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Research Paper

An Economic Analysis of Soil Conservation in Meghalaya

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ABSTRACT

Soil is the most essential input in agriculture, while eroded land suffers from depletion of nutrients such as nitrogen, phosphorus and potassium, organic and moisture content of the soil, and reduction in cultivable soil depth. This study assesses the economics of erosion control technologies. The study was conducted in Meghalaya, based on a survey of 120 adopters and 120 non-adopters' farmers from East Khasi hills and Ri-Bhoi districts. The common soil conservation technologies adopted by the farmers were bench terracing, contour bunding, peripheral bunding, loose boulder bunding and check dam. Among the conservation techniques, bench terracing was adopted in majority (34.17 per cent). For estimating the economics of these conservation techniques, four principal measures *viz.*, Net Present Value (NPV), Payback Period, Benefit Cost Ratio (BCR), Internal rate of returns (IRR) were employed to check the feasibility and viability of the adopted measures. The results of the feasibility analysis for various soil conservation technologies were encouraging as it was evident from the study that all the adopted soil conservation has positive NPV, B-C ratio more than one and high IRR. Hence, farmers can be encouraged in adopting appropriate erosion control measures in their field as it can bring a positive return and enhance the productivity of the soil in the long-term.

HIGHLIGHTS

- Bench terracing, contour bunding, peripheral bunding, loose boulder bunding and check dam were the major soil conservation adopted in Meghalaya.
- Feasibility analysis for the above measures were encouraging.

Keywords: Soil conservation, NPV, B-C ratio, IRR and Payback period

The most essential input in agriculture is soil, and eroded land, suffers from nutrient depletion, including nitrogen, phosphate, and potassium, as well as decreased cultivable soil depth and organic and moisture content (Semgalawe and Folmer, 2000). Soil erosion has a number of negative consequences, including sedimentation in riverbeds, water contamination, and a decline in the soil's water-carrying capacity, all of which can lead to silting in dams and water channels, as well as affecting local flora and fauna. Another effect on the hydrological cycle is that erosion increases water discharge during the rainy season while decreasing it during the dry season (Somanathan, 1991; Semgalawe and Folmer, 2000). As a result of the land degradation, crop yields are reduced, requiring farmers to increase their contribution to deforestation (Lopez, 2002).

Soil erosion and top soil loss are both reduced when suitable soil and water conservation measures

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are used. Terracing, stone walls, re-vegetation, agro-forestry, crop mixture, fallow practises, land drainage systems, and crop residue management are examples of farm-level methods that are widely used around the world (Stocking and Murnaghan, 2001; Teklewold *et al.* 2013). Furthermore, in rain-fed locations, soil conservation methods are critical to maintain crop production in the face of increased water shortages, worsening soil health, and rising drought and desertification incidences, as well as to mitigate the detrimental consequences of climate change and its unpredictability (Kato *et al.* 2011).

Looking at the situation in Meghalaya, the state is also subject to soil erosion due to the state's undulating landscape, steep gradient, and heavy rainfall. Furthermore, soil deterioration is exacerbated by primitive and harmful agricultural practises such as *jhum* and *bun* (Dienngngan *et al.* 2021). Deforestation, wildfires, widespread grazing, unscientific mining, and other factors are having an effect on the state's overall ecological situation. As a result, combatting the degradation of our natural resources, particularly soil, water, and vegetation, as well as investing in their conservation for future generations, will be a major practical job for promoting sustainable development and environmental protection. To preserve cultivable and uncultivable lands from the ravages of erosion, boost and restore soil production, reverse degradative trends, and rehabilitate degraded soil, modern scientific approaches and the creation of new methodologies have become essential. Adoption and dismissal of any technology or methods in agriculture is decides by its costs and returns. Hence, on these backdrops the present research paper developed to demonstrate the economics of various soil conservation measures in the state of Meghalaya.

MATERIAL AND METHODS

Sampling design

Meghalaya has been selected purposively, as there has been limited study conducted in this content. Two districts were selected purposively namely, East Khasi Hills and Ri-Bhoi districts on the bases that the area treated under soil conservation measures was highest in these two districts (GoM, 2019)**.** Based on the pilot survey conducted, three blocks has been identified from each district. Mawkynrew, Mylliem and Sohiong blocks were selected from East Khasi Hills district. 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 have been identified from each block. The farmers that practice soil conservation measures were categorised as adopters and those still continuing conventional farming were categorised as non-adopters. The data were collected from sample of 240 households consisting of 120 adopters and 120 non-adopters.

Analytical tools

To achieve the objectives of the study, the primary data thus collected was processed using analytical tools like tabular analysis for calculating means and percentages of important variables. For evaluating the economics of various soil conservation measure, investment appraisal by capital budgeting technique was employed in the study. The investment made on various soil conservation practices was evaluated using Benefit-Cost analysis (BCA), taking into account the on-site costs and benefits of soil conservation practice. BCA is a basic approach in neoclassical economics adapted by environmental economists for the evaluation of net social or private welfare from environmental remediation or project**.** The costs and benefits were evaluated to find out the economic efficiency of the soil conservation practices and also to determine whether the practices was financially viable or not, *i.e.,* by using four principal measures *viz.*, Net present value (NPV), Payback period, Benefit cost ratio (BCR) and Internal rate of returns (IRR).

Net Present Value (NPV)

Net Present Value or Net Present Worth is the difference between the series of inflows (returns) and outflows (costs) over a three years period of cultivation in the adopted soil conservation measures. It was worked out at 9 per cent discount rate which is the rate for fixed investment by using the equation below:

$$NPW = \frac{P_1}{(1+r)t_1} + \frac{P_2}{(1+r)t_2} + \frac{P_3}{(1+r)t_3} - C$$

Where,

P_1, P_2, P_3= Net cash flow in first, second and third year from the crops grown in the particular soil conservation

r = Discount rate

t_1, t_2, t_3 = Time period and

C = Investment cost, maintenance cost and the operation cost of various crops

Benefit cost Ratio

This criterion indicates the rate of return per rupee invested in particular soil conservation techniques. It was worked out by dividing the sum of discounted net cash flow by the establishment cost at 9 per cent rate of interest.

$$\text{B-C ratio} = \frac{\text{Present worth of gross return}}{\text{Present worth of cost}}$$

Payback Period

The pay Back period represent the time required to recover invested money in the project *i.e.,* the time required for a project to pay for itself. In the present study, Pack back period of various adopted soil conservation was calculated by using the following formula:

$$P = \frac{I}{Y}$$

Where,

P = Pay Back period in pre-defined time units (in present study it is 'years')

I = Capital investment on the project in rupees

Y = Net income realized after meeting production expenditure

Internal Rate of Returns (IRR)

The rate at which the net present value of project is equal to zero is nothing but the Internal Rate of Return (IRR). The net cash inflows were discounted to determine the present worth following the interpolation technique as under.

IRR =

$$\begin{pmatrix}\text{Difference between}\\ \text{the two discount rates}\end{pmatrix} \times \frac{\begin{pmatrix}\text{Present worth of the cash flow at the}\\ \text{lower discount rate}\end{pmatrix}}{\begin{pmatrix}\text{Absolute difference between}\\ \text{the present worth of the cash}\\ \text{flow at two discount rates}\end{pmatrix}}$$

If the IRR calculated appears greater than the reference rate, then the adoption of soil conservation practices in the sample farms is economically attractive. If the IRR calculated is lesser than the reference rate, practices is said to be economically not viable.

RESULTS AND DISCUSSION

Household characteristics

The average age of the sample respondents was 49.94 years; when segregated it was 47.82 years and 52.06 years for the adopters and non-adopters, respectively (Table 1). The result depicted those adopters of soil conservation were much younger than the non-adopters and this imply as the age of the farmers increases, the adoption of the introduced soil conservation decreases. Studies conducted by Tiwari *et al.* (2008); Bekele and Drake (2003); Budry *et al.* (2006) supported these results. They reported that younger farmers are often expected to invest more in soil conservation practices. Because they are more often educated and more aware of soil erosion problem and its solution.

Table 1: Basic information of the sample respondents

Particulars	Units	Adopters (n=120)	Non-adopters (n=120)	Overall (n=240)
Age	years	47.82	52.06	49.94
Family size	no.	5.75	6.69	5.42
Literacy rate	%	69.16	52.50	72.46
Operational land holding	ha	0.51	0.58	0.54
Farming experience	years	22.29	24.37	23.33

Source: *Field survey, 2020-21.*

The number of the family members was seen to be higher in non-adopters' category with an average of 6.69 members whereas in the adopters' category it was 5.75 members. It can be inferred from the above result that lesser is the family members lesser will be the household expenditure and the farmers can have some extra income for investing in conservation measures. Some studies also reported that farmers with larger family sizes are less likely to continue using introduced soil and water conservation practices. Because there is competition for labour between food generating off-farm activities and investment in maintenance of soil and water conservation practices (Fikru, 2009; Aklilu, 2006; Foltz and Jeremy, 2003).

The average literacy rate of the sample respondents was observed to be 72.46 per cent and on segregation between the adopters and non-adopters, the study shows that adopters have high literacy rate (69.16%) compared with that of non-adopters (52.50%). This showed that relatively better educated farmers were more engaged in the adoption of soil conservation practices. Better exposure to education increases farmers' better understanding of the benefits and constraints of soil conservation (King and Alderman, 2001).

The operational holding and farming experience are both dominated by the non-adopters. Garcia (2001) reported a negative relationship between the size of farmland holding and the probability of adopting soil and water conservation practices. This was due to labour intensive nature of constructing soil conservation structures. Whereas, in case of the farming experiences it was expected that more the experiences the farmers were, more likely they will adopt the conservation practice.

Soil Conservation Technologies

Bench terrace was the most commonly adopted soil conservation practice by the adopters in the study area and one-third (34.17%) of the adopter population practiced this conservation technology (Table 2).

Table 2: Types of soil conservation adopted by the adopters (Number)

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

Note: *Figure in parentheses are per cent of total.*

Source: Field survey, 2020-21

Another popular soil conservation in the region was contour bunding which was taken up by 33.33 per cent of the adopter population. In addition to these two soil conservation methods, the other practices which were prevalent in the region includes loose boulder bunding (12.50%), check dam (12.50%) and peripheral bunding (7.50%).

Establishment and maintenance cost of soil conservation measures

The soil conservation measures in this region were highly labour-intensive activity hence, the establishment and maintenance costs of these measures were mostly the product of the "mandays" and wage of labour per day. The labour requirement for construction of soil conservation measures is directly proportional to the increasing slope and the level of stability of soil (Tenge *et al.*, 2005). In the context of this research, the topography of the farmers plot ranges from moderate to steeper slope.

Table 3: Average establishment and maintenance cost of soil conservation measures (₹/ha)

Conservation Techniques	Establishment cost	Maintenance cost
Bench terracing	45108.70	912.75
Contour bunding	24512.93	1133.62
Periferal bunding	9836.07	1246.60
Loose boulder bunding	27102.04	0.00
Checkdam	14767.68	633.33

Source: *Field survey, 2020-21.*

Interestingly, perusal of Table 3, bench terracing which was found to be the most popular soil conservation measure adopted by the farmers has the highest establishment cost at ₹ 45,108.70 per ha as compared to loose boulder bunding (₹ 27102.04/ha), contour bunding (₹ 24512.93/ha), check dam (₹ 14767.68/ha) with the least establishment cost in peripheral bunding at ₹ 9836.07 per ha. In contrast to the establishment cost, peripheral bunding entailed highest maintenance cost at ₹ 1246.60 per hectare which was comparable with contour bunding (₹ 1133.62 per ha) due to these measures being modification of the existing landscape subjected to erosion as a result of high intensity precipitation in the region. In case of bench terracing and check dam the average annual maintenance cost was ₹ 912.75 and ₹ 633.33 per ha respectively. Whereas, loose boulder bunding was a onetime investment measure in the region and there was no maintenance cost involved.

Economic viability of soil conservation

Net present value (NPV)

In this analysis, NPVs reflect the impact of different soil conservation technologies. Among the various soil conservation considered in the region, bench terracing gave the maximum NPV of ₹ 18,9487.96 per ha, followed by check dam with ₹ 17,1348.47 per ha, contour bunding with ₹ 11,5931.83 per ha, loose boulder bunding with ₹ 10,3262.12 per ha and peripheral bunding with ₹ 9,7632.56 per ha at 10 per cent discount rate (Table 4).

Table 4: Financial viability of soil conservation techniques in Meghalaya

Conservation Technique	NPV	B-C ratio	Payback period	IRR (%)
Bench terracing	189244.14	1.83	0.80	26.21
Countour bunding	108098.17	1.37	0.74	19.82
Periferal bunding	97632.56	1.61	0.66	25.34
Loose boulder bunding	115931.82	1.33	0.74	18.45
Checkdam	171348.46	1.58	0.58	24.33

Source: *Field survey, 2020-21.*

The foregoing result indicated the superiority of bench terracing. The superiority of the terracing was also reported by Mishra and Rai (2011) where they found in their study that terrace cultivation shows high NPV in Sikkim. They also stated that terrace cultivation not only stops soil erosion but also diversifies the agro-biodiversity and act as a subsidiary source of income, sustain productivity levels and helps to conserve soil and nutrient loss, soil moisture retention and increases crop yield. Bench terracing has a high initial investment cost (Table 3) in terms of labour and production cost; but is quite effective in conserving soil and nutrient loss in the long run.

BCR, IRR and payback period

The BC-ratio delineates the profits and the significant of the investment made on various projects or technologies. For an investment to be economically viable, the BC-ratio should be more than one. In this investigation, the highest B-C ratio was observed in bench terracing with a value of 1.83 followed by peripheral bunding (1.61), check dam (1.53), contour bunding (1.37) and loose boulder bunding (1.33). The B-C ratio analysis indicates that the investments on the adopted soil conservation measures were economically viable. Hence, farmers can be encouraged to adopt appropriate erosion control measures in their field as it can bring about a positive return and enhance the productivity of the soil in the long-term.

The IRR measures the rate of return that could be realised due to the investment out of the returns generated from within the system. Hence, the IRR suggests more valuable basis of investment and scores over other evaluation criteria, which do not consider the reinvestment opportunities. The bench terracing provides the maximum IRR with value of 26.21 per cent followed by peripheral bunding (25.34%), check dam (24.33%), contour bunding (19.82%) and loose boulder bunding (18.45%). From these results it is clear that investment made on the soil conservation measures is profitable as the IRR value of all the measures is greater than the discounted factor taken at 10 per cent.

Further, the payback period of the different types of soil conservation were 0.8 years for bench terracing, 0.74 years for contour and loose boulder bunding, 0.66 years for peripheral bunding and 0.58 years for check dam. Since, the period required to repay the initial investment on soil conservation in this region was below one year and hence the non-adopters can be motivated to participate in adopting soil conservation measures for improving the performance and productivity of their field.

The overall results on feasibility analysis for various soil conservation technologies are encouraging and advocate the advantages of adopting soil conservation practices to enhance farm income. Among the technologies adopted, bench terracing appeared most profitable in this region.

CONCLUSION

This study was undertaken to understand economic and cost-effectiveness of soil conservation technologies in Meghalaya. Among the soil conservation technologies, more than 34 per cent of the selected farmers adopted bench terracing followed by contour bunding (33.33%), loose boulder bunding and check dam (12.50% each) and few farmers have adopted peripheral bunding (7.50%). In order to assess the cost-effectiveness and feasibility of soil conservation technologies, financial measures such as NPV, B-C ratio, IRR and payback period were computed at 10 per cent discount rate. It was evident from the study that bench terracing has the highest NPV, B-C ratio and IRR. The superiority of the bench terracing may be attributed to its high efficiency in soil erosion control; increased area of cultivation due to conversion of steep slope to relatively flat surface; high intensity cropping and diversified farming. The overall results on feasibility analysis for various soil conservation technologies were encouraging as it was evident from the study that all the adopted soil conservation has positive NPV, B-C ratio more than one and high IRR. Hence, farmers can be encouraged in adopting appropriate erosion control measures in their field as it can bring a positive return and enhance the productivity of the soil in the long-term. Further, the adopting of soil conservation measures is capital intensive and farmers with poor resource will find it difficult to adopt the same. To cope with these constraints, government can intervene by providing financial support or by providing subsidies.

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