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Soil and Water Conservation and dryland farming in the hilly areas of Bangladesh

Conservation de l'eau et du sol en culture sèche dans les régions vallonnées du Bangladesh

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1.0 INTRODUCTION

Bangladesh occupies an area of 144,863 km² lying astride the Tropic of Cancer. The hilly areas cover about 1,734,182 ha mostly in the Greater districts of Chittagong Hill Tracts, Chittagong and Sylhet.

1.1 Climate and Hydrology: The climate is alternating hot, humid in the rainy season and cool, dry in the winter season. Rainfall exhibits considerable spatial variations within short distances and ranges from an annual average of 1,200 mm - 4,500 mm. About 85% of annual rainfall occurs between May-October. The amount increases from west to east across the country. Mean annual temperature is about 25⁰C. Mean monthly temperatures vary between 17⁰C in January and 30⁰C in April-May. Extreme temperatures vary between about 4⁰ and 40⁰C. The most striking feature of country's hydrology is the seasonal cycle of flooding and drainage. The heavy rainfall between May-October comes at a time when the major rivers are bringing large volumes of water from their upper courses thus causing flood in the country.

1.2 Physiography : Broadly, Bangladesh has three major physiographic units: floodplains, terraces and hills. Floodplain constitutes about 80 per cent of the total area whereas terrace and hills occupy about 8 per cent and 12 per cent respectively (Map-1). Based on geology and landform, the hills of Bangladesh may broadly be subdivided as follows (Saheed, 1995).

- 1) **High hill ranges (about 70 percent)**
- 2) **Low hill areas (about 30 percent)**

1) The high hill ranges, about 200-1,000m above msl, include NW-SE trending anticlinal systems of Oligo-Miocene formations of Tertiary age, comprising somewhat consolidated to consolidated shales, sandstones, siltstone and conglomerates, uplifted, faulted, tilted and deeply dissected to form steep to very steep hills. These hills are highly susceptible to water erosion and land degradation and usually have a rather youthful soil mantle ranging from a few cm to several metres in thickness over bedrocks.

2) The low hill areas, about 15-200 m above msl, include the few anticlines, dissected synclines and low outliers of the main hill ranges of Mio-Pliocene Tertiary formations and comprise mostly unconsolidated to semi-consolidated shales and sandstones, locally with plinthite and hard lateritic outcrops. The low hills are nearly flat or rounded topped to steep to very steep, being susceptible to various types of water erosion, but to a lesser degree of severity than the

steeper high hills. Soils are usually old, leached, highly acidic and deep. Active soil erosion and land degradation are taking place in the hilly areas of Bangladesh at an alarming rate.

1.3 Soils: Bangladesh has a wide range of soils. In the high hill ranges, the soils are very shallow to deep, pale brown, slightly to strongly acid, sandy loams to clays, usually overlying decomposing bedrocks at variable depths. They are usually Eutrochrepts, Dystrichrepts and lithosols. In the low hills, soils developed in soft rock materials are usually deep, brown to red-brown, strongly to very strongly acid, sandy loams to clay loams, locally overlying plinthite or hard lateritic substrata. They are mostly Dystrichrepts, Udalfs and Udults. Hill soils in general are well to excessively drained poorly to moderately well drained, grey to pale brown, slightly to strongly acid, sands to clays occur in the valleys and adjoining piedmont plains (Saheed, 1995)

2.0 LAND USE IN HILL AREAS

2.1 Factors influencing Agricultural Land Use: Landforms, hydrology, climate and soil are the major factors those determine the agricultural land use. Hydrological and climatic conditions determine the choice of crops those could be grown in summer and winter seasons whereas soil properties determine the crop yield, especially in valleys and adjoining piedmont plains with alluvial soils. In the hills, plant available soil moisture, organic matter content and depth of soil, and aspect, gradient and length of slope are the additional factors affecting growth and choice of plants. Two sub-regions of the hill areas, high hill ranges and low hill areas, have the following general patterns/types of land use:

The high hill ranges are mostly under scrub, high grass and scattered trees. About one fifth of the area is under state forests, where a viable cover of trees and bamboos occurs. In the remaining unclassified state forest areas shifting cultivation is practised annually covering 5-10% area. Locally plantations of pineapple, orange and rubber occupy small areas. The low hills are mainly under scrubby thickets, grassland, bamboos and tree forest. Shifting cultivation is practised by the tribal people in Chittagong hill tracts and locally in other areas. The crops include early summer highland rice, ginger, banana, chilies and vegetables. Tea is grown on some deep soils having steep to rolling topography. Rubber is grown on terraced very steep to rolling topography. Pineapple cultivation on hills by clearing the forest and planting mostly along the slopes is a faulty agricultural practice causing severe soil erosion. Vegetables, tobacco and wetland rice are the major crops grown in the valleys and adjoining plains. A generalized agriculture and forest land use is shown in Map-2.

3.0 SOIL CONSERVATION AND WATERSHED PROTECTION NEED IN THE HILLY REGIONS OF BANGLADESH.

3.1 Extent and Severity: The hilly areas of Bangladesh are shown in Table-1. The area distribution under different slopping classes is also shown in Table-2. Water erosion is the main cause of soil erosion and land degradation in the hill areas of the country. In Sylhet, growing of pineapple in the hilly areas is causing massive erosion. The plants are grown in rows (about 3'-4' feet apart) which are mostly oriented vertically down the slope. The inter-row spaces are clear-tilled by hoeing leaving the loosened soils highly vulnerable to sheet and gully erosion. Some 5,000 ha under faulty practice of pineapple cultivation in Sylhet area during 19980-81 was a typical example of the severity of the exposure of slopping lands to degradation (Layzell, 1982). In Chittagong Hill Tracts, soil erosion is mainly due to shifting cultivation. Recently, a survey was conducted at 7 different sites namely Khagrachari, Manikchari, Ramgahr, Rangamati, Raikhali and Bandarban to diagnose farming practices and their impacts on soil resource loss in the hill tracts of Bangladesh (Farid 1988). The impact study in the form of soil loss, nutrient loss and sediment deposits was the concomitant consequence of agricultural

practices and operations followed at steep and very steep slopes of hills and ridges of the Chittagong Hill Tract areas. At Khagrachari, about 90% farmers follow Jhum cultivation. Jhum cultivation intensity may be expressed as Khagrachari> Rangamati>Bandarban. In practising jhum, various operations are followed but the major among them are “slash and burning”, dibbling, followed by interculture operation weeding. Besides, there is ranching of livestock animals.

3.2 Soil Loss: The factors responsible for the loss of soil material are rainfall, land slope, slope length, vegetative cover density and management practices etc. The most harmful factor is the farming practice which is found in various forms prone to erosion. Every year more and more land are becoming denuded due to unplanned agricultural expansion. The impact of high intensity rainfall (2,000 to 4500 mm) followed by run-off over greater slope length results in tremendous soil loss. The effect becomes more deleterious with the steepness of the areas (Table 3 and 4). In many cases, gullies are formed. These gullies are scatterdly found in the hill areas. In some cases, the impact was so pronounced that the sub-surface bed-rock was exposed.

3.3 Nutrient Loss: As continuous process of nutrient loss is going on all over the Hill tract areas under high rate of precipitation. The process is accelerated by open cultivation system on steep to very steep land. The depleting soil fertility of hill soils become more serious if the faulty pineapple cultivation goes on unabated.

4.0 DRYLAND FARMING

In a broad sense, dryland agriculture implies agriculture without irrigation. Mulches are used for various reasons but water conservation and erosion control are undoubtedly the most important issues being addressed for agriculture in dry regions (Miah, 1993).

4.1 Selection of Crop: The selection of crop(s) according to slope percentage is of great importance for hill farming. Rooting system, water requirement, absorption capacity and growth habit and canopy structures of different crops are quite different. Experimental results showed that the growth performance and yield of maize is the highest upto 10% slope, cabbage upto 20% slope and banana upto 30% slope (Table-5).

Table-5: Performance of crops at different hill slopes

Crops	Yield (t/ha)		
	Upto 10% slope	10-20% slope	20-30% slope
Maize	3.0 a	2.1 b	1.5 c
Cabbage	52.3 a	50.0 a	15.0 b
Banana	28.5 a	28.2 a	24.9 a

Fertility gradients are generally more pronounced in slopes with lower portion more fertile than areas at the top. Plant nutrients tend to settle in lower areas. Significantly higher yield of guava (52.6% increase) was obtained on hill foot over hill top (Table -6). Excess moisture at maturity/harvesting damaged the rhizomes of turmeric which might be the reason of lower yield at hill foot.

Table-6: Performance of guava and turmeric in different hill elevations.

Guava		Turmeric	
Hill elevation	Yield/plant (kg)	Hill elevation	yield (t/ha)
Top hill	20.89 c	Hill top	12.85 b
Mid hill	26.64 b	Hill slope	15.87 a
Foot hill	31.88 a	Hill foot	11.74 b

4.2 Soil Conservation Measures: Soil erosion causes rapid fertility depletion, damages crops by sedimentation and raising stream beds/river channels by siltation which causes flash floods and limits discharge capacity, irrigation and navigation. So, soil conservation measures should always be a major consideration for sustainable hill farming. The common practices in the hill Tracts is to plant crops up and down the slopes which facilitate soil erosion with the onset of heavy rains. However, plantation should be made along the contours. Simple conservation measures like mulching can reduce topsoil removal. Crops like maize, sesame, turmeric and ginger gave a good yield of 3-4, 1-1.5, 20-30 t/ha respectively when cultivated with mulching. Studies showed that is zero-tillage with surface mulch reduced soil erosion by 3-6 times as compared to traditional method without mulch at 5-15% hill slope (Table-7)

Table-7: Effect of Tillage and Mulching on Soil Erosion in Hill Slope (5-15%)

Treatments	Dry weight of eroded soil (t/ha)
Mulch	22.25. b
No Mulch	58.02 a
Zero-tillage (dibble)	23.77 c
Minimum tillage (furrow planting Conventional tillage (Spading)	35.68 b 61.13 a
Zero-tillage + Mulch	13.12 e
Zero-tillage + no Mulch	34.43 c
Minimum tillage + Mulch	20.12 d
Minimum tillage + no Mulch	51.24 b
Conventional tillage + Mulch	33.43 c
Conventional tillage + no Mulch	88.85 a

4.3 Utilization of soil moisture: The Hill farmers of Bangladesh generally cultivate their crops under rainfed condition. The average yield is low in most cases because of their inadequate knowledge about appropriate sowing time under rainfed cropping system. In Bangladesh, November-December is the best planting time of cabbage in plain land. In hilly region, suitable sloppy lands are available for early cabbage production which gets higher market price. Higher yield of cabbage (51.2 t/ha) was obtained when planted in October at Khagrachari hilly area (Table-8).

Table -8: Effect of sowing time on cabbage yield in hill slope (5-20%).

Sowing time	Yield (t/ha)
September, 15	33.7 b
October, 01	51.16 a
October, 15	34.49 b
November, 01	24.42 c

A study was conducted on effect of sowing time of different maize varieties in hilly areas and significant yield reduction was observed when sowing was done after first week of October (Table-9).

Table-9: Effect of sowing time of the yield (t/ha) of different maize varieties in hill slope (5-20%).

Sowing	Barnali	Shuvra	Pop corn
October, 05	2.82 a	3.23 a	1.88 a
October, 25	1.27 b	1.40 b	0.92 b
November, 15	0.75 c	0.76 c	0.45 c

Field research conducted at Ramgahr area showed that September is the best planting time both for banana and pineapple (Table -10).

Table- 10: Effect of planting time on the yield of Banana and pineapple in hill solpe (10-30%)

Planting time	Yield (t/ha)	
	Banana	Pineapple
August	26.67	73.01
September	34.00	77.23
October	28.63	70.93
November	28.88	62.31

4.4 Tillage Practices: The Cultural management like zero-tillage is one of the most important factors for higher crop production in rainfed agriculture specially in hill region. Research works carried out on different crops in hill slopes (10-20%) under Hill Agricultural Research Station, Khagrachari revealed that zero-tillage gave significantly higher yield of maize, ginger, cowpea and mukhi kachu. But cabbage and tomato performed well in pit methods of planting in hill slope (Table-11).

Table-11: Effect of tillage on the yield of different crops in hill slope (10-20%).

Crop	Yield			
	Zero-tillage (dibbling)	Furrow (minimum)	Pit	Conventional (Spading)
Cabbage	76.33 b	-	97.62 a	80.3 b
Maize	2.87	2.46	-	-
Ginger	8.47	7.38	-	-
Cowpea	1.39	1.56	-	-
Mukhi kachu	21.18	17.97	-	18.06
Tomato	17.73	25.57 b	28.11 a	-

4.5. Moisture Conservation: Mulching is one of the most important cultural technologies for higher production in rainfed farming system. Mulch is reported to conserve soil moisture, protect soil from erosion, reduce soil temperature, minimize evaporation loss and enhance root growth. Considerable yield advantages in various crops due to surface mulch under rainfed hill farming system of Bangladesh have been obtained by many investigations (Table-12).

Table 12: Effect mulch on the yield of different crops in hill slope (10-20%)

Crop	Yield (t/ha)	
	Mulch	No mulch
Cabbage	68.82 a	56.01
Tomato	34.29 a	12.17
Ginger	13.58	1.31
Cowpea	1.56	13.70 b
Banana	14.85 a	19.51 b
Pineapple	26.34 a	6.49 b
Turmeric	12.12 a	18.17
Seedless lemon	29.89	12.47 b
Mukhi kachu	27.30	13.47 b

5.0 SOIL CONSERVATION AND WATERSHED MANAGEMENT STUDY

5.1 Soil Conservation Research Station: This research station was set up at Ramgahr in 1964 with about 200 acres of low hill areas. The aim of this station was raising of crops and plantation of timber and fruit trees without losing the fertility of the topsoil. Much of the area of the farm has been bench terraced and efforts were taken to carry out experiments on growing of almost all major fruit trees and a variety of other crops such as maize, hill rice, cotton etc. with varying degrees of success.

5.2 Soil Conservation and Watershed Management Centre: This research centre has been set up at Bandarban in 1995 aiming to introduce modern hill cultivation with a suitable technology for soil and water conservation and watershed management. The important on-going research programmes are Soil loss and run-off estimation, Gully control by mechanical and vegetative measures, Rehabilitation of degraded land and stabilization of landslide area with jute geo-textile, Soil moisture monitoring and Establishment of sloping agricultural land technology model-1 (Salt-1).

6.0 PROSPECTS FOR PROMOTING SOIL CONSERVATION AND WATERSHED PROTECTION IN BANGLADESH

For intensity of rainfall and varied topographical features in most of our hilly areas (about 1.73 Mha), different types of erosion and depletion of soil occur. Rapidly increasing population push landless farmers onto steeper, more fragile land, which is then cultivated more and more intensively. There are many cases in the hilly regions of Bangladesh where most part of the productive soils has been washed away from the slopes, or where expensive reservoir (like the Kaptai lake) and river beds have been filled rapidly with sediments. The impact of these processes on environmental degradation is also being realized increasingly in recent years. Some of the research issues have been identified for the hilly areas of Bangladesh based on national conservation strategy in achieving sustainable development (Rahman, 1991).

- Semi-detailed land evaluation survey to identify areas suitable for field crops without terracing, field and tree crop on terraces and appropriate kind of terraces, forest plantation and watershed protection forest.
- Soil conservation through contour plantation, inter-cropping, use of cover crops and use of mulches to protect the soil surface and appropriate kinds of water control structures.

The future study is therefore, proposed to develop an integrated soil conservation and watershed management system for the hilly regions of Bangladesh to ensure a sustainable development.

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Mots clés : conservation des sols, protection des eaux, culture sèche, zone collinaire, Bangladesh

Table 1: Hilly areas of Bangladesh.

District (former)	Area (hectares)	% Bangladesh
Chittagong Hill Tracts	1288874	9.02
Chittagong	274283.4	1.95
Sylhet	145506.1	1.02
Comilla	7979.8	0.06
Noakhali	1226.7	0.01
Jamalpur	9927.1	0.07
Mymensingh	2384.6	0.02
Total	1734182	12.15

Table 2: Area by % under different sloping ranges

Name of the district	Area by % in the slopping range of		
	0-20%	20-55%	55% to above
1. Chittagong Hill Tract	3.5	5.5	91.0
2. Chittagong	-	20.3	18.5
3. Sylhet	-	24.6	-

(Source: Forestal, 1966 Vp: 102)

Table 3: Removal and Sediment deposit by sites

Sites	Soil loss in cm	Sediment deposit unconsolidated in ditches and drains (cm)
Khagrachari	0.008-0.5 cm	10-70
Manikchari	0.009-0.9 cm	5-45
Ramgarh	0.005-2.0 cm	2-17
Rangamati	0.02-5.0 cm	9-130
Raikhali	0.04-2.0 cm	11-93
Bandarban	0.006-0.8 cm	3-7
Teknaf	-	-

Table 4: Extent of erosion raising Sunhemp in different slopes

Slope %	Plot size sft	Soil collected (kg)		Soil lost (t/ha)
		late	Tank	
5	125.15	4.3	8	3.4
		3.4	7.9	
10	125.5	11.7	15.0	7.5
		25.0	9.1	7.5
20	127	5	14.2	6.4
		7	13.6	
30	130	31.6	35.2	13.0
		35.1	14	
50	83.5	34.3	29	30
		35.4	33.2	