Sloping Agricultural Land Technology for Hillside Farms in the Chittagong Hill Tracts, Bangladesh

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Introduction

The Chittagong Hill Tracts (CHT) region, situated in the south-east of Bangladesh, consists of three hill districts: Khagrachari, Rangamati, and Bandarban. Its total land area is about 13,191 sq.km (1.32 million ha), 90% of which are sloping lands, about 6% valley bottom lands, and the remaining 4% covered by villages, rivers, and townships (Khisa 2000). Soils of the region are brown to dark brown, well-drained, loamy sands to silty clay in texture low in base cations, and with acidity values from pH 5.0 to 6.0 (Brammer 1986).

'Jhum', or shifting cultivation, is the dominant farming system in the region. The cultivation cycle has now been reduced to 2-3 years [from 9 to 15 years, ed] and is considered unsustainable; a 'jumia' farmer can now barely obtain 3-4 months of food sufficiency from jhum as a result of the land degradation caused by loss of topsoil, reduced soil fertility, and development of aluminium, manganese, and iron toxicities (Arya 1999). Recognising the value of conserving soil resources for economic growth and poverty reduction the Chittagone Hill Tracks Development Board (CHTDB) with the cooperation and support of ICIMOD, has introduced sloping agricultural land technology (SALT) and other appropriate technologies in the CHT under a collaborative network involving five countries (Bangladesh, the People's Republic of China, India, Nepal, and Pakistan) called Appropriate Technologies for Soil Conserving Farming Systems (ATSCFS). This paper presents the experiences of tests, demonstrations, and extension of SALT and other appropriate technologies under the ATSCFS programme in CHT, Bangladesh.

Materials and Methods

On-farm tests and demonstration of contour hedgerows were carried out at Alutila in Khagrachari District following methodological guidelines outlined in Partap and Watson (1994). Nineteen nitrogen fixing trees/shrubs (NFT/S) and three grass species were tested to select suitable hedgerow species, seven showed good potential. They were cut at regular intervals to assess their performance in terms of growth, tolerance to pruning intensities, and biomass production. Fifteen erosion plots consisting of five treatments and three replications were established to assess the effects of hedgerows on controlling soil loss, runoff, and improving soil fertility (T1: farmers' practice without hedgerows but with fertiliser; T2: farmers' practice with *Leucaena* hedge, but without fertiliser; T3: farmers' practice with *Flemingia* hedge, T4: farmers' practice with *Indigofera* hedge; T5: perennial cash crops with *Indigofera* hedge). Changes in the physical properties of soil in plots with hedgerows and without hedgerows were also studied following simple testing methodologies (MBRLC no date). Extension activities through training and provision of

Table 1: Characteristics of recommended hedgerow species

Species	Seed source	Propagation material and its availability	Seed germination	Growth in the field	N- fixation	Pruning tolerance	Coppicing ability	Biomass production	Drought/ fire tole-rance	Uses
Flemingia congesta	Philippines	Seed (available)	Good	Fast	Yes	Yes	Good	High	Yes	GM, EC, AF
Indigofera tysmanii	Local	Seed (available)	Good	Fast	Yes	Yes	Good	High	Yes	E.C., GM, FW.
Desmodium rensonii	Philippines	Seed (available)	Good (hot water treatment)	Fast	Yes	Yes	Medium	High	Yes	EC, GM, AF.
Gliricidia sepium	Local	Seed (available)	Seed (hot water treatment)	Fast	Yes	Yes	Good	High	Yes	GM, EC, FW
Leucaena diversifolia	Phillippines	Seed (available)	Good	Slow	Yes	Yes	Good	Medium	Yes	EC, GM, AF, FW
Vetiveria zizanioides	Local	Rhizome (available)	n/a	Fast	No	Yes	No	Medium	Yes	EC, GM, AF
Thysanolaena maxima	Local	Rhizome (available)	n/a	Fast	No	Yes	No	High	Yes	EC, GM, AF, FW, CC.

GM = green manure, EC = erosion control, AF= fodder, FW = firewood, CC = cash crop seeds/seedlings were carried out in cooperation with local government and non-government organisations (NGOs).

Results and Discussion

Screening and identification of suitable hedgerow species

Of the 22 hedgerow species tested, 5 NFT/S species (*Leucaena* spp, *Flemingia* spp, *Indigofera tysmanii, Gliricidia sepium*, and *Desmodium rensonii)* and two grass species (*Vetiviera ziznoides* and *Thysanolaena maxima)* were proven to be suitable hedgerow species. The characteristics of the recommended hedgerow species are shown in Table 1. The contour hedgerows were effective in controlling runoff and soil erosion (Table 2) and also improved the soil's physical properties (Table 3). The control plots had higher runoff and soil loss than plots with hedgerows.

On-farm Demonstration of SALT and Other Appropriate Technologies

Four SALT models (I,II,III, & IV) modified and adjusted according to the topography of the site were initially developed and later converted into mainly SALT-III (forest crops, fruit trees, and some portion with annual crops) and SALT-IV (fruit trees and cash crops like ginger, turmeric, and aroids). Other appropriate technologies include the use of leguminous cover crops (LCCs), bio-engineering control of landslides by broom grass hedge and planting of bamboo cuttings, gully control by check-dams and vegetation, and rainwater harvesting with cross-dams. Landslides have been effectively controlled by hedgerows of *Thysanolaena maxima* (Khisa et al. 1999) and by planting bamboo cuttings of *Bambusa vulgaris.* Gully erosion is controlled by check-dams with bamboo walls and planting of *Erythrina indica, Lannea* spp, and napier grass. Bio-fencing with *Durantha glumerella* and *Lantana camera* has been found very useful and successfully demonstrated. Composting with cut weeds and grasses and the use of composts has been demonstrated. Use of LCCs for the enrichment of soil with biomass of cover crops with *Mimosa invisa, Mucuna pruriens*, and *Calopogonium mucunoides* is being studied. Stall feeding of livestock, introduction of urea molasses block (UMB), and bee-keeping were not successful for various reasons.

Table 2: Soil displacement and deposition (cm) recorded by erosion pin method

Reading level[1]	Treatments				
	T1[2]	T2	T3	T4	T5
Above hedgerows (30 cm)	-1.81	3.54	5.85	4.31	5.50
Below hedgerows (30 cm)	-1.91	-1.95	-2.73	-1.25	-2.79

[1]Mean readings of 15 hedge lines, 3 replications of each treatment
[2]Recorded at the same level as for hedgerows

Table 3: Physical properties of soil in SALT vs non-SALT plots (1999)

Test	SALT	Non-SALT	Ratio
Ground cover (%)	75.0	25	3:1
Earthwork castings (gm)	441.0	150	3:1
Percolation rate (m/sec)	2.4	3.5	1:1.6
Infiltration (m/sec)	0.7	3.4	1:5
Surface runoff (m)	3.5	7.6	1:2

On-farm Test

The results show that contour hedgerows can be very effective in reducing runoff and soil erosion. Three years after establishment of contour hedgerows on steep slopes (40-55%) at the test site, soil loss was reduced by 60 - 80% and runoff by 50-65%.

The chemical properties of soil in 2001 compared with baseline data from 1995 did not change significantly except for a decline in soil organic matter (SOM). Decline in SOM may be due to insufficient biomass being incorporated in the alleys; insufficient biomass produced by the hedgerows, particularly by *Leucaena* spp; and/or the planting of rice or corn in the alleys of test plots in the rain-fed conditions without any rotation with leguminous crops.

These results suggest that crop rotation of cereals with leguminous crops and promoting leguminous cover crops in the alleys to supplement the pruning material from hedgerows needs to be considered for soil nutrient enrichment.

Extension and Awareness Activities

The impact of extension activities is significant in raising the awareness of soil-conserving farming practices like establishment of contour hedgerows. At the time of writing, 688 people including upland farmers, local leaders, extension staff of agricultural departments, and selected NGO leaders have been trained on SALT. One thousand upland farmers settled under the Upland Settlement Project (2nd phase) have been motivated to adopt contour hedgerows in their agroforestry plots, but with limited success. Farmers' adoption rate is about 50%, mainly because of difficulties in establishing and managing the hedgerows. The Soil and Watershed Management Centre at Bandarban and the Bangladesh Forest Research Institute, Chittagong are now carrying out studies both on-station and on-farm at Bandarban regarding the suitability of different hedgerow species and their impacts on reducing runoff and soil loss as well as improving the productivity of sloping lands. The Hill Agricultural Research Station at Khagrachari of the Bangladesh Agricultural Research Institute has been demonstrating agroforestry models using pineapple as hedgerows.

SALT has been included in the curriculum of B.Sc (Hons.) in Forestry courses at the Chittagong University, Chittagong. The significance of SALT has been widely recognised by participants in a number of local workshops and public consultative meetings arranged by such agencies as the Sustainable Environment Management Programme of UNDP. The National Environment Management Action Plan (Danish International Development Agency) stressed the importance of contour hedgerows. Vernacular literature and video films on SALT have been developed and disseminated to local farmers.

Conclusions

The ATSCFS programme in CHT served as a catalyst for increasing awareness of SALT and other appropriate technologies. It has identified agro-climatically suitable hedgerow species and obtained preliminary but useful results showing that contour hedgerows can effectively reduce runoff and soil erosion. It has raised the interest of local farmers in the use of contour hedgerows, over 50% of trained farmers have established such hedgerows and increased the capacity of government and non-government organisations to establish hedgerows. Other appropriate technologies like water harvesting by cross-dams, on-farm composting, use of leguminous cover crops (LCCs) to increase soil organic matter (SOM), and landslide control with broom grass hedge have been identified as effective and relevant tools for hillside farming along with SALT.

However, wide adoption of these technologies by the upland farmers in CHT depends on providing them with land ownership, without which they will not be interested in investing in the husbandry of their lands. Consistent support and extension services by government and non-government organisations, making suitable hedgerow seeds/seedlings available, and more demonstrations of site-specific on-farm SALT models in different parts of CHT are needed. Incorporation of leguminous beans or pulses as relay/rotation/intercropping, or growing of LCCs for nutrient enrichment or increasing SOM in the soil, needs to be studied further and demonstrated for improving the fertility and productivity of hillside farms in CHT.

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