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Land Degradation Situation in Bangladesh and Role of Agroforestry

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ABSTRACT

Degradation of land is a vital issue throughout the world with the particular references to Bangladesh as it a threat to agricultural productivity. Agroforestry, a land use system is being popular in many countries to protect the land from various types of degradation. Studies have proved that agroforestry can check soil erosion to some extent, increase soil fertility, reduce salinity, alkalinity, acidity and desertification etc. ultimately improve soil health which keep the land suitable for agricultural production. The article has drawn on the basis of various reviews focusing the land degradation situation of Bangladesh and potentialities of agroforsetry.

Key words: Land degradation, desertification, agroforestry.

INTRODUCTION

Land degradation is one of the major ecological issues of the world. Land degradation means loss in the capacity of a given land to support growth of useful plants on a sustained basis (Singh, 1994). It is result of many factors or/and combination of factors which damage the soil, water and vegetation resources and restrict their use or production capacity. Considering its impact on food security and environment, it is being important in many corners of the world. The productivity of some lands has declined by 50% due to soil erosion and desertification of the world. Like other countries, Bangladesh is not exception in facing threat of land degradation. Due to different types of land degradation, Bangladesh lost a substantial amount of production which in terms of hundreds of billion taka in every year (BARC, 1999). It is high time to be conscious to minimize the land degradation in Bangladesh, a small country with 1, 47,570 sq. km and about 140 million people. The ever-increasing growth rates (1.48%) caused a spurt in all round consumption level. To meet up the demand of the present and forthcoming generation it is need to bring more land under agriculture and increase productivity. It is true that the utilizable land is finite, for that we should think about the vertical expansion of land following the concept of agroforestry to maximize production.

With the growing realization that agroforestry is a practical, low cost alternatives for food production as well as environmental protection, forest departments of many countries are integrating agroforestry programmes with conventional silvicultural practices (Swaminathan, 1987). Most agroforestry systems constitute sustainable land use and help to improve soil in a number of ways. Some of these beneficial effects are evidence in a number of experiments carried out in different

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parts of the world (Nair, 1987; Young, 1989). Through agroforestry, many countries could not only minimize the land degradation but also increased the production (GTI, 1995; Mishra and Sarim, 1987; Swaminathan, 1977). From mid eighties to till now, agroforestry research in Bangladesh concentering mainly still on identification and characterization of existing agroforsetry practices, development of modules, screening of species in socio-economic context and management of agroforestry system etc. (Miah *et al.,* 2002). It is a new area of study with a potential for assuring land sustainability. But we are lagging behind in this context. Keeping all these things, on the basis of reviews, an effort was made to highlight the extent of land degradation situation in Bangladesh and the potentialities of agroforestry minimizing various types of land degradation so that it may serve as a tool to research, planning or development works.

LAND DEGRADATION - A GLOBAL CONCERN

The total land area of the world exceeds 13 billion-hectare but less than half of it can be used for agricultural activity including grazing. Potentially arable land constitutes 3031 million ha of which 2154 million ha are potentially cultivable in developing countries and 877 million ha are in developed countries. About 1461 million ha. is cultivated of which 784 million ha. & 677 million ha. are in developing and developed countries respectively (Dudal, 1982). Large-scale degradation of land resources has been reported from many parts of the world (Hillel, 1991). The economic impact of land degradation is extremely severe in densely populated South Asia, and sub-Saharan Africa.In South Asia, annual loss in productivity is estimated at 36 million tons of cereal equivalent valued at US$5,400 million by water erosion, and US$1,800 million due to wind erosion. It is estimated that the total annual cost of erosion from agriculture in the USA is about US$44 billion per year, i.e. about US$247 per ha of cropland and pasture. On a global scale the annual loss of 75 billion tons of soil costs the world about US$400 billion per year, or approximately US$70 per person per year. From Table 1, it appears that about 70% of the total land of the world is under degradation (Dregne and Chou, 1994).

Table 1. Estimation of all degraded lands (in million km^2) in dry areas

Continent	Total area	Degraded area	% Degraded
Africa	14.326	10.458	73
Asia	18.814	13.417	71
Australia and the Pacific	7.012	3.759	54
Europe	1.456	0.943	65
North America	5.782	4.286	74
South America	4.207	3.058	73
Total	51.597	35.922	70

(Source: Dregne and Chou, 1994).

EXTENT OF LAND DEGRADATION IN BANGLADESH

Major types of land degradation that occurs in Bangladesh are- water erosion, soil fertility depletion, salinization, waterloggoing, pan formation, active flood plain etc. Among them, water erosion and fertility depletion are the main factors. The soils of hilly area are the most susceptible to water erosion in which sheet, rill and gully erosion occurs. About 75% of the hilly areas have very high susceptibility to erosion, 20% have high susceptibility and 5% have moderate susceptibility to erosion (BARC, 1999). Faulty 'Jhum' cultivation in hilly area causes gully erosion and losses of soil ranges from 10 to 120 t/ha/ yr. (Farid *et al*., 1992). Decline of soil fertility occurs through and combination of lowering of soil organic matter and loss of nutrients. The average organic matter content of top soils (high land and medium high land situation) have gone under from about 2% to 1% over the last 20 years due to intensive cultivation which means and decline by 20-46% (Miah *et al*., 1993). Removal of nutrients is also and threat to the agriculture. The negative soil nutrient balance have found in the country and the net removal of major nutrients (N, P, K, S) are as high as ranges between 180 and 250 kg/ha/yr. (Karim *et al*., 1994). The extent of land degradation and its economic impact are given in the Table 2 and 3 respectively.

Table 2. Types of land degradation and their extent in Bangladesh

Type of land degradation	Area (million ha.) affected by different degrees of degradation*			Total affected area (M.ha.)
	Light	Moderate	Strong	
1. Water erosion	0.1	0.3	1.3	1.7
- Bank erosion	-	1.7	-	1.7
2. a. Soil fertility decline	3.8	4.2	-	8.0
2. b. Soil organic matter depletion	1.94	1.56	4.05	7.55
3. Water logging	0.69	0.008	-	0.7
4. Salinization	0.29	0.43	0.12	0.84
5. Pan formation	-	2.82	-	2.82
6. Acidification	-	0.06	-	0.06
7. Active flood plain	-	-	-	1.53
8. Deforestation	-	0.3	-	0.3
9. Barind	-	-	-	0.773

(Source : BARC, 1999(modified).
(*Light: Original biotic functions are largely intact. Production loss is between 5-10%. Moderate: Original biotic functions are partially destroyed. Production loss is between 20-25%. Strong: Original biotic functions are largely destroyed. Production loss is 60-75 %.)

Table 3. Estimation of the cost of land degradation in Bangladesh

Nature of degradation	Physical quantity of lost output	Taka equivalent/yr (Million)
Water erosion	Cereal production loss = 1.06 Mt/yr	6613.84
	Nutrient loss = 1.44 Mt/yr	25576.46
Fertility decline	Cereal production loss = 4.27 Mt/yr	26641.48
	Addl. Inputs = 1.22 Mt/yr	21668.88
Salinization	Total production loss = 4.42 Mt/yr	27577.25
Acidification	Total production loss = 0.09 Mt/yr	561.51

(Source: BARC, 1999).

BENEFICIAL EFFECTS OF AGROFORESTRY ON SOIL

On the basis of various experimental evidences, Dwivedi (1992) pointed out some beneficial effects of agroforestry on soil, such as: (i) reduction of loss of soil as well as nutrients through reduction of run-off, (ii) addition of carbon and its transformation through leaf, twig, bark fall etc., (iii) nitrogen enrichment by fixation of nitrogen by nitrogen fixing trees, shrubs etc., (iv) improvement of physical conditions of soil such as water holding capacity, permeability, drainage etc., (v) release and recycling of nutrients by affecting biochemical nutrient cycling, (vi) more microbial associations and addition of more root biomass, (vii) moderately effect on extreme conditions of soil acidity and alkalinity (viii) creating more favourable microclimate by windbreak and shelterbelt effect and (ix) lowering effect on the water-table in areas where the water table is high.

Agroforestry techniques involving planting multipurpose trees that are tolerant of the adverse soil conditions have been suggested as a management options for reclamation of problem areas (King and Chandler, 1978).

Agroforestry for erosion control

Young (1989) reported that trees and shrubs have several functions to control erosion like (i) to increase soil cover, by litter and pruning (ii) to provide partly permeable hedgerow barriers (iii) to lead to the progressive development of terraces, through soil accumulation upslope of hedgerows

(iii) to increase soil resistance to erosion, by maintenance of organic matter (iv) to stabilize earth structures by root systems (v) to make productive use of the land occupied by conservation works. Alley cropping or hedgerow cultivation is very helpful in controlling of soil erosion in the hilly area. Hill Tract Development Board of Bangladesh identified five nitrogen fixing trees species like *Leucaena leucocephala, Gliricidia sepium, Indigofera tysmani, Fleminigia* spp. and *Desmodium rensonii* etc. and two grass species *Vetiviera zizanoides* and *Thysanolaena maxima* for controlling run off and erosion in the hilly region of Bangladesh (Khisa *et al*., 2002).. Singh *et al*. (1990) found that runoff and soil loss were substantially reduced when small watersheds with agriculture were replaced either by trees and grasses (silvipasture) or with mechanical measures. In a study, Wiersum (1984) found that different agroforestry systems cause lowest soil erosion (Table 4).

Table 4. Rate of erosion in tropical forest and tree crop systems

Agroforestry systems	Erosion (t/ha/yr)		
	Minimum	Median	Maximum
Multistory tree gardens	0.01	0.06	0.14
Natural rain forest	0.03	0.30	6.16
Shifting cultivation, fallow period	0.05	0.15	7.40
Forest plantations undisturbed	0.02	0.58	6.20
Tree crops with cover crop or mulch	0.10	0.75	5.60
Shifting cultivation, cropping period	0.40	2.78	70.05
Taungya, cultivation period	0.63	5.23	17.37
Tree crops, clean weeded	1.20	47.60	182.90
Forest plantations, burned or litter removed	5.92	53.40	104.80

(Source: Wiersum, 1984).

Agroforestry for improving soil fertility

Trees can add a substantial amount of nutrients into the soil. (Singh and Hazra, 1995) reported that silviculture system helped in appreciating available nutrients (N, P, K), organic carbon and reducing soil pH and EC (mmhos/cm) comparing degraded land and untreated hills and hillocks. In agroforestry system, plantation of leguminous tree is encouraged that can fix a substantial amount of nitrogen from the atmosphere. Typical rates of nitrogen fixation for herbaceous legumes are in the range of 40-200 kg N/ha/yr (Nutman, 1976; Larue and Patterson, 1981; Gibson *et al*., 1982). By adding organic matter, trees can improve the physical properties like structure, porosity, and water holding capacity etc. of soil and also modify the temperature by shading and litter cover. In a long term alley cropping experiment involving *Gliricidia sepium, Leucaena leucocephala, Cassia siamea and Cajanas cajan* species in rainfed flat land ecosystem, Miah *et al*. (2001) found that soil health improved and nitrogen fertilizer could be saved considerably with all species without significant losses of cereals (rice, wheat, maize) and vegetables (cabbage and tomato). Young (1989) done a tentative grouping of agroforestry practices according to their effects on soil fertility is given below:

1. Practice with substantial positive effect on soil fertility
    - improve tree fallow
    - trees on croplands
    - plantation crop combinations
    - homegardens
    - hedgerow intercropping
    - trees on erosion control structures
    - windbreaks and shelterbelts
    - biomass transfer
    - trees on rangelands or pastures

- woodlots with multipurpose management
- reclamation with multipurpose management

2. Practice with small positive of neutral effects on soil fertility
    - boundary planting
    - plantation crop with pastures
3. Practices with positive or negative effect on soil fertility
    - shifting cultivation
4. Practices with neutral or negative effect on soil fertility
    - taungya

Agroforestry for saline soils

Vegetation hinders the loss of water through evaporation results lower salinity in the area under vegetation. Plant species which can withstand high salt content and thrive under high watertable conditions should be selected for planting. Species of *Atriplex, Prosopis, Tamarix, Casuarina, Kochia, Zizyphus, Salvadora and Acacia* are most tolerant to underground saline water situation. Yadava and Prakash (1995) found that *Termnalia arjuna, Albizzia procera*, *Eucalyptus* 'hybrid' and *Leucaena leucocephala* were more tolerant and survived up to ECe12.2 dS/m and *Dalbergia sissoo* were slightly tolerant as it survived up to ECe 6.70 dS/m. A study under *Acacia nilotica* and *Eucalyptus terticornis* in Karnal, India, lowering of pH from 10.5 to 9.5 in five years and of electrical conductivity from 4 to 2 has been reported but with tree establishment assisted by addition of gypsum and manure. (Gill and Abrol, 1986.; Grewal and Abrol, 1986.)

Agroforestry for alkali soils

Alkali or sodic soils contain excess soluble salts capable of alakaline hydrolysis which interferes the growth of crop plants. Some tree species like *Prosopis jiliflora, Acacia nilotica, Casuarina equisetifolia, Tamarix articulata, Achras japota etc. can tolerate more than* pH 10.0, *Pitchecellobium dulce, Salvadora persica, Salvadora oleoides, Capparis decidua, Terminalia arjuna,Cordia rothii, Albizzia lebbek, Pongramia pinnata, Sesbania sesban, Eucalyptus tereticornis, Parkinsonia aculeata, Cassia carandus, Psidium guajava, Zizyphus mauritiana, Aegle marmelos, Emblica officinalis, Punica granatum, Phoenix dactylifera, Tamarindus indica, Syzygium cumuni* etc. can tolerate pH 9.1 to 10.0 and *Acacia auriculiformis, Azadirachta indica, Melia azaderach, Populus deltoides, Grewia asiatica, Vitis vinifera, Mangifera indica, Kijellea pinnata, Moringa oleifera, Grevillia robusta, Butea monosperm, Pyrus communis, Sapindus laurifolius, Ficus sp.* etc. can tolerate up to pH 9.0 (Dagar *et al*., 1994).

Agroforestry in desertification control

Tree planting in region threatened by desertification is aimed at environmental protection. Trees have multiple functions in ecosystems. There is no substitute in the maintenance of ecosystem balance. Although we cannot restore original forest, there are conditions, which favour the possibility of re-afforestation. Success or failure of the management depends on the site conditions, plant species selection, and planting techniques. A large scale of plantation of *Casuarina equisetifolia* in the Nanshan Island of China caused reduction of wind speed by 60 % and evaporation by 12.5 % and also increased the yield (FAO, 1978).

Agroforestry for acid soil

Agroforestry systems are the appropiate management of acid soils because perennial woody vegetation can recycle nutrients, maintatin soil organic matter and protect the soil from surface, erosion., and runoff (Nair, 1993). There are some multipurpose tree species which are highly adapted to acidity eg. *Alnus nepalensis, Parkia javanica, Parkia facataria, Michelia oblonga, Melenia arborea* etc. moderately adapted eg. *Acacia auriculiformis, Michelia alba, Michelia lenigata* etc. and less adapted eg. *Leucaena leucocephala, Robinea pseudoacacia, Cryptomeria japonica, Cryptomeria torulosa, Pinus kesiya* etc. (Dhyani *et al.,* 1995).

TREE SPECIES ON THE BASIS OF THEIR SUITABILITY IN BANGLADESH

Soil pH, coppicing ability, nitrogen fixation ability, 'joe' condition of the soil, drought, salinity, heat and pest tolerance etc. are to be considered to select the suitable species in suitable places, (Bhuiya *et al.,* 2000). They also suggested selecting trees on the basis of soil condition as follows-

Ganges floodplain: Date palm, Sissoo, Mahogany, Babla, Teak, Raintree, Hogpalm, Coconut, Betel nut, Ipil-ipil etc.

Bramhaputra floodplain: Mango, Black berry, Coconut, Mahogany, Sissoo, Raintree, Simul, Kadam, Neem, Olive, etc.

Tista floodplain: Mango, Litchi, Jackfruit, Bakain, Neem, Sissoo, Simul, Babla, Akasmoni, Minziri, Sal, Mahagony, Jamrul, Koroi etc.

Barind tract: Babla, Khair, Datepalm, Akasmoni, Eucalyptus, Mango, Litchi, Raintree etc.

Madhupur tract: Sal, Jackfruit, Mahogany, Simul, Koroi, Neem etc.

Saline area: Jau, Coconut, Babla, Ipil-ipil, Koroi, Raintree etc. in low to moderate saline area and Sundari, Keora, Goran, Bain etc. in high saline area.

Hill tract: Teak, Gamar, Telsur, Koroi, Capalish, Gorjan etc.

CONCLUSION

Land degradation is a global concern for agricultural productivity. It is the demand of time to check the further degradation and restore the degraded land. Agroforestry systems appear to have the potential to control erosion, improve soil fertility, and so lead towards sustainable land use. Agroforestry is being treated as and component of sustainable agriculture in many countries. Research is need in specific land degradation situation to generate appropriate technologies. Training should be provided to the agricultural researchers and extension personnel. Planning of agroforestry is to be framed out at the top level. Linkage with international organizations should be developed. Selection of suitable species, selection of appropriate technology, sufficient inputs and effective organization etc. should be kept in mind during the initiation of agoforestry programme minimizing the land degradation.

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