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FARMERS' PERCEPTION ON SOIL EROSION, ITS CAUSES AND ADOPTION OF ITS MITIGATION MEASURES IN TWO GEWOGS OF EASTERN BHUTAN

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ABSTRACT

This study was conducted in two gewogs (blocks) of Jarey and Thangrong under Lhuentse and Mongar districts in Eastern Bhutan to assess the farmer's perception on the soil erosion, its causes, and adoption of Sustainable Land Management (SLM) practices. A total of 47 and 90 respondents from Jarey and Thangrong respectively who participated in the implementation of SLM measures were interviewed. Field observations were made where necessary. Data was analyzed using descriptive and chi-square test at significance level of $p<0.05$ and presented in tabular or graphical representations. The study revealed that farmers have a good knowledge on identifying the indicators, causes, severity of soil erosion including positive impact from implementation of SLM measures. A significantly high proportion of farmers in Jarey (97.87%) and Thangrong (92.22%) perceived washing down of soil during rainy season as main indicator of soil erosion. Similarly, significant proportion of the respondents (95.74% and 93.33%) from two gewogs indicated heavy rain as main cause of soil erosion besides cultivation on the steep slope (91.49% and 90%). Further, 76% and 56% of the respondents in Jarey and Thangrong respectively perceived high soil erosion, whereas only 15.89% and 15.56% have witnessed low rate of soil erosion. Significantly higher proportion of respondents in Jarey (85.11%) and Thangrong (90%) observed reduced soil erosion after implementing the SLM measures. About 29.79% of farmers in Jarey faced labor shortage while 38.89% of farmers in Thangrong perceived no immediate benefit from SLM measures. High proportion of farmers in Jarey (96.25%) indicated the need of financial support from government and 95.64% of respondents in Thangrong expressed the financial and short-term interventions (seed and seedlings) assistance for scaling out SLM in future. This study recommends community consultation through participatory approach to raise awareness and design appropriate SLM interventions based on

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local context and also taking into account incentive package to address short term livelihood needs of the farmers, which otherwise is difficult to achieve due to long gestation period of SLM interventions.

Keywords: Sustainable Land Management, soil erosion, awareness, farmers' perception, mitigation measures

1.0 INTRODUCTION

Soil erosion is the single most critical environmental degradation problem in the developing world (1). Worldwide, soil erosion is the extensive form of land degradation in dry lands. Hence, the Sustainable Land Management (SLM) measures are widely accepted, adopted and advocated by the world community to reduce negative impact on environment (2). Severely eroded soil due to soil erosion in the hill and mountain regions reduced the crop yield up to 50% (2).

Bhutan is situated in the foothills of the Eastern Himalayas with most of its mountain ranges running from north to south. Most of the arable land in Bhutan is located on rugged terrain with slope up to 70% (13) due to which the country has inherently limited resources of productive land for agriculture. The predominantly steep slopes place those arable land under extreme risk of degradation (3). Approximately 80% of population relies upon agriculture for their livelihood (5) with majority of farmers practicing rain-fed agriculture on steep hillside (6). Relatively flat irrigated paddy fields suitable for paddy cultivation are limited and scattered along the main river valleys. Like elsewhere, soil erosion in the rainfed and semi-arid tropics remain apparently threatening to the sustainability of rainfed agriculture in Bhutan (12). During the tillage operation in such land setting, the top soil from the upper part of the field is being moved down. As per the annual soil erosion rate measurement research undertaken by the National Soil Services Centre (NSSC), the annual soil loss through water induced surface erosion under traditional farming practices in Bhutan is 6.42 t/ha. The loss of fertile top soil leaves the subsoil on the upper part of the slopes exposed and less productive. At the same time, the eroded topsoil gets accumulated at the lower parts of the field which possess the threat of slumping if the conservation measures are not intervened (13). Tamene & Vlek, *et al* (2008) also reported higher runoff rates and higher precipitation contributing to rapid detachment and transport of soil particles at higher elevations with difficult topographies.

Although the SLM technologies such as bench terracing and stone bunds were promoted as early as 5th five-year plan (1981-1986) in Bhutan, it is only in the recent years that the government recognized the problem of land degradation and promoted SLM measures widely to avoid, reduce and restore degraded land. For example, the government has initiated the national level land management campaigns to sensitize and promote SLM measures starting 2005. Later, starting 2006, number of SLM projects were implemented to roll out best practices and

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approaches across the country. The SLM interventions, e.g., Napier grass hedgerows have reduced soil erosion rate by about 40% as compared to traditional farming practices (13). Yeshey et al (2018) reported 10% increase in crop yield after the implementation of soil erosion control measures in one of the SLM sites in Bhutan.

Despite the above initiatives undertaken by the government, there is no proper study and assessment done about the people's perception towards soil erosion, its causes and the adoption of SLM technologies. In absence of this understanding, the promotion and adoption of SLM technologies become a challenge. Therefore, the current study was convened with the objectives to: i) Document the understanding of farmers about the soil erosion, its causes, indicators and management practices, and ii) Provide policy recommendations to the government to design and implement SLM programs.

2.0 METHODS

2.1 Description of the study sites

The study was carried out in the two separate gewogs (blocks), Jarey under Lhuentse Dzongkhag (district) and Thangrong under Mongar Dzongkhag (Figure 1). In these two gewogs the SLM activities, primarily contour hedgerows & stone bund were extensively implemented through the funding support from the Bhutan Trust Fund for Environmental Conservation (BTFEC) in 2015.

Jarey is one of the remotest Gewogs under Lhuentse Dzongkhag located at 27°27'14.13''N and 91°07'36.05''E with altitude range from 1500m - 2400m above the sea level (asl). Jarey Gewog falls under temperate and sub-tropical climatic conditions with extreme cold in winter and moderate summer. It is characterized with thinly populated and scattered settlements over an area of 137.61 sq. km. The land holdings are mostly located on steep south facing slopes and ridges with high risk of soil erosion. The land use is dominated by dry land accounting to about 1036.8 acres with staple crop being maize followed by wheat, legume and mustard. The small quantity of upland paddy cultivation is also adopted apart from irrigated paddy cultivation. Farmers also rear cattle which form one of the main sources of dairy products.

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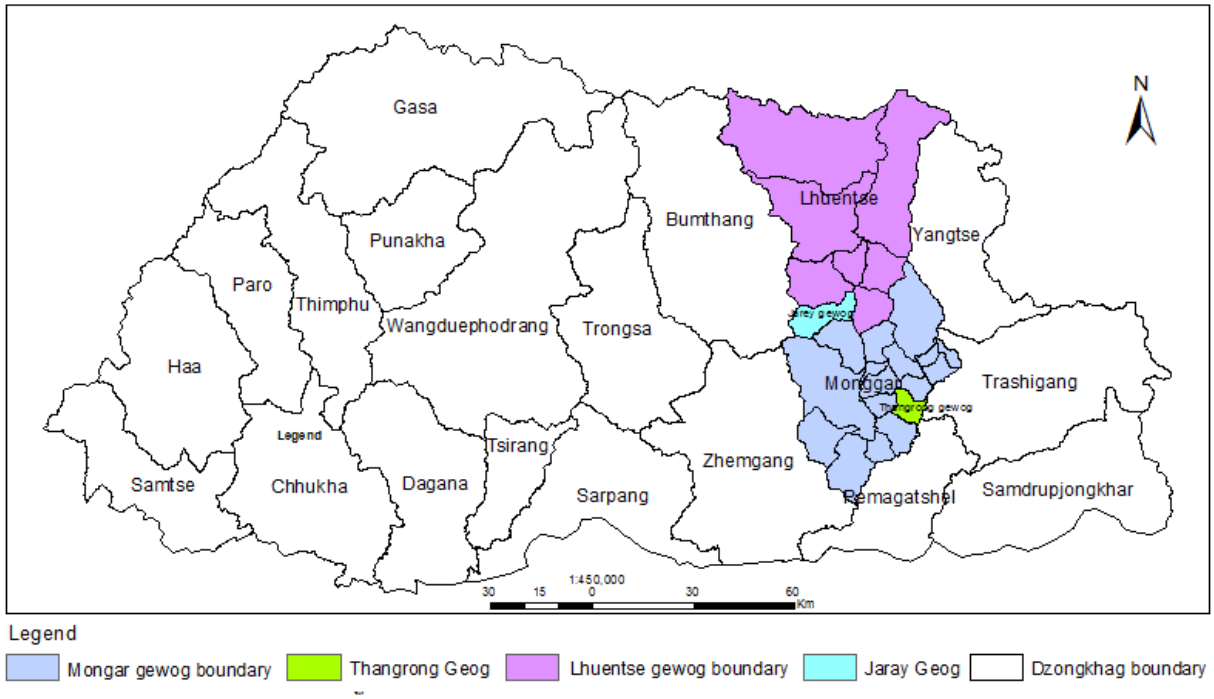

Figure 1: Bhutan map showing study location

Thangrong gewog is located about 51 kilometers away from Mongar Dzongkhag with geographical area stretching from 27°11'52.72N and 91°21'04.46''E with an altitude range of 1000m to1400m asl. The gewog is comprised of 327 households and 2,813 people in an area of 69 sq. km. The topography of the gewog ranges from high mountain terrain with gentle to steep slope and undulated deep gorges. All the five chiwogs are widely dispersed and dissected with the huge gorges. With the advancement of road connectivity into these chiwogs through the steep terrains, it has triggered massive destruction to the environment with numerous landslides which is further aggravated during the monsoon. Dry land agriculture is the dominant land use covering around 1,000 acres. Maize is the main cereal crop while potato is the primary cash crop. Irrigated paddy cultivation is taken up on a limited scale.

2.2 Sampling, research design and analysis

The data for the study was obtained from in-depth interviews of 160 households randomly selected from two Gewogs. The interviewees were randomly selected from the list of the household in both the gewogs. The perception study was conducted in February 2021 using a structured survey questionnaire to acquire farmers' views on soil erosion and impact of implementing the SLM measures. The interview questionnaires were composed of both close and open-ended questions that include farmers' perceptions of soil erosion, soil fertility decline,

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knowledge and use of land management practices, positive impacts of SLM in controlling soil erosion. Respondents were selected using systematic random sampling techniques on lists of households obtained from the respective gewog administrations. Every seventh household on the list was included in the sample. A household consists of a unit of one family that dwells in the same house and depending on the same farmland and farm resources. The interviews were conducted by visiting the chiwogs and with the household members who have participated in implementing the SLM activities. The interview was carried out using local dialect (Chocha Ngacha - Jareygewog, Sharchopkha - Thangronggewog) which enabled the respondents to understand questions and provide clear answers.

All data cleaning, analysis and graphical representation were prepared using various scientific packages from python programming language (4-7). Specifically, descriptive and non-parametric (chi-square test) were used at the probability level of $P \leq 0.05$. The chi-square test was used to assess the statistical significance between the proportion of respondents 'replies in favor of a certain question'.

3.0 RESULTS AND DISCUSSIONS

In this section, the paper presents and discusses the results of the study. Subsequent to the description of household and farm characteristics, farmers' perceptions on soil erosion indicators and associated problems are presented. It is followed by discussions on farmers' perceptions on the causes of erosion, productivity decline, and aspects of soil fertility change. In the last section, farmers' knowledge and use of conservation measures are discussed.

3.1 Household demographic and socio-economic parameters

The characteristic of the sample households covered in the study is presented in Table 1. The respondents' age ranged from 15 to 87 years, while the average age was 43 and 40 years in Jarey and Thangrong respectively. Majority of the land owned by farmers in both the gewogs are dry land with an average of 2.54 acres while the wetlands are mostly scattered with an average area of 0.49 acres. In Jarey, the average land holding by the individual household was 3.18 acres whereas in Thangrong the average of 2.25 acres of land is owned by a household. The mean land holding size in the both gewogs is in line with Bhutan's average land holding per household which is 3.4 acres (RNR census of Bhutan 2019).

Almost all the farmers in both the gewogs practice subsistence farming of both livestock and crops with only small portion being sold in the local market. Thangrong has a comparatively higher average number of livestock per household (12.12) in comparison to that in Jarey (6.64). The majority of respondents in both the study gewogs were female (85.11% in Jarey and 73.33% Thangrong). The average family size was eight in both the gewogs with high illiteracy rate of

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42.55% and 31.11% in Jarey and Thangrong respectively. However, 40.43% of respondents in Jarey and 48.89% in Thangrong attended the non-formal education.

The study found that significantly higher proportion of household in Jarey (61.70%) earned an annual income of less than Nu. 15000, while only 17.02% of total respondents earned annual income of more than Nu. 45,000.00. On the contrary, the results suggest equal proportion of households belonging to different income category in Thangrong (Table 1). The farmers in Thangrong who earn annual income of more than Nu. 45000 is 17.42% more compared to Jarey. The more group of farmers earning more than Nu. 45000 in Thangrong might be possibly due to their involvement in off farm activity. Educated farmers are usually engaged in the off-farm activity where only illiterate ones are left to be involved in implementing the SLM activities (8).

Table 1: Demography and socio-economic characteristics of respondents in two study locations

Parameters	**Jarey (n=47)**		**Thangrong (n=90)**	
Quantitative variables	**min-max**	***mean (SD)***	**min-max**	***mean (SD)***
Age	17-87	43.64 (25.65)	15-75	40.79 (13.94)
Family size	1-21	8.91 (4.35)	2-18	8.11 (3.35)
Total Land holding (Acre)	0.45-20	3.18 (3.7)	0.30-8	2.25 (1.60)
Total livestock	0-25	6.64 (5.91)	0-53	12.12 (10.00)
Qualitative variables	**Percent (Count)**	***X²***	**Percent (Count)**	***X²***
Gender		23.17 **		19.6 **
Male	14.89 (7)		26.67 (24)	
Female	85.11 (40)		73.33 (66)	
Education Category		52.45 **		97.87 **
Illiterate	42.55 (20)		31.11 (28)	
Non-formal education	40.43 (19)		48.89 (44)	
Class < 6	4.26 (2)		8.89 (8)	
Class 6-8	6.38 (3)		3.33 (3)	
Class 8-10	4.26 (2)		3.33 (3)	
Class 10-12	2.13 (1)		4.44 (4)	
Degree and above	0.00 (0)		0.00 (0)	
Annual Income		34.45 **		7.6 ns
< 15000	61.70 (29)		23.33 (21)	
15000-30000	12.77 (6)		27.78 (25)	
30000-45000	8.51 (4)		14.44 (13)	
> 45000	17.02 (6)		34.44 (31)	

*X2 = chi-square test; * Significant at P ≤ 0.05.** Significant at probability level, P ≤ 0.01.*

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3.2 Farmers' perception on the indicators of soil erosion

As indicated in the result (Table 2 and Table 3), significantly higher proportion of respondents in both the study areas perceived all the soil erosion indicators prescribed in the semi-structured questionnaire. Among various indicators of soil erosion, significantly higher proportion of respondents in Jarey (97.87%) and Thangrong (92.22%) observed soil erosion during the heavy rain. The soil erosion is exhibited more severely on the steep slope farmland that received a high amount of rainfall (9). Majority of respondents in both the study sites identified the decline in soil fertility as one of the serious problems that has affected the agricultural land. Similarly, significantly higher proportion of respondents from both the gewogs identified soil erosion as the main factor for the poor plant performance and low yields (10).

Reducing the soil depth as a result of soil erosion was reported less when compared to other indicators. About 80.61% of farmers have observed a reduction in the soil depth over the years due to soil erosion. Although continuous soil erosion might have eroded the soil causing the soil depth to decrease over the time but farmers might have failed to observe it. Farmers' perception of soil erosion problems are mostly limited to their physical evidence (12). Rill erosion is usually formed in the cultivated land by the concentrated water flow during the downpour forming the small channels. Subsequently, gradual widening of the rills develops into a gully which completely deteriorates land making it unfit for agriculture works. Rill and gully erosion is reported high by the farmers of Thangrong (86.67%) whereas respondents from Jarey reported 78.71%. Farmer's observation of rill and gully erosion in Thangrong might have been through the physical evidence as majority of the cultivated lands are on the slopes. One reason for the low rate of observation of rill erosion in Jarey might be the fact that contour hedgerows established in the past might have reduced the incidence of erosion in their field.

Table 2: Indicators of soil erosion and land degradation in Jarey Gewog, Lhuentse, Bhutan (n=47)

Indicators of soil and land erosion	Yes (%)	No (%)	X^2
Washing down of soil during rainy season	97.87	2.13	43.89 **
Declining soil fertility	95.74	4.26	39.34 **
Poor crop growth	89.36	10.64	29.13 **
Decreasing crop yield	89.36	10.64	29.13 **
Reduced soil depth	72.34	27.66	9.38 *
Appearance of more stones on the surface	93.62	6.38	35.77 **
Rill and gully erosion	78.72	21.28	15.51 **

*X2 = chi-square test; * Significant at P ≤ 0.05.** Significant at probability level, P ≤ 0.01.*

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Table 3: Indicators of soil erosion and land degradation in Thangrong Gewog, Mongar, Bhutan (n=90)

Indicators of soil and land erosion	Yes (%)	No (%)	X^2
Washing down of soil during rainy season	92.22	7.78	64.18 **
Declining soil fertility	90	10	57.60 **
Poor crop growth	90	10	57.60 **
Decreasing crop yield	90	10	57.60 **
Reduced soil depth	88.89	11.11	54.44 **
Appearance of more stones on the surface	91.11	8.89	60.84 **
Rill and gully erosion	86.67	13.33	48.4 **

*X2 = chi-square test; * Significant at P ≤ 0.05.** Significant at probability level, P ≤ 0.01.*

3.3 Farmers' awareness and cause of soil erosion

The research revealed that the farmers have experienced soil erosion and land degradation on their farms regardless of established SLM structures. The study found that 100% respondents in Jarey were aware of soil erosion whereas in Thangrong only 7.78% respondents lack knowledge about the soil erosion. The Chi-square test (Table 4) also indicated that there are significant differences in the proportion of respondents who observed rain as the main cause of soil erosion. The major causes of the soil erosion mentioned by the farmers of both the gewogs include heavy rain, cultivation on the steep slopes, labor shortage to practice SLM practices and intensive cultivation. The heavy monsoon rain is the main cause of soil erosion from the cultivated field, especially during the early crop growth stage. Rainfall leads to significant loss of soil from the farm plots that are located on the steep slope as many farmers managed their field on the slopes having more than 20% gradient. Generally, soil loss is observed high as slope steepness increases on both cultivated and uncultivated soils (13).

Farmers also recognized deforestation as another cause of soil erosion in their community. About 72.34% of respondents from Jarey and 63.33% from Thangrong observed deforestation leading to soil erosion. Removing vegetation leads to poor infiltration of the rain water thereby causing the surface runoff those channels into the farmland triggering landslides. Soil erosion and runoff can be significantly increased after removal of vegetation especially in the mountainous areas (14). The vegetation covers can enhance the water infiltration, reduce surface runoff and as a result substantially retards sheet erosion (15). Farmers also blamed population pressure as the cause of soil erosion, which they might have observed after intensive utilization (over cultivation) of farmland and deforestation inflicted while collecting timber for house construction.

Labor shortage and capital constraint in implementing land management practices were perceived as other contributing factors to the soil erosion in both the gewogs. About 91.49% of

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respondents in Jarey expressed the labor shortage problem while 8.51% have not felt labor shortage as a serious issue. Lack of capital has affected least to soil erosion as both the gewogs have implemented SLM activities under the fund support from the projects.

Table 4: Awareness, causes of soil and land degradation in two study locations

Particulars	Jarey *(n=47)*			Thangrong *(n=90)*		
	Yes (%)	No (%)	X^2	Yes (%)	No (%)	X^2
Awareness on soil and land degradation						
Farmer aware of land degradation and soil erosion	47 (100)	0 (0)	0^{ns}	83 (92.22)	7 (7.78)	64.178^{**}
Causes of soil erosion						
Heavy rainfall	45 (95.74)	2 (4.26)	39.34^{**}	84 (93.33)	6 (6.67)	67.60^{**}
Deforestation	34 (72.34)	13 (27.66)	9.38^{*}	57 (63.33)	33 (36.67)	6.4^{*}
Cultivation on steep slope	43 (91.49)	4 (8.51)	32.36^{**}	81 (90)	9 (10)	57.6^{**}
Increasing population pressure	33 (70.21)	14 (29.79)	7.68^{*}	53 (58.89)	37 (41.11)	2.84^{ns}
Removal of crop residue	37 (78.72)	10 (21.28)	15.51^{**}	45 (50)	45 (50)	0^{ns}
Over cultivation	40 (85.11)	7 (14.89)	23.17^{**}	56 (62.22)	34 (37.78)	5.38^{*}
Labor shortage	43 (91.49)	4 (8.51)	32.36^{**}	67 (74.44)	23 (25.56)	21.51^{**}
Lack of capital	34 (72.34)	13 (27.66)	9.38^{*}	61 (67.78)	29 (32.22)	11.38^{**}

X^2 = chi-square test; ns = non-significant at $P > 0.05$, * Significant at $P \leq 0.05$.** Significant at probability level, $P \leq 0.01$.

3.4 Farmers' perception of soil erosion severity

Farmers have diverse perceptions regarding the extent of soil erosion in their farmland. About 76% of respondents in Jarey observed high erosion, 8.51 % moderate and 15.89% low. In Thangrong gewog, 56% of farmers witnessed high erosion, 22.22% moderate and 15.56% observed low. The proportion of farmers in both the gewogs who observed high severity of erosion (66.31%) were significantly higher than those who perceived low. According to a significantly higher proportion of respondents in two gewogs, soil erosion is inflicting severe problems in their cultivated farmland. The reason could be associated with the existence of farmland on the steep slopes and poor management of established SLM practices coupled with habit of livestock tethering in the hedgerow sites. However, those farmers who have not responded to the high soil erosion might be attributed to the well-established contour hedgerows that functions in arresting the soil erosion during the rainy season. Soil erosion is controlled by the contour hedgerows acting as permeable barrier by slowing down the runoff (16).

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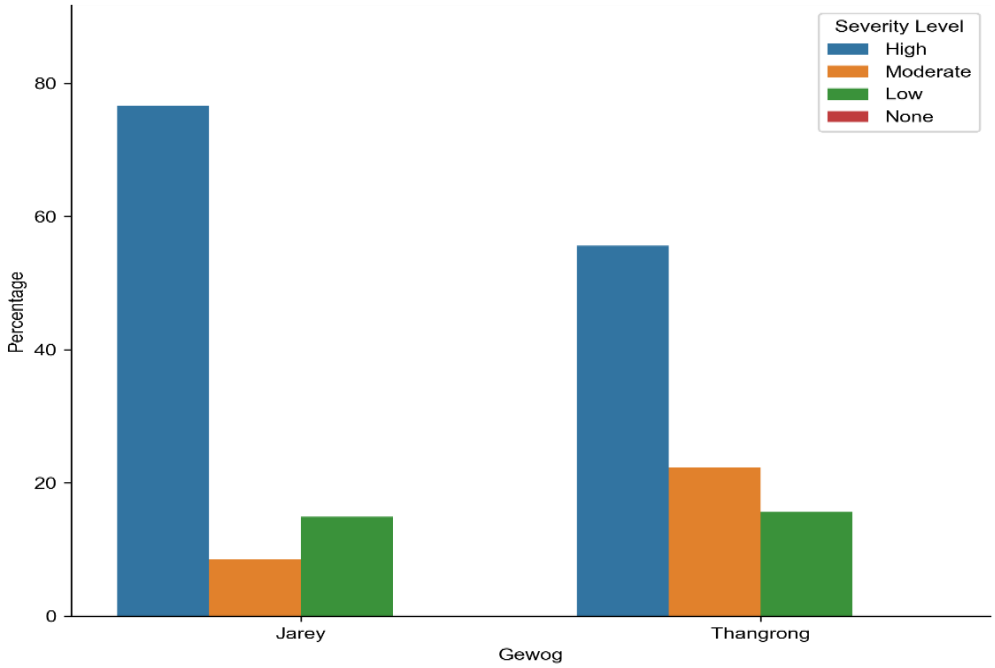

Figure 2: Soil erosion severity in the two gewogs

3.5 SLM adopted by the farmers

When asked about the SLM activities adopted, the respondents of both the gewogs reported that they have implemented the measures like terracing, contour hedgerows (Napier grass) and stone bunds (Figure 3). Out of different SLM activities, 6.38% of respondents in Jarey gewog adopted terrace, 53.19% contour hedgerows and 63.83% stone bunds. However, the respondents in Thangrong gewog reported no terrace development other than 91.11% contour hedgerows and 25.56% stone bunds. The presence of terrace development only in Jarey could be because it falls under the Global Environment Facility (GEF) project sites that supported the terrace development. However, terraced fields are observed in a few pockets of Thangrong gewog but no terrace development was done for the purpose of soil erosion control.

In Thangrong gewog, majority of the respondents (91.11%) reported using contour hedgerows as soil erosion control measure and only a handful of farmers have adopted stone bund. In contrast, farmers of Jarey gewog indicated slightly higher use of stone bunds compared to contour hedgerows. The contour hedgerows as favored techniques used by the majority of farmers in Thangrong gewog might be related to the mass establishment of hedgerows in the past supported by the projects. The maximum adoption of stone bund at Jarey gewog might be due to the presence of more stones in fields whereby farmers took up stone bund as soil erosion control measures. Stone bunds provide effective soil erosion control and improve productivity through

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soil fertility and moisture conservation. The study conducted by Kassie et al (2008) (17) in northern Ethiopia showed that stone bunds are more effective in dry agricultural land that receives less rainfall.

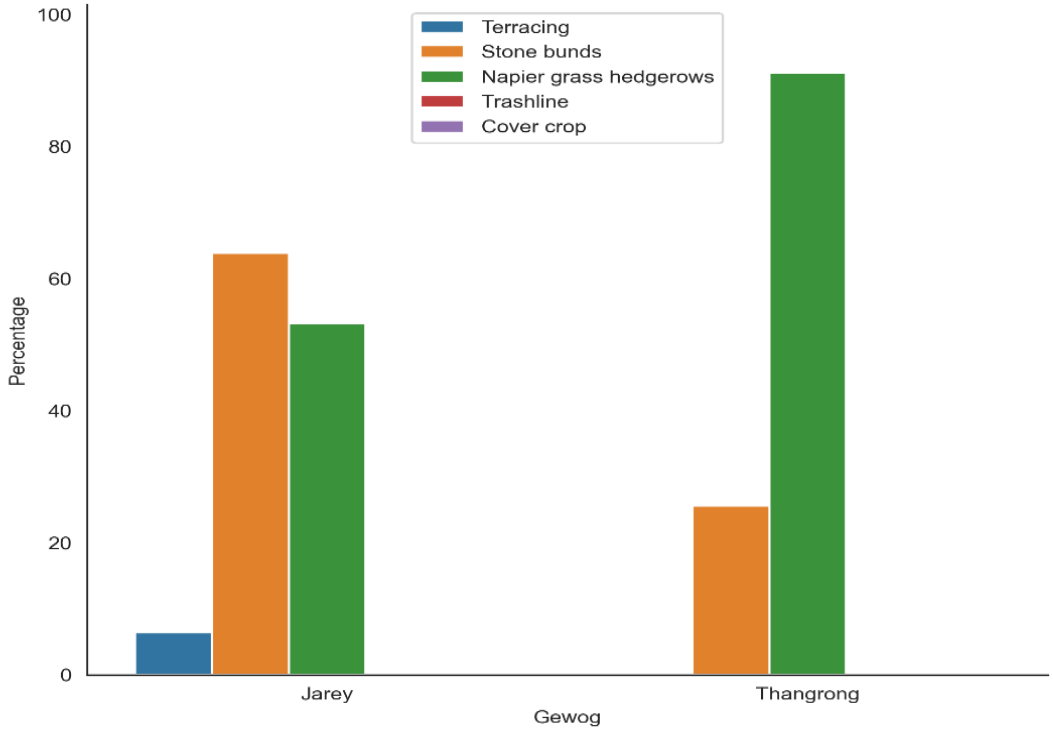

Figure 3: SLM activities adopted by the farmers

3.6 Farmers observation after implementing SLM

The respondents were assessed based on the physical observation resulting from implementation of soil erosion control measures. The effective soil erosion control provided by the SLM measures was observed by farmers of both the gewogs. In addition, the chi-square test showed that the proportion of respondents who perceived change brought by the erosion control measures were significantly higher than those who did not perceive them in two study gewogs (Table 5). In Jarey, significantly higher proportion of the respondents perceived reduced soil erosion (85.11%), easy to work (76.60%), more fodder availability from hedge (55.32%), increase crop yield (61.70%) and better agriculture landscape (80.85%). Similarly, in Thangrong gewog, significantly higher proportion of the respondent perceived reduced soil erosion (90%), easy to work (87.78%), more fodder availability from hedge (91.11%), increase in crop yield (66.67%) and better agriculture landscape (90%) were most important observation made from the SLM measures.

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In both the gewogs, a higher proportion of farmers who observed reduced soil erosion and more fodder availability from the hedge might be due to the effective barrier formed from the contour hedgerows and the easy access to fodder from the hedges. The hedgerows supplied adequate fodder that the farmers need no longer to go into the forest to collect fodder or look after cattle and hence more time can be given to other important activities in the farm. The natural terraces formed by the hedgerows can reduce the slope steepness on the sloping land and notably reduce the soil erosion and runoff (18). In one of the studies conducted by Xu et al (2000) ((19) in China, the contour hedgerow inter-cropping helps in reducing the runoff and soil erosion up to 24.8% and 16.9% to that of agriculture land on the slopes under traditional management. Increase in the crop yield might be attributed to the workability of the farmland after forming the natural terrace as a result of sediment arrest on the ridges and enhanced amount of water infiltration. The hedgerow enhances the capacity in blocking the soil erosion which influences the soil particle distribution on the slope and silt deposition in front of the hedgerows (18).

Table 5: Changes observed after implementation of SLM in two study sites

Particulars	Jarey *(n=47)*			Thangrong *(n=90)*		
	Yes (%)	**No (%)**	X^2	**Yes (%)**	**No (%)**	X^2
Reduced soil erosion	40 (85.11)	7 (14.89)	23.17 **	81 (90)	9 (10)	57.60 **
Easy to work	36 (76.60)	11 (23.40)	13.30 **	79 (87.78)	11 (12.22)	51.38 **
More fodder availability from hedge	26 (55.32)	21 (44.68)	0.53 ns	82 (91.11)	8 (8.89)	60.84 **
Increase in crop yield	29 (61.70)	18 (38.30)	2.57 ns	60 (66.67)	30 (33.33)	10 **
Better agriculture landscape	38 (80.85)	9 (19.15)	17.89 **	81 (90)	9 (10)	57.60 **

X^2 = chi-square test; ns = non-significant at $P > 0.05$, * Significant at $P \leq 0.05$.** Significant at probability level, $P \leq 0.01$.

3.7 Challenges in adopting SLM measures

In both the study sites, the challenges faced by the farmers while taking up the SLM activities were significantly low (Table 6). The farmers of Jarey reported labor shortage (29.79%), lack of capital (10%), lack of know-how (9%), post care maintenance (2%) and no immediate benefit gained (6%). Likewise, the respondent from Thangrong outlined labor shortage (10%), lack of capital (3.33%), lack of know-how (5.56%), post care maintenance (24.44%) and no immediate benefit gained (38.89%). According to the survey, the majority of the respondents have not faced challenges while adopting the SLM activities. Upon comparing the two gewogs, a high proportion of respondents in Jarey reported labor shortage as a challenge, whereas adopters of Thangrong have faced difficulty in post care maintenance and no immediate benefit gained after implementing SLM measures. The one reason for the labor shortage faced by the farmers of Jarey while implementing SLM activities could be due to the shortage of adult males whereas females have to look after household chores and children at home. The chance of practicing SLM

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measures is high in male headed households since its construction and maintenance demand labor force (20). Nevertheless, in both the gewogs, SLM activities were funded and implemented through the project without leaving it to the household level. The training on SLM was imparted to the adopters followed by involvement of labor from individual households for establishment of SLM structures in their gewog. Therefore, through labor sharing techniques, the labor pressure was perceived low.

In contrast to the respondents of Jarey, a high proportion of respondents in Thangrong perceived challenges in post care maintenance and reaping no immediate benefits from SLM. The farmers might have experienced such challenges due to huge coverage of SLM activities (contour hedgerows) which requires intermittent trimming of hedge and often neglected thereby resulting into no immediate benefits in controlling soil erosion.

Table 6: Challenges encountered during adoption of SLM measures in two study sites

Challenges in adoption of SLM measures						
Particulars	**Jarey *(n=47)***			**Thangrong *(n=90)***		
	Yes (%)	**No (%)**	***X²***	**Yes (%)**	**No (%)**	***X²***
Labor shortage	14 (29.79)	33 (70.21)	7.68 **	9(10%)	81(90%)	57.6 **
Lack of capital	10 (21.28)	37 (78.72)	15.51 **	3 (3.33)	87 (96.67)	78.40 **
Lack of know-how	9 (19.15)	38 (80.85)	17.89 **	5 (5.56)	85 (94.44)	71.11 **
Post care maintenances	2 (4.26)	45 (95.74)	39.34 **	22(24.44)	68 (75.56)	23.51 **
No Immediate benefit gained	6 (12.77)	41 (87.23)	26.06 **	35 (38.89)	55 (61.11)	4.44 *

X^2 = chi-square test; ns = non-significant at $P > 0.05$, * Significant at $P \leq 0.05$.** Significant at probability level, $P \leq 0.01$.

3.8 The SLM coverage in two gewogs

The percentage of different SLM activities coverage in two study sites (Figure 4). A significant difference in the two gewogs were observed in terms of the number of SLM activities implemented and adopted by the farmers. Jarey gewog adopted a high area of hedgerows (37.7%), stone bund (36.5%), check dams (21.2%) and terracing (4.5%). In Thangrong, a significantly higher proportion of farmers have adopted hedgerows (89.9%) as one of the measures to combat the soil erosion and only few areas were under the stone bund (10.1%). The contour hedgerows coverage in Thangrong gewog is comparatively higher than the Jarey gewog as a result of SLM campaign initiated under the BTFEC project in 2015. It was during the land management campaign that a huge area under the Thangrong was brought under contour hedgerow as mitigation measures against the prevailing soil erosion problem. Other SLM measures like stone bunds, although exists in scattered areas, were hardly mentioned by the respondents during the survey. The majority of the farmland in Thangrong is on the steep

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topography with stony surfaces that are usually small in size and not suitable for stone bunds construction.

The study found that a greater number of SLM activities were adopted by the farmers of Jarey gewog which may be attributed to the vulnerability of the site and the need for such interventions. The farmers perception on soil erosion and its impacts significantly influences their interest in adopting soil and water conservation structures (21). The adoption of terraces, stone bund and check dams by the farmers of Jarey might be attributed to the decision of landowners after perceiving the severity of soil erosion in the gewog. Farmers' decisions were largely determined by their knowledge of the problem and the perceived effectiveness from the program (22).

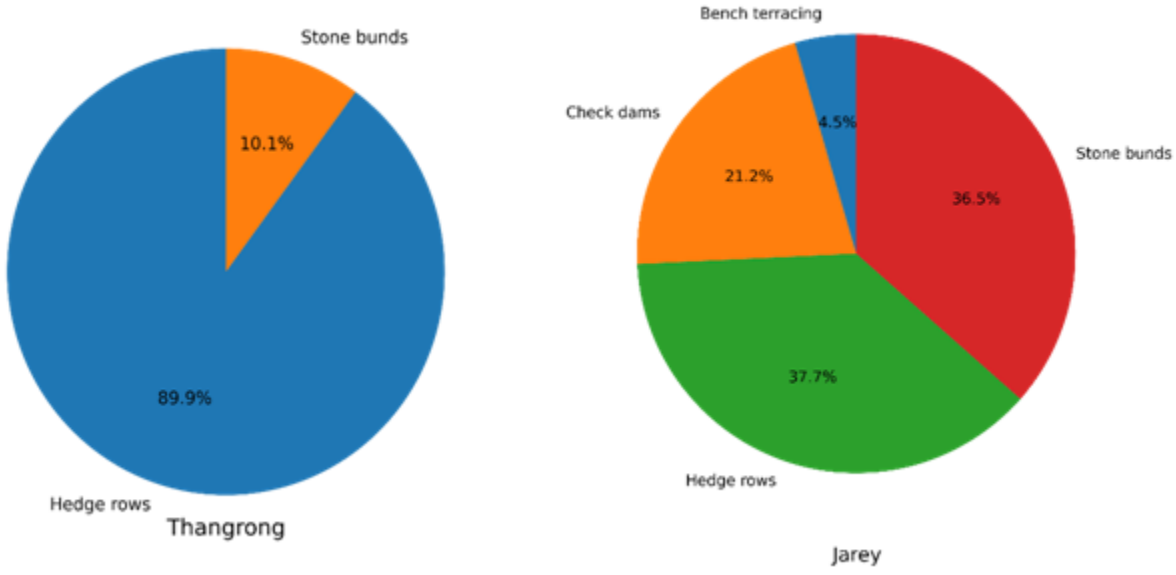

Figure 4: Different SLM activities adopted by the farmers of two gewogs

3.9 Farmers perception on support requirements for SLM adoption

The respondents were asked regarding the support that they would require to replicate and scale out SLM interventions in the future (Table 7). The higher proportion of farmers from Jarey gewog (96.25%) expressed the need of awareness program on the importance of SLM, (95%) provide financial support to take up SLM measures, (89.11%) built capacity on SLM best practices, (89.11%) provide regular technical backstopping on SLM by extension and (69.82%) support in short term interventions (seed and seedlings). Similarly, in Jarey gewog majority of the respondents indicated importance of providing (95.64%) financial support to take up SLM measures, (95.64%) support in short term interventions (seed and seedlings), (94.32%) Provide regular technical backstopping on SLM by extension, (92.05%) Create awareness on the

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importance of SLM and (87.88%) build capacity on SLM best practices. The higher proportion of respondents from Jarey gewog who perceived the need of awareness on the importance of SLM might be due to the lack of knowledge on soil erosion and its impact on soil fertility decline by the rest of the farmers in a village. Though an awareness program was conducted before initiation of the SLM program in both the gewogs, the farmers still feel the need to sensitize them on the importance of SLM and its best practices in combating land degradation.

The capacity development on SLM best practices was perceived less important in comparison to other determinants. This might be due to the fact that the training was already imparted to the farmers of both the gewogs to build their capacity on the proper method of SLM implementation. Farmer's knowledge and information plays an important role in implementing effective soil and water conservation measures (23). In contrast, respondents of Thangrong gewog claimed support in short term interventions (seed and seedlings) which might encourage other farmers to take up SLM in their gewog. This is arguably true as often farmers get encouraged by any form of incentives that they get from the government in taking up activities and seed and seedlings gives them opportunity to earn extra income. The study shows that the number of farmers who found the importance of regular technical backstopping on SLM by extension was somewhat lower in Jarey gewog. However, farmers are benefited by the assistance of the agriculture extensions in any sort of agriculture related activities in their respective gewogs. The agriculture extension in both the gewogs played a pivotal role in overall coordination of SLM implementation.Frequent contact with extensions and regular site visits was identified as a key strategy for technology dispersion (24).

Table 7: Government interventions to support upscaling SLM measures

Government interventions	Jarey *(n=47)*	Thangrong *(n=90)*
Build capacity on SLM best practices	89.11	87.88
Create awareness on the importance of SLM	96.25	92.05
Provide financial support to take up SLM measures	95	95.64
Provide regular technical backstopping on SLM by extension	89.11	94.32
Support in short term interventions (seeds, seedlings)	69.82	95.64

4.0 CONCLUSION

The study revealed that there was a significantly high proportion of farmers who perceived soil erosion as a serious threat to their land and crop productivity in both the gewogs. The farmers from both the gewogs (>99%) reported to have observed soil erosion and their negative impact on the soil fertility. Almost all the farmers have identified different indicators of soil erosion in which high proportion farmers from Jarey have perceived washing down of soil during the rainy

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season (97.87%) and declining soil fertility (95.74%) as one of the indicators of soil erosion. Similarly, respondents from Thangrong have indicated soil loss due to heavy rain (92.22%) and appearance of more stone on the surface (91.11%) as major indicators of soil erosion. The farmers' perception of soil erosion due to heavy rainfall and cultivation on the steep slope are perceived as major causes of erosion in their farmlands.

The most frequently emphasized direct cause of soil erosion by the farmer respondent in two gewogs includes: heavy rainfall (94.5%), cultivation on steep slope (90.7%), labor shortage (82.9%), deforestation (67.8%) and increase in population pressure (64.1%). The farmers have also identified the severity trend of the soil erosion in their respective gewog as high, medium and low. Majority of farmers in both the gewogs have indicated a high rate of erosion, (76%) Jarey and (56%) Thangrong affecting the farmland in various ways. As mitigation measures, the farmers have adopted various SLM activities such as contour hedgerows, stone bunds, check dams and terracing. Significantly higher proportion of farmers in Thangrong (91.11%) adopted contour hedgerow as compared to Jarey (53.19%). Majority of farmers from both the study gewogs perceived that the soil erosion is reduced after implementing the SLM activities. Moreover, farmers also asserted that such interventions have enhanced workability, improved yield and adequate fodder availability from hedgerows to livestock. In both the study gewog, no major challenges were faced by the farmers while implementing the SLM activities. However, some farmers of Thangrong reported challenges in post care maintenance and lack of immediate benefits from the established contour hedgerows. In addition, farmers from both the gewogs also expressed the support needed from the government in further scaling up the SLM measures. About (96.25%) of farmers from Jarey perceived the importance of creating awareness on SLM while (94.64%) respondents of Thangrong stated that short term interventions (incentives like seed and seedling) would encourage them in up-scaling SLM measures in future.

5.0 RECOMMENDATIONS

To roll out SLM best practices successfully, it would be important to consult local communities through participatory approach to understand their local context and design appropriate SLM interventions. Awareness raising should always precede actual implementation of SLM in the field. Other critical support to incentivize SLM interventions is to develop incentive package so that the farmers can benefit from short term interventions while they await longer term benefits likely to generate from those SLM interventions that have long gestation period, e.g., hedgerows, stone bunds, etc. This is particularly true for those resource poor households who are more concerned about their immediate livelihood needs than longer term benefits.

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