

Experiences on Measures to Soil Conservation and Utilization of Water Sources for Productivity in a Watershed Area of Bangladesh

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Abstract: The results of development activities and experiences on adaptive trials in a watershed understudy (1998—2001) are highlighted. Study area is in the Bandarban hill district. Productivity has been deteriorating due to various factors. To improve the farm productivity and to minimize soil erosion attempts have been made with participation of the poor hill farmers. Tree planting by Auger Hole Method minimized soil loss, planting time and labor costs manifolds over the traditional tree planting practices without sacrificing the survival rate of seedlings. The auger provided to tribal/non-tribal communities for tree planting purpose and proved useful considering the easy handling facility, mostly for the seedlings in bag of 4"×6", 5"×7" and 6"×9" sizes. To combat soil loss five adaptive trials are being conducted with Collaborating Farmers (CFs). Trials have increased crops productivity to some extent and intensified the land use systems but there are mixed experiences of failure and success. In these trials forest and horticultural species including agricultural crops introduced are performing well. The entirely unused seasonal ditches, natural water reservoirs inside hill series and poorly managed perennial ponds have been brought under cultivation for ploy culture of fishes. The fish production contributed to their income. Realizing potentiality of fish production, CFs have excavated perennial ponds and reorganized the backyard ditches into perennial ponds, which are contributing to harvesting scarce water and utilizing for farm activities. To diffuse the concepts, it is felt necessary to continue these works with their participation.

Keywords: soil conservation, participatory approach, productivity enhancement

1 Introduction

Management of watershed is a complex and giant task in the mountain areas. Due to removal of vegetation on steep slope and with the on start of severe monsoon biophysical environment degraded there. Moreover, due to unknown specificity of unique features in the environment, it has become Herculean tasks for sustainable management (Sen *et al.*, 1997). The soil quality and soil health is related with sound environment (Sojka and Upchurch 1999) which triggered over productivity of crops as well as to contribute healthy global environment. Fails to harvest that consensus of conservation would turn the soil environment to degradation and ultimately would inbreed poverty. Importance of watershed management was realized since long ago. The king of Sri Lanka (1153—1186 A.D) quoted that, 'Let not a drop of water be allowed to flow into the sea without being used (Kapila and Henry 1999). Chinese people have struggled against soil loss and achieved invaluable experiences since 1000—771 BC (Tingfu 1992). As the pioneering country China has done tremendous achievement on watershed management. Some activities were also initiated in Chiang Mai of Thailand in this regard.

Bangladesh containing total 0.143 M • km² land of which 0.152 M • km² is covered by mountain. She may be deemed as a watershed area of Southern Himalayan Slopes. Her major watershed areas mostly lie in Chittagong, Chittagong Hill Tracts, Sylhet, etc. (Sharma 1999). Hassan (1984) opined that dominating problems there are as follows: uneven distribution of rainfall, shifting cultivation, high deforestation rate and poor management practices and over exploitation. To mitigate the problems no remarkable work was done here. Regarding soil loss under different management conditions some works was done (Layzell 1982, Khisha 2001). Alexander *et al.* (1980) stated that taungya, as an age-old practice of South-Asian countries. They experienced that only one crop of rice may be allowed in taungya systems

which resulted minimum soil disturbances and helpful in reducing soil erosion. Young (1989) opined that due to shortened fallow (3–6 years) period of shifting cultivation that has tended to an inefficient practice. Hill Farming Systems in Bangladesh with narrow technical background are no longer able to satisfy the needs of the society (Nair 1989). In this regard Arya (2000) mentioned that income producing hedgerows and agro forestry components are necessary to integrate in settled agriculture. Annexation of ITK and modern concept of improved AF may contribute in enhancing productivity by protecting the watershed (Bose *et al.*, 1997). In pursuit of these adaptive trials are being conducted in BFRI since 1998 to till date. Main objectives of studies were as follows:

- Developing techniques of soil conservation and management in slope land cultivation system with participation of farmers.
- To increase productivity of land and income through utilization of unused seasonal ditches and small water reservoirs.

2 General methodology of study

The study areas are located in hill district of Bandarban, south-eastern (about 22°—22°15' N-latitude and 92°15' — 92°30' E-longitude) part of Bangladesh. Areas are extended over scattered 10 paras (villages) of Sualok union and Sadar union. Prior to trials, situational analysis and the perceived needs of the farmers have been assessed through Participatory Rural Appraisal. From 10 paras of different ethnicity about 250 farmers have been acquainted with different agroforestry (AF) components and relevance to improvement of economy, soil quality and soil health. In selecting AF components farmer's choice has been prioritized. Two-way communications were made for rapport building with farmers. From planning stage, the farmer's participation has been ensured. Tree seedlings were planted by auger hole method. The farmers did manage the farms and relevant data were collected in accordance to necessity of researchers. Tree-crop base AF methods were designed. For evaluation, comparison was made with farmer's practice and the trials under test.

Biophysical conditions: the study area occupies about 0.263 M • ha of forestland, 0.064 M • ha cultivable and uncultivated land of 0.095 M • ha. Hills of Tertiary age, elevation: 100m—300m, slope gradients: 30%—80%. General soil type: Brown hill soil, mostly loamy, infertility. Climate: tropical, temp: 16.0°C—34.9°C, rainfall: 2,766 mm, drought: 4—6 months (Nov. to April), severe rainfall affect: June-August (90% of total rainfall occurs, magnitude of soil erosion increased). Community: tribal (—7) and non-tribal, population: 5,000 app., male female ratio: 54:46. Family size: 5.5 nos., literacy: 30%. Existing Farming Systems: jhum/shifting cultivation with mixed cropping practice, raising forest and horticultural plantation. Major cropping patterns in valley: fallow-fallow-Transplanted aman, Fallow-aus- T.aman, vegetables-fallow-T.aman, cucumber-fallow-vegetables, cucumber-brinjal-fallow etc.

3 Brief of the experiments with materials and findings

3.1 Experiment-1: auger method for tree planting minimizes soil loss and planting cost

3.1.1 Brief of the experiment

Pit preparation is a prerequisite for planting seedlings. In Bangladesh traditional tree planting pit size is $(30 \times 30 \times 30) \text{cm}^3$ ^(T1) to $(20 \times 20 \times 20) \text{cm}^3$ ^(T2). Pit is dug out by shovel/hoe. Auger method ^(T3) has developed by BFRI for planting seedlings with minimum tillage (Emdad and Paul 1997). Auger sizes are 100cm—135cm in length with an auger diameter of 8 cm—10 cm /or may be variable. To prepare a planting pit, auger is twisted into the soil surface until it reaches the desired depth. Depth should correspond to the polybag size of seedling to be planted. Auger pits are smaller than standard pits, but not detrimental. Continue twisting the auger until soil is finely cultivated. To facilitate seedling planting, pit may be widen by twisting the auger in a circular motion. Pit preparation time varies with soil and site factors. It reduces the time required for site preparation and tree planting without adversely affecting tree survival and growth. It also minimizes soil erosion. Auger is lighter and more durable than traditional planting tools. Durability and price of augers depend on quality of iron and steal. Its unit price is higher

(\$7—15) than that of traditional tools (\$2—5). Due to many advantages over traditional spades and hoes, augers are strongly recommended for all planting sites in Bangladesh for roadsides, embankments and hillsides—any strip site where erosion is a potential problem. It is easy working for women.

3.1.2 Findings

Trials were conducted on hill (slopes 50%—70%) with *A. auriculiformis* and *Hopea odorata*. Results showed that it required time* 13.5 hours/ha to open pit for planting with an auger that is about 1/3rd of T¹ and one-half of T². Trials showed no adverse affect on survival (80%) or growth of the mentioned species. Auger pits provide a significant environmental advantage over traditional pits. Amount (O.D.wt.) of soil excavated from T¹ & T² was 11.4 (T¹) to 6.6 (T²) kg/pit, or 43.3 ton/ha** to 19.7 ton/ha** respectively. But in auger pits, amount of soil excavated was only 0.6 kg /pit, or 1.8 tons /ha. Although excavated soil is returned to planting pit, it is still vulnerable to erosion when rains begin. Erosion is very likely during planting period (monsoon) on steep slopes, roadsides and embankments. Trials showed that erosion loss from standard pits were 17.0 t/ha to 8.0 t / ha (40%—50% of excavated soil) but less than 0.2 t/ha from auger pits (only 10% of excavated soil). Auger was provided free of cost to CFs of 10 villagers of the watershed areas. They planted stumps of teak, polybag seedlings of *G. arborea*, jackfruit, *Syzygium spp*, lemon, *Bambusa spp*, *A. auriculiformis*, *H. odorata*, Papaya, *Olea europea*, *Eucalyptus spp*, *P. emblica*, *C. equisetifolia*, etc, survived satisfactorily. Farmer's attitude to adapt the technology was enthusiastic due to easy working and minimizing time but they did not consider the minimizing of soil loss. But lesser soil loss by auger method contributing towards restoration of fertile topsoil too. The method needs popularization and large-scale auger preparation facilities.

* Observations indicated that effective working time is 50%. ** 3,000 planting points/ha

3.2 Experiment-2: trials of sloping agricultural/afland technology (SALT)

3.2.1 Brief of the experiment

SALT is a sustainable AF system for slopping land condition. Watson and Laquihon(1985) found SALT economically viable and environmentally friendly. Ong (1994) suggested alley/hedgerow inter cropping in SALT plot. The technology has mixed experiences of failures and successes. Experiences suggested that it must be site specific. SALT trials should be conducted for at least 5 years before conclusions. BFRI has incorporated SALT trials in the watershed areas as a means of modifying the traditional jhum cultivation systems.

3.2.2 Findings

In trial plot contour rows were established by hedge (species *gliricidia*, *ipil-ipil*, *Indigofera tasmanii*, *Desmodium*) at 4-6m distance. *I. tasmanii* showed better performance in SALT-1 and SALT-2. At 3 pruning (1st+2nd +3rd pruning 3.5+ 2.7 + 2.8=9.0 ton/ha foliage at 1.0m height) it produced 9.0 t/ha foliage. Estimated soil erosion loss was 15—20 t/ha and 12—18 t/ha in the 1st and 2nd year respectively at 65 % slope gradient (Paul and Emdad 2001). However, in SALT plot, CHTs Development Board (1996) allowed up to 35% slope gradient for seasonal crops, 35%—70 % for fruit trees and more than 70% for forest species. Soil erosion loss in improved AF practices is apparently less than traditional one. At Bandarban site the magnitude of soil erosion loss was found in the following order: fallow > pineapple > rice > agro forestry (Paul, *et al.*, 1996). Under 55%—65% slope land condition (texture SCL-CI) average soil loss was found 9.70 ton/ha, 27.86 ton/ha, 23.80 ton/ha and 7.70 ton/ha respectively in the cropping practice rice- fallow- pineapple and AF plots. Yield of some crops under SALT plot was as follows: Local rice (spatial mixed)-1.2t/ha; Rice, BARI-21 (spatial)-2.2t/ha; Maize (inter cropping)-2.6t/ha; Zinger (spatial)-18.0t/ha and local sesame (Inter mixed)-0.50t/ha. High labor involvement in hedgerow development under SALT sometime makes the hill farmers reluctant to adopt this technology. However, this attitude may be overcome through intensive training and motivational activities. But in the present study there was lack of seed source.

3.3 Experiment -3: under and mixed planting in *tectona grandis* for minimizing soil erosion

3.3.1 Brief of the experiment

Soil loss in plantation of *T. grandis* (teak) is as serious problem in steep hills. To combat that attempts were made. Trial (Expt-1) was conducted under 16 years old and Expt-2 in one year teak plantations. Seedlings of *A. auriculiformis*, *Dipterocarpus spp.*, *Azadirachta indica* and *Bambusa spp* were planted with participation of CFs over 0.50 ha and 1.0 ha of hilly land. In consideration of characteristics (nitrogen fixer, initial shade lover, anti pathogenic and soil binder respectively) the species were selected. The introduced species were planted in between rows of teak with spacing 2m—3m. Seedlings were planted by auger hole method except *Dipterocarpus* species. To quantify soil loss Pin method has been followed.

3.3.2 Findings

Expt-1 showed that at 1st year survival of seedlings were 50% but in the following year that was unable to compete under teak. Their stock density was 3,000 seedlings/ha. The cause of incompatibility of the introduced species may be due to canopy closeness (90%), heavy soil texture and very steep condition of the hill. In Expt-2 that survival was 95% in the 1st year but declined to 85% in the following year. Plantation floor was covered with different type of grass/weeds. There site quality was better than Expt-1. Soil erosion was estimated about 5.0 ton/ha. In one-year-old plantation till date the introduced species are showing compatibility with teak. The experiment needs continuity of the study.

3.4 Experiment - 4: trials of natural vegetative buffer strip (NVS) in soil conservation

3.4.1 Brief of the experiment

NVS practice was originated from upland of Mindanao, the Philippines (Stark *et al.*, 1999). In NVS practice naturally occurring grass and herbs are maintained in 50cm wide contour strips. The naturals left which proved at least as effective as the planted hedgerow in controlling erosion. This practice was found less competitive with crops and planted tree. In the study mostly of NVS weeds were *Lantana camera L*, *Mikania micrantha*, *Eupatorium odoratum L*, *Canavalia virosa* etc. Weeds were quantified. Under NVS, natural vegetation of local origin was intensively utilized for hedge purpose in place of N-fixing hedge plants as in SALT. Trees and crops were grown in inter spaces of NVS. This method is under study.

3.4.2 Findings

NVS trial plots were set up with 2CFs in 1.50 ha of land. Introduced forest (9), horticultural (7) and vegetables plants NVS lines were set up at 3m—5m distance and maintained a natural weed line of 0.50m—0.60m wide. At 1st year weed biomass was estimated 2 ton/ha (O.D wt.). Moisture content in weeds ranged 80%—90%. Field preparation was done at pre-monsoon and planting was carried out in monsoon. Most of the tree species (2,600 nos.) were planted by auger hole method. At 1st year survival of species were 98% and 85% in the next year. Forest species planted on upper slope, horticultural species in mid but only rice in valley was planted by farmer's initiatives. Estimated soil loss was 7 ton /ha—9 ton /ha in the 1st year but failed to collect in the following years. Farmers were happy with yield of banana, pineapple and papaya. It needs further study.

3.5 Experiment-5: trial on contour trash line (CTL) for soil conservation

3.5.1 Brief of the experiment

CTL is a soil conservation practice for slope land cultivation. Trial conducted in one plot (0.80 ha). Its effectiveness in upland AF practice can be readily utilized for restoration of soil loss, fertility and moisture infiltration. In this practice slashed weed materials were kept in contour lines of 2 m—4 m apart at post monsoon in 1st year that served as obstacle to run-off water and contribute to infiltration. Weed biomass was recorded at 1st year at 3 intervals of time. Hills were fallow for several years. Weeds were mostly *Lantana camera L*, *Mikania micrantha*, *Eupatorium odoratum L*, *Canavalia virosa*, etc. AF crops cultivate in the inter-spaces of CTL. Forest species (7 nos.) and horticultural (8 nos.) crops were

cultivated during June-July 1998 with farmer's participation.

3.5.2 Finding

Seedlings were planted with standard spacing. Survivals of species were 98% on an average at 1st year, which gradually declined to 90% in 3rd year. Forest species were planted mostly covering the upper slope but horticultural species in mid and lower slope. Slashed fresh biomass was found 4.5 ton/ha in April, 3.8 ton/ha and 3.4 ton/ha in respectively in the next September and December, quantity of which declined to 50% in the following year. At 3rd year weeding in June and September was proved worth to suppress weeds. Performance of banana, papaya, jackfruit, guava, lemon, pomelo, etc were very satisfactory. With the produced crops CFs were happy. CTL is apparently effective in controlling soil erosion, restoring soil fertility and crop productivity. The experiment needs continuity of the study.

3.6 Experiment- 6: utilization of small water reservoir/ seasonal ditches for fish polyculture

3.6.1 Brief of the experiment

Study area has potentiality of fish culture in seasonal ditches, water reservoir and mini ponds. To meet up the increasing national demand (2.73 million MT)/yr. in 2000 of fish nutrition, it is necessary to boost up production. In this regard 40 farmers have been sensitized imparting training on improved fish culture. Objectives were to introduce fish culture techniques for higher productivity, cash generation and nutrition by using unused water bodies. About 3.5 ha of water body containing 13 ponds and 7 ditches, brought under polyculture of fish. Earlier farmer's practice was tilapia dominating. CFs participated in polyculture with 7 species of 40—50 nos. stock density /decimal. Fish species were carps (grass, silver), ruhu, mrigel, Chinese carp, Katla and Thai sarputi. Supplementary feed was provided. CFs were inspired to plant trees around the perennial ponds. In some seasonal ditch preparation, bund were constructed by CFs participation but the researchers provided fingerlings. Ponds belong to religious organization/school have been prioritized for the study.

3.6.2 Findings

Average weight gain of fishes was 350g—700g at 6 months. Gross income was \$1000—1250/(ha • yr). CFs were encouraged with fish ploy culture. In managed ditches carps, performed well. Though the growth of Thai sarputi was low but still farmers are interested its cultivation. Demonstration created positive impact, 3 CFs had re-excavated seasonal ditches into perennial ponds and 4 CFs excavated new ponds with their means near by the homestead /foot hill of the watershed areas. Reserved water contributing to their agricultural activities and supplementing scarcity of water during drought. Some CFs superimposed *Tilapia* species in the seasonal ditches, which jeopardized growth of other fishes. CFs felt discouraged to cultivate African *Clarias batrachus* despite of its growth, which was tested in a CF ditch for one year.

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