is more than one and IRR varies from 22.17 to 41.59% Tea plantation without SWC measure is also economically viable upto 15% discount rate in scenario I and II. In scenario III, only cover crop in tea plantation gave BCR of 1.05 at 10% discount rate and remaining SWC measures are not economically viable under this scenario.

Sensitivity analysis results of only SWC measures showed that all the three SWC are economically viable at all the discount rates and scenarios as BCR was more than unit and IRR was higher than the prevailing bank interest rates. Higher economic viability of these

Table: 4
Sensitivity analysis of tea plantation with conservation measures and only conservation measures

Treatment	Discount rate (%)	Tea plantation with SWC measures			Only SWC measures		
		Scenario			Scenario		
		I	II	III	I	II	III
Control	10	1.16	1.21	0.97			
	15	1.08	1.12	0.90			
	20	0.99	1.03	0.82			
	IRR (%)	18.77	25.76	-189.34			
CST	10	1.19	1.23	0.99	1.64	1.71	1.36
	15	1.10	1.15	0.92	1.43	1.49	1.19
	20	1.01	1.05	0.84	2.63	1.31	1.05
	IRR (%)	22.17	28.17	-101.83	40.77	42.69	26.88
Cover crop	10	1.26	1.31	1.05	2.32	2.42	1.93
	15	1.20	1.25	1.00	2.30	2.40	1.92
	20	1.13	1.18	0.94	2.29	2.39	1.91
	IRR (%)	38.40	41.59	-3.35	73.51	73.46	73.78
CST+ Cover crop	10	1.21	1.26	1.00	1.65	1.71	1.37
	15	1.14	1.19	0.95	1.61	1.68	1.34
	20	1.07	1.12	0.89	1.59	1.65	1.32
	IRR (%)	32.26	36.7	-41.76	68.17	68.76	63.88

Scenario: I: Decreased yield of green tea leaves by 20%; II: Increased cost of production by 20%; III: (1+2)

SWC measures even under scenario III shows soundness and profitability of these SWC measures under adverse situation of increased input price and decreased yield of crop due to drought or any natural/manmade unfavorable conditions. This suggests that farmers can take up SWC measures in old tea plantation without any hesitation by investing own or borrowed capital from any financial institution. Similarly any financial institution can support resource poor small tea growers in terms of financing SWC measures which have both tangible benefits for the farming community and intangible benefits for the society and environment.

4. CONCLUSIONS

The results of the research study have shown that growing of cover crop with CST in new tea plantation is more effective in controlling soil erosion and is economically viable and attractive to the tea growers in the region.

Planting and establishment of new tea plantation on sloping land involves high initial capital investment which is considered to be the major constraint to small and marginal farmers in particular. Growing of some economically important and erosion resisting crop as a cover crop is highly beneficial to farmers to get some returns in the initial years of tea plantation to meet out part of their investment, apart from preventing soil erosion. It was also observed that cover crop alone fails to serve the purpose of soil conservation without CST. Therefore it is suggested that CST must be followed as a SWC measure alongwith growing of cover crop in new tea plantation to achieve economic returns and protection against soil erosion on hill slopes.

Although the SWC measures are financially attractive to farmers, but majority of them have limited capital to invest in SWC measures since planting of tea clones itself needs high capital investment. Small scale credit schemes at reasonable interest rate by any financial institution or tea processing factories, group or joint farming for sharing their labours, annual phasing out the tea planting depending on investment capacity are the some of the mechanisms to overcome the problem of high initial investment cost.

However, this research study focused at farm level mainly on on-site or tangible benefits of SWC measures in new tea plantation. On the other hand intangible benefits/off-site effects of erosion and SWC measures are much more important. In order to prevent on-site and off-site ill effects of soil erosion, farmers need to be sensitized and motivated to adopt SWC measures on individual field. Farmers are not aware about on-site ill effect due to relatively deep soil and fragmented land holdings. The region is one of the 14 bio-sphere reserves of the country, therefore effective SWC measures need to be adopted on high priority to prevent ecological degradation.

REFERENCES

Abonesh Tesfaye, Roy Brouwer, Pieter van der Zaag, Workneh Negatu. 2016. Assessing the costs and benefits of improved land management practices in three watershed areas in Ethiopia. *Int. Soil Water Cons. Res.*, 4: 20-29.

Adhikary, P.P., H.C. Hombegowda, Barman, D., Jakhar, P., Madhu, M. 2016. Soil erosion control and carbon sequestration in shifting cultivated degraded highlands of eastern India: performance of two contour hedgerow systems. *Agroforest. Syst.*, http://dx.doi10.1007/s10457-016-9958-3.

Ali, M.H. and Talukder, M.S.U. 2008. Increasing water productivity in corn production-A synthesis. *Agric. Water Manage.*, 95: 1201-1213.

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. 1998. *Crop Evapo-transpiration - Guidelines for Computing Crop Water Requirements*. FAO Irrigation and Drainage Paper 56, FAO, Rome, Italy.

Ananthacumaraswamy, S., Hettiarachchi, L.S.K. and Dissanayake, S.M. 2003. Soil and foliar sulfur status in some tea plantations of Sri Lanka. *Commun. Soil Sci. Plant Anal.*, 34: 1481-1497.

Bai, Z.G., Dent, D.L., Olsson, L. and Schaepman, M.E. 2008. Global assessment of land degradation and improvement. 1. Identification by remote sensing. Report 2008/01, ISRIC - World Soil Information, Wageningen, 78 p.

Barbier E. and Bishop J. 1995. Economic values and incentives affecting soil and water conservation in developing countries. *J. Soil Water Cons.*, 50(2): 133-137.

Barua, D.N. 2008. Science and Practice in Tea Culture. 2nd Ed. Tea Research Association, Kolkata.

Basu, Majumder, A.B., Bera, A. and Rajan, A. 2010. Tea statistics: Global scenario. *Int. Tea Sci.*, 8: 121-124.

Bhattacharyya, T., Ram Babu, Sarkar, D., Mondal, C., Dhyani, B.L. and Nagar, A.P. 2007. Soil Loss and crop productivity model in humid subtropical India. *Curr. Sci.*, 93(10): 1397-1403.

Dang, M.V. 2005. Soil-plant nutrient balance of tea crops in the northern mountainous region, Vietnam. *Agric. Ecosyst. Environ.*, 105: 413-418.

De Graaff, J., Amsalu, A., Bodnar, F., Kessler, A., Posthumus, H. and Tenge, A. 2008. Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. *Appl. Geogr.*, 28: 271-280.

De Graaff, J., Graaff, J., Valk, W. and Fleskens, L. 2001. Impact assessment of land and water management Lecture notes Erosion and soil and water conservation group. The Netherlands: Wageningen University.

Den Biggelaar, C., Lal, R., Wiebe, K. *et al.* 2004. The global impact of soil erosion on productivity. *Adv. Agron.,* 81: 1-95.

Enters, T. 1998. Methods for the economic assessment of the on-and off-site impacts of soil erosion. Issues in Sustainable Land Management No. 2. International Board for Soil Research and Management, Bangkok.

Ephraim, Nkonya, Alisher, Mirzabaev and Joachim, von Braun. 2016. Economics of Land Degradation and Improvement - A Global Assessment for Sustainable Development. Springer International Publishing AG Switzerland is part of Springer Science + Business Media (www.springer.com), 686 p. DOI 10.1007/978-3-319-19168-3.

Falkenmark, M. and Rockström, J. 2004. Balancing water for humans and nature: The new approach in eco-hydrology. London, Sterling, VA: *Earthscan*, 247p.

Giller, K.E., Cadisch, G., Ehaliotis, C., Adams, E., Sakala, W.D. and Mafongoya, P.L. 1997. Building soil nitrogen capital in Africa. In: Replenishing Soil Fertility in Africa. Buresh, R. J., Sanchez, P.A. and Calhoun, F. (eds.). SSSA Special Publication 51. SSSA and ASA, Madison, pp. 151-192.

Gittinger, J.P. 2004. Economic Analysis of Agricultural projects. Economic Development Institute. The World Bank. http//www.stanford.ed/group/FRI/Indonesia/document/gittinger/output/title.htm. 21 1984 2004.

Hewitt, A., Dominati, E., Webb, T. and Cuthill, T. 2015. Soil natural capital quantification by the stock adequacy method. *Geoderma,* 241-242: 107-114.

Kerr, J. 1998. The economics of soil degradation: From National policy to farmers' fields. In: Soil erosion at Multiple scales, Principles and methods for assessing causes and impacts. Penning de Vries, F.W.T., Agus F. and Kerr, J. (eds). CABI Publishing in association with IBSRAM, Bangkok, Thailand.

Madhu, M. and Tripathi, K.P. 1997. Soil and Water Conservation practices in tea at Nilgiris: Some facts. *Ind. Farm.,* 47(1):33-36.

Madhu, M., Naik, B.S., Jakhar, P., Hombegowda, H.C., Adhikary, P.P., Gore, K.P., Barman, D. and Naik, G.B. 2016. Comprehensive impact assessment of resource conservation measures in watershed of eastern region of India. *J. Environ. Bio*., 37: 391-398.

Madhu, M., Sahoo, D.C., Sharda, V.N. and Sikka, A.K. 2010. Rainwater-use efficiency of tea [*Camellia sinensis* (L.)] under different conservation measures in the high hills of south India. *Appl. Geogr.*, 31:450-455.

Madhu, M., Sikka, A.K., Tripathi, K.P., Ragupathy, R. and Singh, D.V. 2001. Contour staggered trenching and cover crop for soil and water conservation in new tea plantation in Nilgiris. *Ind. J. Soil Cons.*, 29(1): 1-6.

Maji, A.K. 2007. Assessment of degradation and wastelands of Indian. *J. Ind. Soc. Soil Sci.,* 55(4): 427-435.

Mandal, D., Sharda, V.N. and Kumar, A. 2009. Soil Loss Tolerance Limits for Conservation Planning in Different States of India. Central Soil and Water Conservation Research and Training Institute, Dehradun, India. 102 p.

MEA. 2005. MillenniumEcosystem Assessment: Ecosystems and Human Well-being 5. Island Press Washington, DC.

Nellemann, C., MacDevette, M., Manders, T., Eickhout, B., Svihus, B., Prins, A.G. and Kaltenborn, B.P. (eds). 2009. The environmental food crisis - The environment's role in averting future food crises. A UNEP Rapid Response Assessment. United Nations Environment Programme, GRID-Arenal, www.grida.no.

Ninan, K.N. 2007. The Economics of Biodiversity Conservation: Valuation in Tropical Forest Ecosystems. London, United Kingdom: Earthscan Publication.

Olson, K.R., Ebelhar, S.A. and Lang, J.M. 2010. Cover crops effects on crop yields and soil organic content. *Soil Sci.,* 175(2):89-98.

Pimentel, D., Harvey, C., Resosudarmo, P. and Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L., Fitton, L., Saffouri, R., Blair, R. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. *Science,* 24(267): 1117-1123.

Posthumus, H. and De Graaff, J. 2005. Cost-benefit analysis of bench terraces: A case study in Peru. *Land Degrad. Dev.,* 16:1-11.

Prasad, R.N. and Biswas, P.P. 2000. Soil resources of India. In: Singh, G.B. and Sharma, B.R. (eds). Fifty years of natural resource management research. Indian Council of Agricultural Research, New Delhi, pp. 13-30.

Sharda, V.N., Dogra, P. and Prakash, C. 2010. Assessment of production losses due to water erosion in rainfed areas of India. *J. Soil and Water Cons.,* 65(2): 79-91.

Chand, Subhash, Raghupathy, R. and Madhu, M. 2009. Dynamics of agrarian structure of Nilgiris district of Tamil Nadu and its implication. *Indian J. Soil Cons.,* 37(3): 217-223.

Telles, T.S., Sonia, Carmela Falci Dechen, Luiz Gustavo Antonio de Souza, Maria de Fátima Guimaraes. 2013. Valuation and assessment of soil erosion costs. *Scientia Agricola*, 70(3): 209-216.

Tenge, A.J., De Graaff, J. and Hella, J.P. 2004. Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands Tanzania. *Land Degrad. Dev.,* 15: 99-114.

Tenge, A.J., De Graaff, J. and Hella, J.P. 2005. Financial efficiency of major soil and water conservation measures in West Usambara high lands, Tanzania. *Appl. Geogr.,* 25: 348-366.

Thomas, R. 2008. Opportunities to reduce the vulnerability of dryland farmers in central and west Asia and north Africa to climate change. *Agric. Ecosys. Environ.,* 126(1-2): 36-45. doi:10.1016/j.agee.2008.01.01.

Tripathi, K.P. and Sikka, A.K. 1999. Slope area characterization of the Nilgiris. *Indian J. Soil Cons.,* 27(1): 78-79.

Unger, P.W. and Stewart, B.A. 1983. Soil management for efficient water use: an overview. In: H.M. Taylor, W.R. Jordan and T.R. Sinclair (eds.). Limitations to efficient water use in crop production. Madison, Wisconsin, USA: ASA, CSSA and SSSA, pp. 419-460.

Young, I. and Crawford, J. 2004. Interactions and self-organization in the soil-microbe complex. *Sci.,* 304: 1634-1637.