Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.7, No.5, 2017

Reclamation of Degraded Land through Agroforestry Introduction in Bangladesh

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Abstract
The challenge is now daunting how feed more than six billion people (nearly 16 billion by 2020) even as key resources become scarcer. Almost 25% of the world's land area is degrading and about two billion people directly depend on degraded areas. In china more than 400 million are affected by land degradation. Particular references show that land degradation is a vital problem in Bangladesh and as a great threat of agricultural productivity. A land use system called Agroforestry is being popular in many countries around the world to protect the land from various level of land degradation. Studies from different dimensions show that agroforestry can check soil erosion to some extent, reduce salinity, alkalinity, acidity, desertification's and increase soil fertility level. I also improve soil healths which keep land suitable for agricultural production. This passage mainly focuses on the land degradation situation in Bangladesh and potentialities of agroforestry on the basis of various reviews.
Keywords: Agroforestry System, Land Degradation, Deforestation

1. INTRODUCTION

The world population growth is steadily increasing and the situation is even more alarming in developing countries. For instance, Bangladesh is characterized by a great bio-physical diversity and dividing the country in several agro-ecological zones, each with specific flora and fauna. It therefore is an important centre of endemism and biodiversity (Zewge and Healey 2001). Due to the overpopulation (170 million) growth of Bangladesh and Overgrazing and deforestation for agricultural activities, construction material and fuel wood, overall natural forest cover had to decrease to a great level. The combination of high endemism and first habitat degradation in Bangladesh leads to a great risk of species distribution (Zewge and Healey 2001). Poverty and natural resources degradation had negatively reinforce each other; that is as the land is degradated, lower the agricultural productivity resulting in decreasing the income level and food security and vice versa (Eyasu 2002, Selamyehun 2004; Wakeneand Heluf2000). This has resulted in migration of the rural poor people to urban areas, increased cultivation into marginal land, encroachment into forest regions and also depletion of land resource base of small holders (Demelet al., 2000). The productivity of some land has declined by 50% due to soil erosion and desertification of the world. Due to different types of land degradation, Bangladesh lost a substantial amount of agricultural production which in terms of hundreds billion taka in every year (BARC, 1999). Moreover the country's topographic nature has made it more liable to degradation (Girma 2000). 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 the productivity.

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 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 concentring 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. Keeping all these things, on the basis of reviews, an effort was made to highlight the extent of land degradation status 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.

2. CONCEPT OF LAND DEGRADATION- A GLOBAL CONCERN

According to UNEP (1999), land degradation is the temporary or permanent lowering of the productive capacity of land. It is one of the biggest problems in the world particularly at third world countries, threatening the lives of millions of people in the humid, sub humid and dry lands, albeit/although at different levels Robert .J; et al (2008). Degradation commonly occurs when negative human activities become supplemental to the natural factors. The main human activities include overgrazing, over-cultivation, inefficient irrigation systems that do not correspond with soil water requirements and deforestation as well as industrial pollution, population increases is also the other drivers of land degradation (UNCCD 2003). Erosion is one of a number of forms of soil degradation, including deterioration of physical, chemical and biological properties (Young 1989) all of which require attention. Therefore, the problem of soil erosion could be socioeconomic and/or environmental issue and it has become a global issue widely considered in management and conservation of natural resources (Morgan, 1995).

Moreover, one of the main objectives of land resource management is aimed at soil conservation, since maintenance of integrity of soil quality, properties, process, and diversity is deemed essential to ensuring sustainable land use (Hurni, 1993). As well-known land degradation has a vast side effect on the earth. The main consequences of land degradation, which impact negatively on human livelihoods and on the environment, are generally well known. They include: shortages of firewood and other wood, shortages of (NTFP) non-timber forest products (EFAP, 1994), increased sediment deposits, floods and landslides, drying up of springs and water bodies; siltation of dams, increased incidence of water-borne diseases, loss of biodiversity, climate change, desertification, all these reduce land productivity and affect food security (Robert.J et al., 2008).

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 hectare and 677 million hectare 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 shows 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)

3. PRESENT CONDITIONS OF LAND DEGRADATION IN BANGLADESH

Water erosion, soil fertility depletion, water logging, pan formation salinization, active flood plain etc. are the major types of land degradation in Bangladesh. Among all of them, water erosion and fertility depletion are the main factors. The soils of hilly area are very much susceptible to water erosion in which sheet, rill and gully erosion occurs. About 70% of the hilly areas have very high susceptibility to erosion, 25% 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 the 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% to1% over the last 20 years due to intensive cultivation which means and decline by 25-46% (Miah*et al*., 1993). The negative effect of 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 present status of land degradation and its economic impact in Bangladesh are given in the Table 2 and Figure 1 respectively.

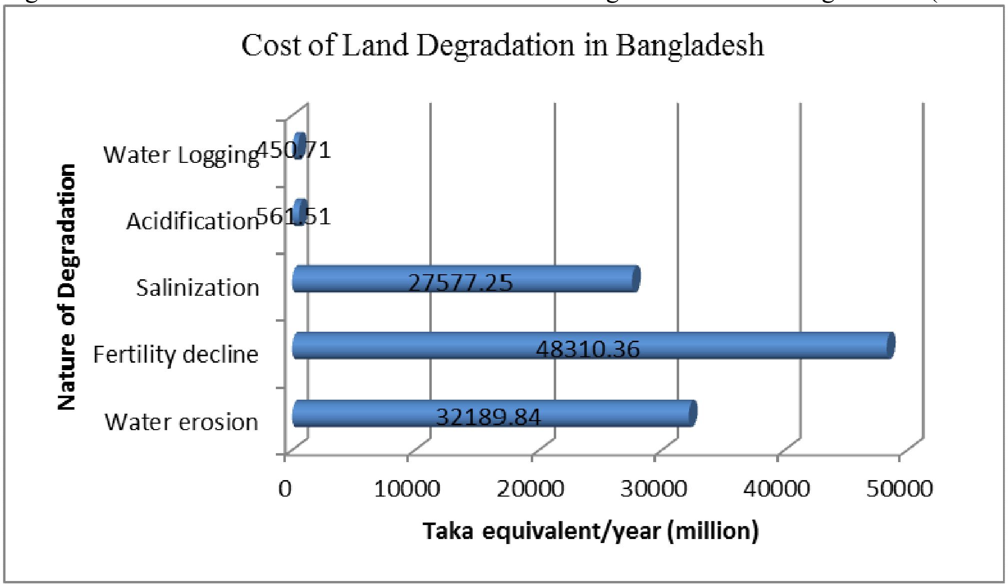
Table2. Types of land degradation and their present status in Bangladesh

Type of land degradation	Area (million ha.) affected by different degrees of degradation			Total affected area (M.ha.)
	Light	Moderate	Strong	
Water erosion	0.3	0.6	1.5	2.4
Soil fertility decline	3.2	4.8	2.5	10.5
Soil organic matter depletion	1.54	2.32	5.04	8.86
Water logging	1.05	0.016	-	1.07
Salinization	0.45	0.65	0.12	1.22
Acidification	-	-	-	0.11
Active flood plain	-	-	-	1.53
Deforestation	-	0.4	-	0.4
Barind	-	-	-	0.77

(Source: BARC, 1999(modified))

(*Light: Original biotic functions are largely intact. Production loss is between 10-15%. Moderate: Original biotic functions are partially destroyed. Production loss is between 25-30%. Strong: Original biotic functions are largely destroyed. Production loss is 70-75 %.)

Figure 1: Estimation of the cost of land degradation in Bangladesh (Source: BARC, 1999)



4. BENEFICIAL EFFECT OF AGROFORESTRY IN REHABILITATION OF DEGRADED SOIL

Nair (1993) reported as many factors of development in the 1970s contributed to the general acceptance of agroforestry as system of land management, that it is applicable to both farm and forest. It has the potential for improvement in the physical, chemical and biological conditions of soils and thus the main advantage of agroforestry systems is in their ability to bring favourable changes in all the three conditions and also includes; (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.

4.1 Agroforestry on Conservation of Soil and Water

Udawatta et al., (2002) reported that agroforestry and contour strip had a combined significant effect on runoff, sediment, and nutrient loss reduction as compared with non-agroforestry treatments. (Nair, 1993) and (Young, 1989) supported that leguminous trees have shown potential of reducing soil erosion through five principal ways: interception of rainfall impact by tree canopy, surface runoff impediment by tree stems, soil surface cover by litter mulch, promotion of water infiltration, and formation of erosion resistant soil structure. Similarly, Okigbo and Lal (1997) reported that the cover measure involving the use of vegetation for soil protection, maintains the hydrological balance in which the surface run-off component in the hydrological cycle would be minimized. In the same way Juo and Thurow (1998) reported that vegetative barriers are generally used in combination with mechanical land treatments such as micro catchments. Agroforestry has a potential for erosion control through the soil cover provided by tree canopy and litter, in addition to the role of trees in relation to the runoff-barrier function (Nair, 1993). The role of trees and shrubs in erosion control could be direct or supplementary. In direct use, the trees are themselves the means of checking runoff and soil loss. In supplementary use, control is achieved primarily by other means (grass strips, ditch and-bank structures, and terraces); the trees serve to stabilize the structures and to make productive use of the land, which they occupy. Thus, once the tree and grass species inside and around the micro catchments are established, a combined system of land treatments can increase infiltration and control of erosion. This could in turn improve physical, chemical, and biological attributes of the soil for fertility maintenance.

4.2 Improvement of Soil Fertility through Agroforestry

In the broad sense, the productivity of the land is its suitability for production, the main components of which are light, water and soil. Udawatta et al., (2002) reported that maintenance and enhancement of soil fertility is vital for global food security and environmental sustainability. Regarding the soil fertility, Eyasu (2002) has reported that soil fertility comprises physical changes, which is the capacity of the soil to provide plants with foothold, moisture and air, and chemical conditions, which determine the capacity of the soil to provide plants with nutrients. Young, (1989) defined soil fertility as the capacity of the soil to support the growth of plants on a sustained basis under given condition of the climate and other relevant properties of the land. In line with this, Eyasu (2002) reported that declining soil fertility in tropical rain fed agriculture is becoming a serious problem for a growing number of people. Similarly Kandji et al., (2006) reported that low soil fertility is a major problem to food production and one of the key biophysical constraints to increased agricultural growth in sub-Saharan Africa. To curb/control the problems of soil fertility, agroforestry approach might play a positive impact. There are different types of agroforestry practices that improve soil fertility management/ improvement: fallows, hedgerow, alley cropping, tree on cropland, plantation on physical structures. Soil fertility decline results from the combined effect of lowering of soil organic matter, deterioration of physical properties, lowering of nutrient content, and in some cases acidification that is commonly associated with the decline in soil fertility (Young, 1989).

But, if measures are not taken on time to avoid the loss of soil fertility, it might be a headache to growing population especially in developing countries. Roa et al (1998) reported that leguminous trees species have shown some potential for soil fertility improvement and soil conservation since soil fertility improvement can be achieved through biomass transfer, long/short term fallows, nitrogen fixation. In the same way, Ajayi et al., (2008) reported that trees/shrubs improve the physical properties of soils. In particular, soil aggregation is higher in fields where trees are being grown, and this enhances water infiltration and water holding capacity of soils thereby reducing water runoff and soil erosion. It is also reported by Acharya and Kafle (2009) that leaf litters in agroforestry systems enrich the soil fertility by providing organic matters, leaves control the speed of the raindrops and allow them to go down to the land surface slowly which helps water to infiltrate into lower part of the soil surface. Agroforestry systems have high potential in solving the problem of soil fertility when compared to nontree/shrub based systems. Roa et al (1998) stated that the maintenance of soil fertility in AF based systems could be achieved through increase or maintain nutrient status, increasing soil fauna and flora, better soil aggregation, lower bulk density improved soil porosity, increase water infiltration had compared to the bare soil.

4.3 Improve Acidic and Alkali Condition of Soil by Agroforestry

Agroforestry systems are the appropriate management system of acid soils because perennial woody vegetation are able to recycling nutrients, maintain soil organic matter and protect the soil from surface erosion and runoff (Nair, 1993). There have 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* and less adapted multipurpose tree species are eg. *Leucaena leucocephala, Robinea pseudoacacia, Cryptomeria japonica, Cryptomeria torulosa, Pinus kesiya* etc. (Dhyani *et al.,* 1995).

Alkali soils contain excess soluble salts capable of alakaline hydrolysis which interfere the growth of crop plants. Some tree species like *Cassia carandus, Psidium guajava, Zizyphus mauritiana, Aegle marmelos, Emblica officinalis, Punica granatum, 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, Albizzia lebbek, Cordia rothii, Pongramia pinnata, Sesbania sesban, Eucalyptus tereticornis, Parkinsonia aculeata, 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).

4.4 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 water table conditions should be selected for planting. Species for example *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.).

4.5 Control of Desertification through Agroforestry

Trees have multiple functions in ecosystems and aimed at environmental protection. There is no substitute in the maintenance of ecosystem balance. Although it cannot be possible to 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).

4.6 The Services of Agroforestry at Socio-economic Issue

Agroforestry could be a suitable option for socio-economic issue for different communities at different levels. Agroforestry gives farmers the opportunity to spread their income and risks over different products and with time (Jama B and Zeila A. 2005). Furthermore well-chosen Agroforestry combinations may result in a better spread and more efficient use of labour and machinery. At last, many Agroforestry systems and their products lend themselves for value adding activities. Also the demand for biomass production for fuel, fibre and waste management are expected to rise. The stronger the pressure on the price development of arable productions, the more attractive AF will become as an economic alternative to conventional farming.

For instances, apart from diversification of income, agroforestry systems may have direct economic advantages. It gives landowners the opportunity to maintain a crop, while establishing trees on their land. Indirect economic benefits.AF practices may reduce the costs for labour and chemical input by suppressing weeds and pests. For example, the tree might be a host of predators of crop pests and the intercropping of tree alleys decreases the weed problem heavily compared to a pure forest stand. Trees in AF systems may benefit from the crop fertilization weeding and irrigation increasing wood and fruit production. Animals often show to appreciate trees for their wind-protection and shade. Trees have a climate stabilizing effect and reduce wind-chill and heat-stress. As such trees not only contribute to the well-being of the livestock, but may also have an economic advantage (Jama B and Zeila A. 2005).

5. TREE SPECIES ON THE BASIS OF THEIR SUITABILITY IN BANGLADESH

Saline area	**Madhupur tract**	**Barind tract**	**Tista floodplain**	**Ganges floodplain**	**Bramhaputra floodplain**	**Hill tract**
Jau, Coconut, Babla, Ipil-ipil, Koroi, Raintree, Sundari, Keora, Goran, Bain etc.	Sal, Jackfruit, Mahogany, Simul, Koroi, Neem etc.	Babla, Khair, Datepalm, Akasmoni, Eucalyptus, Mango, Litchi, Raintree etc.	Mango, Litchi, Jackfruit, Bakain, Neem, Sissoo, Simul, Babla, Akasmoni, Minziri, Sal, Mahagony, Jamrul etc.	Date palm, Sissoo, Mahogany, Babla, Teak, Raintree, Hogpalm, Coconut, Betel Nut, Ipil-ipil etc.	Mango,Black Berry, Coconut, Mahogany, Sissoo, Raintree, Simul, Kadam, Neem, Olive, etc.	Teak, Gamar, Telsur, Koroi, Capalish, Gorjan etc.

6. CONCLUSION

Agroforestry strategies have the potential to rehabilitate degraded land to support livelihoods, improve food security, restore ecosystem services, and ease pressure on forests but achieving these gains is not easy. The process takes time and effort, good policies and enforcement, and substantial investments to help small-scale farmers, who are unlikely to have the resources to restore degraded lands without support. Secure land tenure is crucial, as many of these investments take years to pay off. Monitoring before and after is also essential to ensure that interventions achieve the desired goals, and if they don't, make the necessary adjustments. 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 agroforestry programme minimizing the land degradation.

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