Indian Journal of Agricultural Economics
Volume 78, Number 1, January-March 2023

The Adoption and Impact of Soil Conservation in the Hilly Region of Meghalaya

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ABSTRACT

The paper has assessed the factors affecting the adoption of soil conservation measures and their impact on crop productivity, income and income distribution and employment generation using data from 240 households in the hilly region of Meghalaya, India. Binary logistic regression model, paired t-test, Gini index and Lorenz curve were employed to achieve the desired objectives. The factors which were found to significantly affect the adoption of soil conservation by the farmers included age, sex, education, farm income, off-farm income, access to credit, slope and training. Adopters found a positive percentage change in the average yield over the non-adopters in all the selected crops with the highest percentage change in carrot (24.81 per cent) followed by maize (22.37 per cent), cabbage (13.60 per cent), potato (11.80 per cent), and French bean (8.08 per cent). In both the adopters and non-adopter categories, the majority of the farmers belonged to the income group of Rs. 30001- Rs. 60000 (39.17 per cent and 48.33 per cent respectively) followed by Rs. 60001- Rs. 90000 (35.83 per cent and 30.83 per cent respectively). Adopters had an additional income of Rs. 16,723.65 per household which was significant when compared to the non-adopters. Additionally, the Lorenz curve and Gini index (0.28 for adopters and 0.38 for non-adopters) depicted a comparatively even income distribution among the adopters. Per farm employment showed a significant difference of 285.95 man-days and 243.18 man-days in adopters and non-adopters, respectively. Thus, in view of increasing climate change, it can be suggested that adoption soil conservation measures could be one of the adaptation strategy for sustaining crop production which will enhance the livelihood of resource poor farmers dwelling in the ecologically fragile regions such as the hilly region of Meghalaya.

Keywords: Soil conservation measures, factors affecting, impact, adopters and non-adopters

JEL: A10, O11, O12, Q13, Q50

I

INTRODUCTION

Land degradation is a temporary or permanent impairment of productivity of land through deterioration of physical, chemical or biological aspects (Sreenivas *et al.*, 2021). India is bestowed with vast natural resources. However, it suffers from a variety of land degradation problems affecting the quality and quantity of available land. India homes more than 18 per cent of world's population over an area that is just 2.42 per cent of global spread (Bhattacharyya *et al.,* 2015). Out of the total reported geographical area of 329 mha of India, about 146.8 mha are degraded (NBSS and LUP,

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This study forms a part of the Ph.D. research work and the authors gratefully acknowledge the funding support by Ministry of Tribal Affairs, Government of India in the form of NFST Fellowship to carry out this work. The authors are also thankful to CAU, Imphal for facilitating this research in benefitting manner.

2005). Soil degradation is the prime indicator of land degradation and among soil degradation, soil erosion is the major problem (Lahiry, 2012). Water and wind erosion are the major causes of land degradation, which contributes more than 70 per cent, and salinity contributes 15 per cent of the total degraded area (Mythili and Jann, 2016). Per capita availability of agricultural land in India is 0.12 ha whereas world per capita agricultural land is 0.29 ha (PIB, 2019) and has been expected to reach a level of meager 0.09 ha by 2075 (Navalgund, 2006).

With the increasing pressure of land degradation, India has been continuously using sustainable soil management techniques through a range of approaches. In 1994, India joined the United Nations Convention to Combat Desertification (UNCCD) and recently committed to achieving land degradation neutrality of at least 26 mha by 2030 (Mandal and Giri, 2021). India has implemented various policies and programmes to address soil erosion and land degradation problems such as setting up of Central Soil and Water Conservation Research and Training Institute (CSWCRTI) at Dehradun to study the run-off and soil losses of the country, initiation of soil conservation in the catchment of river valley projects (RVPs) to control premature siltation of reservoirs which in turn enhances productivity of the catchment areas, launching of integrated watershed management in the sixth Five Year Plan to enhance productivity of degraded lands and minimise siltation of reservoirs and many other such programmes has been framed.

Soil conservation is today universally regarded as a sustainable agricultural practice as it minimises soil disturbance (Teklewold *et al*., 2013). Among farm-level measures, the widely adopted measures include terracing, stone walls, revegetation, agro-forestry, crop mixture, fallow practices, land drainage systems and crop residue management (Stocking and Murnaghan, 2001). Adoption of proper soil conservation measures limits soil erosion and reduces top soil loss. However, adoption and dismissal of any technology or methods in agriculture is governed by its costs and returns (Tyngkan *et al*., 2022). Therefore, the present study seeks to identify the factors affecting the adoption of soil conservation measures and the impact of soil conservation on farm profit and its constituents - revenue and cost.

II

MATERIAL AND METHODS

Study Area

Description of Study Area

Meghalaya is vulnerable to soil erosion. This is due to the oscillatory nature of the topography, steep gradient, and heavy rainfall of the region. In addition, encroachment and deforestation of forest land, the ever-increasing demand for food, agricultural practices on sloping land, and indiscriminate shifting cultivation have also exacerbated the problem of soil erosion. In order to address these consequences of soil erosion, depletion, emergence of wastelands, decreasing trend of land productivity, depletion of water sources, deterioration of soil health etc., the Soil and Water Conservation Department, through their various government schemes and programmes sought to address these issues through conservation, restoration and improvement of natural resources. The major programmes employed were, Watershed Development Project in Shifting Cultivation Areas (WDPSCA), Accelerated Irrigation Benefits Programme (AIBP), NABARD Loan- Soil and Water Conservation Scheme under RIDF, Soil and Water Conservation in the Catchment of River Kopili, RashtriyaKrishiVigyanYojana (RKVY) and The Cherrapunjee Ecological Project- Restoration of Degraded Lands under Sohra Plateau **(**Government of Meghalaya, 2021). The major concentration of the schemes wasto avert and plaid the ill effects of soil degradation *via* terrace farming, contour bunding, peripheral bunding, loose boulder bunds, check dam, afforestation, etc.

The different programmes had been initiated and reported to have been successfully continuing across the state. It was reported that 37891.50 ha of land had been adopted in the different programmes with a total cost of Rs. 5228.90 lakh. Across districts, East Khasi Hills (5035.00 ha) had the highest area treated for soil and water conservation followed by Ri-Bhoi district (5000.00 ha) (Table 2) (Government of Meghalaya, 2021). On basis of the total area treated for conservation measures, these two districts were taken up for the present study.

Soil Conservation Measures in the Study Area

For agricultural fields, erosion control structures were recommended to reduce soil and water losses while also giving long-term advantages. Mechanical soil conservation methods must be included in any good soil conservation programme. They may stabilise farmlands by lowering slope length and/or steepness, as well as produce plant-friendly conditions by preventing soil erosion and retaining precipitation. The most frequent structural measures used in agricultural areas were levelling, bunding, and terracing (Sharda and Dhyani, 2004). Bench terrace, contour bunding, peripheral bunding, loose boulder bunding, and check dam are the prevalent soil conservation techniques used by farmers in this region (Table 1). In the East Khasi Hills district, it was revealed that, majority of farmers adopted contour bunding (50.88 per cent) as an erosion control strategy, followed by terracing (38.60 per cent), loose boulder bunding (7.02 per cent), and peripheral bunding (3.51 per cent). In the Ri-Bhoi district, the survey depicted that, a greater number of farmers adopted bench terracing (30.16 per cent) to control soil erosion in their farming field, followed by check dam (23.81 per cent), contour bunding, and loose boulder bunding (with the same percentage share of 17.46 per cent). Overall, the study showed that majority of farmers (34.17 per cent) adopted bench terracing as one of the most common mechanical measures to prevent soil erosion. During the survey, adopters stated that terracing aids in boosting agricultural output, reducing soil losses, and making field preparation easier.

TABLE 1. DISTRIBUTION OF SAMPLE FARMERS BY NUMBER OF ADOPTION MEASURES

(No.)

Particulars (1)	East Khasi Hills (2)	Ri-Bhoi District (3)	Overall (4)
Bench terracing	22 (38.60)	19 (30.16)	41 (34.17)
Contour bunding	29 (50.88)	11 (17.46)	40 (33.33)
Peripheral bunding	2 (3.51)	7 (11.11)	9 (7.50)
Loose boulder bunding	4 (7.02)	11 (17.46)	15 (12.50)
Check dam	0 (0.00)	15 (23.81)	15 (12.50)
Total	57 (100.00)	63 (100.00)	120 (100.00)

Source: Field Survey, 2020-21.
Note: Figures in parentheses are percentage to total.
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Sampling, Data Source and Data Collection Techniques

Meghalaya was selected purposively, as limited studies have been conducted in this area. Two districts were selected purposively namely, East Khasi Hills and Ri-Bhoi districts on the basis that the area treated under soil conservation measures was highest in these two districts (Table 2**.** Based on the pilot survey conducted, three blocks had been identified from each district. Mawkynrew, Mylliem and Sohiong blocks from East Khasi Hills district and Umsning, Umling and Jirang blocks were selected from Ri-Bhoi district. Villages were also selected purposively after the pilot survey. In the present study, two villages had been identified from each block which brings to a total of 12 villages (Table 2). The farmers who practiced soil conservation measures were categorised as adopters and those still continuing conventional farming were categorised as non-adopters. Thus, the data were collected randomly from the sample of 240 households consisting of 120 adopters and 120 non-adopters.

TABLE 2: SELECTED BLOCKS AND VILLAGES FOR STUDY

District (1)	Block (2)		Village Name (3)
	Mawkynrew	a	Laitlum
		b	Laitkyrhong
	Mylliem	a	Myrkhan
East Khasi Hills		b	Nongumlong
	Sohiong	a	Sohksar
		b	KynrohNongbri
	Umsning	a	Umsarang
		b	Umtyrkhang
	Umling	a	Nongkhrah
		b	Pahammaloi
Ri-Bhoi	Jirang	a	Umlakru
		b	Wahsynon
Total	6 Blocks		12 Villages

Source: Field survey, 2020-21.

Data Source and Data Collection Techniques

Questionnaires, in-depth interview, focus group discussion and field observation were used as the main primary data collection techniques. The questionnaire included both the closed and open ended questions which enabled to collect data from the respective household farmers of both the adopters and non-adopters of the soil conservation practices. In-depth interviews were also conducted with the key informants such as the officers' in-charge in the respective division who were considered knowledgeable about the general situation of soil conservation practices.

Drawing upon the literature on technology adoption and particularly on the adoption of soil conservation measures (Asfaw and Neka, 2017; Kumar *et al.,* 2020; Darkwah *et al.,* 2020) the required variables were chosen. Adoption of soil conservation practices is determined by synergic and interactive effects of numerous socio-economic factors, availability and access to financial and capital resources, physical features of the land/plot and institutional support. Accordingly, factors determining adoption of soil conservation practices could be categorised into three groups: (a) household-specific characteristics, (b) economic and institutional factors and (c) land/plot characteristics. Information relating to household-specific characteristics, viz*.,* age, education, family size, farm assets, livestock, asset, and farm size, land tenure, farm income and off-farm income were collected. Soil conservation measures are highly capital-intensive; therefore, adoption of these practices is inadequate in scale and intensity (rate of adoption and its intensity) due to financial hardships and liquidity constraints. Therefore, variables such as access to credit and off-farm income were also included. Another set of explanatory variables pertained to physical features of the plot/land, include slope, soil erosion and fertility levels. It has been reported that the higher the slope of the plot, the higher the probability of adoption since steeper slopes are more prone to soil erosion (Atnafe *et al.,* 2015; Belachew *et al.,* 2020). So these variables were also taken into to consideration to check its relevancy in Meghalaya. Extension services and training were also taken into consideration as it was believed that the farmers in contact with extension service centres had more access to information and advisories about soil and water conservation and their expected benefits. A positive impact of extension services was reported by many researchers (Shiferaw and Holden, 2000; Bekele and Drake, 2003; Mango *et al.*, 2017; Mbaga-Semgalawe and Folmer, 2000). And also if farmers participated in training on soil conservation measures, then they were expected to have more technical knowledge regarding its use and implementation, leading to a higher probability of adoption. Some researchers reported that lack of technical support negatively affects the adoption of conservation measures (Bekele and Drake, 2003; Dessie *et al.,* 2012). Information like farmers' income from different sources, level of employment generation per ha, per family and per worker (in man-days), etc. were collected to assess the impact of soil conservation measures. The survey was conducted during the year 2020-21.

III

ANALYTICAL TOOLS

To achieve the objectives of the study, the primary data thus collected was analysed using tools like tabular analysis, ordered logistic regression model and Lorenz curve and Gini coefficient index. A brief description of the analytical tools has been presented below.

Econometric Model of Adoption of Soil Bunds

The decision to adopt or not to adopt a particular soil conservation measures is a binary decision. The adoption of a particular soil conservation measure decision can therefore be analysed with binary choice model.

Three types of model have been proposed in the econometric literature for estimating binary choice models: the linear probability, logit and probit models. Several authors, provides an empirical study on the adoption of various agricultural technologies using these types of models (Asfaw and Neka, 2017; Singha, 2019; Kumar *et al.*, 2020).

In the present study, binary logistic regression model was used to analyse the relationship between the dichotomous dependent variable and the independent variables. It enabled to determine the impact of multiple independent variables on the dependent variable (He *et al.*, 2007). Thus, a logistic regression procedure using maximum likelihood estimation is employed to estimate the probability of a practice being used. The farmers' behaviour toward the adoption of soil conservation is described by the equation below

Prob (event)= Prop (Y, 1=represents i-th farmer adopted; and 0=otherwise)

Let Xi represent the set of parameters including socio-economic, farming, institutional factors, and village-specific characteristics which influence the adoption decisions of the i-th farmer. For the farmer, Zi is an indirect utility derived from the adoption decision, which is a linear function of k explanatory variables (X), and is expressed as:

$$Zi = \beta_0 + \sum_{i=1}^{n} \beta_i X_{ki}$$

Where, β_0 is the intercept term and $\beta_1, \beta_2, \beta_3, \ldots\ldots, \beta_{i1}$ are coefficients associated with each explanatory variables X_1, X_2, X_3,……, X_{ki}. Gathered in a vector X, these factors explain the adoption decision or the probability that the i-th farmer adopt soil conservation measures

$$P_i = \frac{e^{Zi}}{1 + e^{Zi}}$$

Where, Pi denotes the probability that the i-th farmer's adoption decision and (1-Pi) is the probability that Yi is 0. The odd (Y=1 versus Y=0) to be used can be defined as the ratio of the probability that farmers adopts (Pi) to the probability of non-adoption (1-Pi), namely odds=Pi/(1-Pi). By taking the natural log, we get the prediction equation for an individual farmer:

$$\ln\left(\frac{\mathrm{Pi}}{1-\mathrm{Pi}}\right) = \ln \mathrm{odds} = \beta_0 + \sum_{i=1}^{n} \beta_i X_{ki} = Z_i$$

Where Z_i, is also referred to as the log of the odds ratio in favour of adoption of soil conservation. The variables included in the logistic regression model has been described and presented in Table 3.

TABLE 3: DESCRIPTION OF VARIABLES INCLUDED IN LOGISTIC REGRESSION MODEL

Variables (1)	Description (2)	Expected outcome (3)
Dependent variables		
Adoption	Whether a farmer has adopted a particular soil conservation or not (1 if yes o if no)	
Explanatory variables		
Age	Respondent's age (in years)	-
Family size	Number of household member	±
Sex	1 if household head is male, otherwise 0	±
Education	Level of Schooling (0=illiterate, 1= literate)	+
Off-farm income	Sources of off-farm income (1 if yes, otherwise 0)	±
Landholding	Size of landholding (in hectare)	+
Credit	Access to credit (1 if yes, 0 otherwise)	+
Farming experience	Number of years involved in farming	+
Tenure	Land tenure (1 if owned, otherwise 0)	+
Slope	Slope of the plot (1 if slope, otherwise 0)	±
Extension	Contact with extension personnel (1 if yes, otherwise 0)	±
Training	Training receive for soil conservation measures (1 if yes, otherwise 0)	+

Impact Estimation Technique

Paired t-test

Paired t-test was used to determine the mean differences of the two observations. In this study, the mean differences between the adopters and non-adopters were examined. The value of 't' for the difference was computed by the formula

$$t = \frac{\sqrt[d]{n}}{S}$$

Where,

d= Mean of difference for the characteristics between the adopters and non-adopters of soil conservation measures

s= Standard deviation

n= Sample size

t= Follows 't' distribution with 'n-1' degree of freedom

Gini Concentration Ratio and Lorenz Curve

For examining the income distribution of the sampled household and for comparing the equitability of the income distribution between the adopter and the non-adopters of soil conservation measures Lorenz curve and Gini Concentration Ratio (GCR) was employed in the analysis.

The Lorenz Curve **(**Lorenz, 1905**),** used by economists to assess income/wealth distribution and by demographers to quantify population distributions, is a visual representation of the cumulative proportion of population, ranked from the lowest income/ wealth, against the cumulative proportion of income/wealth. In the special case of equal distribution of income/wealth, the Lorenz curve takes the analytical form *y= x*; in all other cases, and assuming that the measured variable remains positive, the Lorenz Curve is convex to the y-axis and never rises above the line of equality, *y=x*.

The Gini Coefficient (Gini, 1912), a measure of distribution inequality, is defined as the ratio of the area between the line of equal distribution and the observed Lorenz Curve to the area under the uniform distribution, and has values within the range 0 (perfectly uniform distribution) to 1 (complete inequality). In an equivalent representation, the Gini index is the Gini coefficient expressed as a percentage, and is equal to the Gini coefficient multiplied by 100.

The pre-requisite for calculation of the Lorenz curve and Gini coefficient is the income of the sample respondents. Using the formula present by Brown (1994) Gini coefficient can be estimated as follows:

$$L = 1 - \sum_{i}^{n} P_i (Y_i + Y_{i+1})$$

Where,

L= Gini Concentration Ratio

P_i= Proportion of population of i-th adopter of soil conservation measures

Y_i= Cumulative proportion of total income

n= Number of adopters

IV

RESULTS AND DISCUSSION

Descriptive Summary of the Variables

The summary statistics of the above variables are presented in Table 4. The average age of sampled farmers is 49.94 years; and when segregated, it was 47.82 years and 52.06 years for the adopters and non-adopters, respectively which were found to be significantly different at 10 per cent level. For variables *viz.*, family size, sex, education, off-farm income, landholding, tenure and slope, statistically, there was no difference between the adopters and non-adopters. However, for variables credit and extension, a significant difference at 1 per cent level was expressed. Whereas for the variables, farming experience and training a statistical difference at 10 per cent and 5 per cent levels, respectively was observed between the adopters and non-adopters. From the summary of the explanatory variables, it can be stated that the adopters were systematically different from non-adopter farmers.

TABLE 4: STATISTICS OF VARIABLES USED IN THE EMPIRICAL ECONOMETRIC MODEL

Variable (1)	Total farmers (2)	Adopters (3)	Non-adopters (4)	Mean difference between the adopters and non-adopters (5)
Adoption	240	120	120	-
Age	49.94	47.82	52.06	-4.24*
Family size	5.42	5.75	6.69	-0.94
Sex	0.67	0.73	0.61	0.12
Education	0.74	0.83	0.68	0.15
Off-farm income	0.68	0.71	0.65	0.06
Landholding	0.54	0.51	0.58	-0.07
Credit	0.47	0.64	0.31	0.33***
Farming experience	23.33	22.29	24.37	-2.08*
Tenure	0.75	0.85	0.65	0.2
Slope	0.79	0.82	0.76	0.06
Extension	0.36	0.56	0.21	0.35***
Training	0.51	0.66	0.37	0.29**

Source: Field survey, 2020-21.
Notes: ***, ** and * represent significance levels at 1 per cent, 5 per cent and 10 per cent, respectively.

Determinants of Adoption of Soil Conservation Measures

The Validity of the Model

The coefficients of the binary logistic regression model were estimated by maximum likelihood methods. The Hosmer and Lemeshow statistic was used as it is one of the most reliable tests of model fit for binary regression (Sidibe, 2005). The results presented in Table 5 delineated the non-significant of Chi-square statistic (p-value>0.05) indicating that there was no difference between the observed and the predicted value indicating that the model estimates fit with the data at an acceptable level. Chi-square statistics with a p-value under 0.05, according to Sidibe (2005), indicate a poor fit for a binary logistic regression model. The overall percentage of correct predictions was 92.56 per cent.

Results of the Model and Discussion

Table 5 showed that 9 explanatory variables in the model were significant (3 variables at 1 per cent level and 6 variables at 5 per cent level) in explaining soil conservation adoption behaviour in hilly state of Meghalaya.

The results from the binary logistic regression analysis indicated that the age of the farmers played a significant role on the adoption of soil conservation practices at 5 per cent level (p-value=0.044) with an estimate of -0.161. The age had a negative impact on adoption, signifying the younger farmers had a high likelihood of adopting erosion control strategies. The findings also indicated that as farmers age, they get fatigued and were unable to properly care for their farmland. Younger farmers, on the other hand, were more willing to adopt modern farming methods. The findings were comparable with those of Budry *et al.* (2006); Tiwari *et al.* (2008) who found that younger farmers were more likely to invest in soil conservation measures as they were more educated and aware of soil erosion problems and solutions.

TABLE 5. FACTORS INFLUENCING ADOPTION OF SOIL CONSERVATION PRACTICES

Determinant (1)	Estimate (2)	Std. Error (3)	P-value (4)
Age	-0.161**	0.159	0.032
Family size	1.983**	0.864	0.014
Sex	3.007***	1.002	0.002
Education	0.871**	0.310	0.041
Off-farm income	-1.242**	0.769	0.033
Landholding	0.219**	0.294	0.021
Credit	0.615***	2.435	0.000
Farming experience	0.219^{NS}	0.717	0.231
Tenure	0.065^{NS}	0.824	1.066
Slope	1.725***	0.794	0.048
Extension	0.732^{NS}	0.842	0.380
Training	0.518**	0.033	0.041

Hosmer and Lemeshow Test: Chi-square, 232.28; p-value, 0.506. -2log-likelihood, 187.12 (a); Cox and Snell R^2, 0.315; Nagelkerke R^2, 0.421; overall percentage of right predictions, 94.56 per cent.

Source: Field survey, 2020-21

Notes: *** and ** indicate 1 and 5 per cent level of significance and NS indicate non-significant.

The adoption of soil conservation techniques was associated significantly (p-value=0.014) with the size of the family having an estimated value of 1.983 which specified that more the number of the family members higher was the probability farmers adopting soil conservation measures. Similar findings were reported by Million and Kassa (2004) and Habtamu (2006). They claimed that small-scale household families were less likely to embrace soil conservation measures because they lacked the necessary labour to implement and maintain the conservation measures. On the other hand, according to Foltz and Jeremy (2003); Aklilu (2006), farmers with larger family sizes were less likely to continue using introduced soil and water conservation practices, since there was a shortage of labour between off-farm activities that generated food and investments in soil and water conservation methods.

The gender of the farmers played an important role in the adoption of conservation measures. The results showed that gender of the farmers positively (estimated value=3.007) and significantly influenced the adoption (p-value= 0.000) at 1 per cent level. It showed that male farmers were more likely to involve in adopting soil conservation. Related to this finding, study carried by Asfaw and Neka (2017); He *et* *al* (2007**)** stated that male-headed households had a higher chance to involve in soil conservation practices since these measures were labour intensive.

As anticipated, the education of the farmers was significantly associated with the adoption of soil conservation at 5 per cent significant level (p-value=0.041) and at an estimated value of 0.871. This signified that farmers with better education level had positive correlation with the adoption of soil conservation as they had a better understanding of the benefits of conservation measures. The positive significant impact of education was also reported by Tiwari *et al.* (2008); Tadesse and Belay (2004) stating that higher the education levels of the farmers higher the probability of the adoption of improved agricultural technologies.

The size of farm land was found to be positively associated with continuous use of conservation structures and statistically significant (p value=0.021) with an estimate of 0.219. The positive coefficient implies that farmers with relatively larger holdings had higher probability to apply conservation technologies in their farm. This can be attributed to the fact that conservation structures occupy part of the productive land and farmers with larger farm size can afford retaining structures compared to those with relatively lower farm size. This study, was in line with the finding of Tedesse and Belay (2004), who determined that farmers with greater farm sizes had more financial resources and additional acreage to allocate to enhancing technology adoption. However, this was contradicted by Habtamu (2006) and Darkwah *et al.* (2020) which reported a negative relationship between size of holdings and the probability of continuous use of soil conservation measures which might be due to labour intensive nature of constructing soil conservation structures.

When it came to land characteristics, tenure had positive effect (estimated value=0.065) on the adoption of soil conservation measures (SCM). That was because tenure ensured, same area would be used in the future, providing incentives to invest in conservation activities (Gebremedhin and Swinton, 2003) and reap the long-term advantages. Numerous studies found that possessing secured tenure had a positive impact on the adoption of soil conservation methods (Baidu-Forson, 1999; Shiferaw and Holden, 2000; Teshome *et al.*, 2013). The slope of the plot (estimated value=1.725), as predicted, was strongly associated with a greater likelihood of SCM implementation (p-value<0.05). This meant that the steeper the plot's slope, the more likely was the cultivator to adopt SCM.

The institutional variables such as extension services, training and credit availability were positively impacting the adoption SCM. The results show that training (estimated value=0.518 and p-value<0.05) and credit (estimated value=0.295 and p-value< 0.001) has a positive and significant association with the decision of adopting conservation practices at 1 per cent level. This implies that the availability of credit or financial assistance and training exposure about the conservation practices enhance the probability of adopting the same. In case of extension service, as anticipated, it had positive influence on the adoption of SCM, even though it was insignificant. This explained that, farmers who receive good information from extension personnel were more ready to apply new soil conservation methods and retain existing ones. However, because of the limited level of interaction between farmers and extension agents, the effect was small. Many other researchers had observed similar findings (Mbaga-Semgalawe and Folmer, 2000; Bekele and Drake, 2003; Mango *et al.*, 2017). Their investigations found that having access to an efficient extension service, training, and credit can help the farmers not only understand the negative impacts of land degradation, but also become more aware of the available technologies and financial support.

Impact of Soil Conservation Measures

Yield of Selected Crops

Crop production is the major livelihood activity for the majority of the sample households in the study area. The common crops grown by the adopters and non-adopters include french bean, potato, cabbage, carrot and maize. Hence, these crops were chosen for comparing the yield and are presented in Table 6. The results showed a positive percentage change in the average yield over the non-adopters in all the selected crops. This could be due to the effect of soil conservation measures adopted. The highest percentage change of crop productivity over the non-adopters was witnessed in carrot (24.81 per cent) followed by maize (22.37 per cent), cabbage (13.60 per cent), potato (11.80 per cent) and French bean (8.08 per cent), respectively. The finding of this study confirmed that adoption of soil conservation measures in farmers' field enhanced the crop productivity which in turn benefits the farmers in realising higher return from their crops.

TABLE 6: PERCENTAGE CHANGE IN AVERAGE YIELD BETWEEN ADOPTERS AND NON-ADOPTERS

Crop (1)	Adopters (q/ha) (2)	Non-adopters (q/ha) (3)	Per cent change (4)
French bean	8.71	8.01	8.08
Potato	62.10	54.78	11.80
Cabbage	64.96	56.13	13.60
Carrot	10.20	7.67	24.81
Maize	14.74	11.44	22.37

Source: Field survey, 2020-21.

Income from Different Sources

The examination of Table 7 showed the income of the adopters and non-adopters obtained from various sources. The mean difference of the total income over the non-adopters was estimated and the results revealed the positive significant difference at 1 per cent level with the mean difference of ₹16723.77 per household. Major source of income in both the adopters and non-adopter was from agriculture crops and contributed 60.28 per cent and 58.84 per cent respectively, followed by service including business, labour work and finally from livestock. This pattern was similar in both the categories. The mean difference in income from the agricultural crops was positively significant at 1 per cent level with the mean difference of ₹11098.10. This could be due high productivity of crops, diversified and intensified farming in adopting of soil conservation. The results were in line with the findings of Bravo-Ureta *et al*. (2006); Abebe and Bekele (2014). They stated that the income of the adopter households was significantly higher than the non-adopter households. Their findings showed that when farmers applied sustainable soil and water conservation techniques on their farm holdings, crop yield and annual farm income increased. As a result, investing in natural resource management, such as soil conservation techniques, will increase farm income, and farmers will be incentivized to do so. More specifically, around 8 per cent of the income sources of the adopters were from livestock, whereas this was only 5.27 per cent for the non-adopters with the mean difference of ₹3199.95 per household and statistically significance at 5 per cent level. Similarly, 16.87 per cent and 21.84 per cent of the income of adopters and non-adopters respectively comes from services and business with a mean difference of ₹-666.60. Farmer's source of income from labour work had a comparable contribution in both the adopters and non-adopters, respectively with significance mean difference at ₹3092.32 per household.

TABLE 7: FARM AND OFF-FARM INCOME OF THE SAMPLED HOUSEHOLDS

(₹/household)

Sl No. (1)	Particulars (2)	Adopters (3)	Non-adopters (4)	Mean difference over non-adopters (5)
1.	Agriculture crops	52398.60 (60.28)	41300.50 (58.84)	11098.10***
2.	Livestock	6900.45 (7.94)	3700.50 (5.27)	3199.95**
3.	Service including business	14666.70 (16.87)	15333.30 (21.84)	-666.60
4.	Labour	12953.30 (14.90)	9860.98 (14.05)	3092.32**
	Total	86918.98 (100.00)	70195.33 (100.00)	16723.77***

Source: Field Survey, 2020-21.
Notes: *** and ** indicates 1 and 5 per cent level of significance and figure in parentheses are percentage to total.

Pattern of Income Distribution

The income distribution of the adopters and the non-adopted of soil conservation measures was evaluated and compared. It was found that in the adopters and non-adopters' categories, majority of the farmers falls in the income group of ₹30,001-₹60,000 followed by ₹60,001-₹90,000. In estimating the difference over the non-adopters, the income group level below ₹30,000 and ₹30,001-₹60,000 depicted the negative difference. The results indicated that most of the non-adopters belonged to the low-income group. From the income group level ₹60,001-₹90,000 till the income group of above ₹1,50,000, positive differences were observed (Table 8). The findings signify that a greater number of the adopters were in higher income group than the non-adopters.

TABLE 8: CATEGORY OF INCOME OF THE ADOPTERS AND NON-ADOPTERS OF SOIL CONSERVATION IN MEGHALAYA

Income groups (₹)	Frequency		Difference over non-adopters
	Adopters	Non-adopters	
(1)	(2)	(3)	(4)
Below 30000	3 (2.50)	9 (7.50)	-6.00
30001-60000	47 (39.17)	58 (48.33)	-11.00
60001-90000	43 (35.83)	37 (30.83)	6.00
90001-120000	16 (13.33)	10 (8.33)	6.00
120001-150000	8 (6.67)	4 (3.33)	4.00
Above 150000	3 (2.50)	2 (1.67)	1.00
Total	120 (100.00)	120 (100.00)	

Source: Field survey, 2020-21. *Note*: Figure in parentheses are percentage of total.

Income Concentration

In comparison the situation between the adopters and non-adopters, it was found that the income distribution of the adopters of soil conservation was relatively much better than the non-adopters as depicted by Lorenz curve (Figure 1), which showed that the Lorenz curve of the adopters was closer to the equality line. Similarly, Gini coefficient ratio (GCR) of the adopters and non-adopters were 0.28 and 0.38, respectively (Table 9), indicating that income was more evenly distributed in adopters' category with lower GCR. The results explained, farmers with soil conservation measures might have similar productivity and return from their crops and hence, reduces the disparity of their income. In a study conducted in China, Rahim *et al.* (2018) discovered that soil and water conservation had a significant impact on per capita income and reduced the income gap among rural households. Their findings supported the idea that soil conservation could help boost agricultural economic growth and reduce rural poverty.

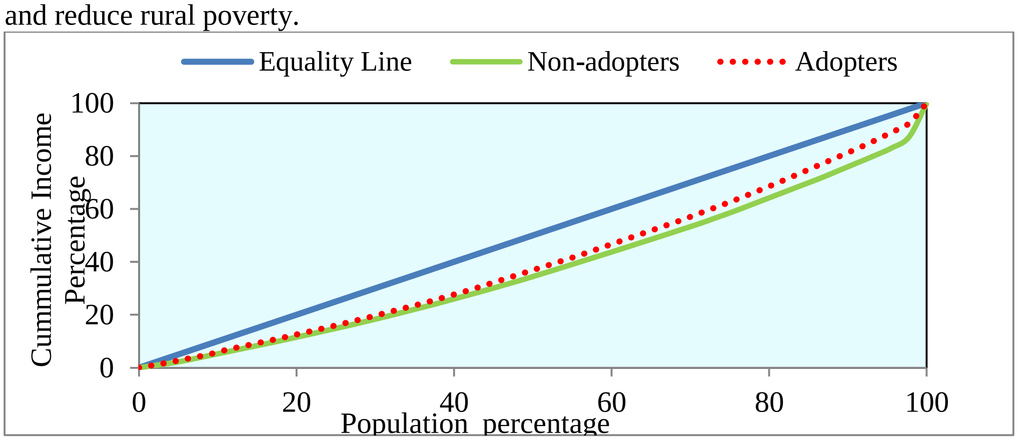

Figure 1. Lorenz Curve for Adopters and Non-Adopters of Soil Conservation

TABLE 9: GINI CONCENTRATION RATIO (GCR) OF INCOME BETWEEN ADOPTERS AND NON-ADOPTERS

Particulars (1)	Adopters (2)	Non-adopters
CGR	0.28	0.38

Source: Field Survey, 2020-21.

Per Farm Employment Opportunity

Per farm employment generation of sampled households was estimated from the selected common crops (Table 10) of the adopters and non-adopters. The results indicated that total employment generation from various selected crops were 285.95 man-days and 243.18 man-days for adopters and non-adopters, respectively and significant mean difference was observed at 5 per cent level. The positive differences over the non-adopters in all the crops elucidated that soil conservation practices had a positive impact on soil fertility and crop productivity of cultivated lands. These benefits of soil conservation encouraged the farmers to adopt intensified farming and hence, increase the requirement of labour in the field. Thus, per farm employment level of the adopters was higher than the non-adopters. The finding was in confirmation with the study of Mondal and Loganandhan (2013); Dingankar *et al.* (2017) which concluded that adoption of soil conservation technologies increased the production levels, cropping intensity and shifts from low labour intensive to high labour-intensive crops which in turn shift the labour absorption per hectare of the cropped land.

TABLE 10: EMPLOYMENT GENERATION FROM SELECTED CROPS

Sl No.	Particulars	Employment generation (man-days)		Mean difference over non-adopters
		Adopters	Non-adopters	
1.	French Bean	37.68	29.31	8.37^{NS}
2.	Potato	64.54	52.44	12.1^{NS}
3.	Cabbage	55.21	47.33	7.88^{NS}
4.	Carrot	77.87	68.76	9.11^{NS}
5.	Maize	50.65	45.34	5.31^{NS}
Total		285.95	243.18	32.15**

Source: Field Survey, 2020-21.
Note: **indicates 5 per cent level of significance and NS indicate non-significant

V

CONCLUSION AND POLICY IMPLICATION

The study assessed the factors that have an association with the adoption of soil conservation measures and its impact on the crop productivity, income and employment generation. The results showed that the adoption of introduced soil conservation measures in the study area was positively influenced by gender of the household head, education status of the household head, family size, off-farm income, access to credit, slope of the plot and availability of training on soil conservation measures at statistically significant level. On the other hand, age of the household head has negatively and significantly influenced the adoption of soil conservation which signifies that younger farmers have a greater likelihood to adopt soil conservation measures in their field. The other factors that insignificantly but positively influenced the adoption of soil conservation measures were land tenure and contact with extension personnel. Therefore, for widespread adoption of soil conservation measures in the hilly region of Meghalaya, the younger farmers must be encouraged to take up training programmes and educate them about the importance and benefits of soil conservation as younger farmers are more willing to adopt modern farming methods. Since a majority of the farmers in the study area were resource poor, for improving their financial capacity, there was a need for expanding credit facilities. Furthermore, there was a need to expand the extension services and training facilities, particularly focusing on the benefits of the conservation efforts to encourage farmers to take up soil and water conservation measures. Moreover, soil conservation programme should emphasise strengthening social networks for successful conservation outcomes. The impact of soil conservation measures on the crop productivity, extent of farm income and income distribution and employment generation were also evaluated. The impact results showed that the productivity of the selected crops was higher in adopters than that of the non-adopters. In terms of comparison, adopters had higher income as compared with that of the non-adopters with a significant mean difference. Moreover, the Lorenz curve and Gini index depicted a comparatively even distribution of income among the adopters. Regarding the per farm employment generation the result showed a positive and significant mean difference over the non-adopters. This elucidated that soil conservation practices have a positive impact on soil fertility and crop productivity of cultivated lands and these benefits encouraged the farmers to adopt intensified farming and hence, increase the requirement of labour in the field. Therefore, in view of increasing climate change, it can be suggested that adoption of soil conservation measures could be one of the adaptation strategy for sustaining crop production. To sum up, the investment in soil conservation technologies must be encouraged for sustaining the livelihood of resource poor farmers dwelling in the ecologically fragile regions such as the hilly region of Meghalaya.

Received May 2022. *Revision accepted December 2022.*

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