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Management of hill and mountain soil

of North Eastern India through agroforestry interventions

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In order to feed the growing population, India has to produce more from the land available in the coming years. This quest for increasing food production with increaseing population pressure is likely to strain hilly and mountain eco-system. Marginal and sub-marginal lands have been brought under plough without taking adequate conservation measures. This has led to degradation of natural resources (land, water and vegetation) causing poor fertility status, soil erosion, low available soil moisture, acidic non-irrigated soil, etc. Thus it becomes imperative that management should be catered by subsequent systems as per the climatic variability resource available includes-agroforestry system, nutrient management strategies with efforts on mulching-use of locally available materials etc.

Key words: Agroforestry, Hill & Mountain Soils, North-East India

THE HILLY and mountainous areas of North-East India are marked by diversity, remoteness, cultural identity, fragility etc. The north eastern region (NER) of India, comprises the states of Meghalaya, Mizoram, Nagaland, Sikkim, Arunachal Pradesh, Assam, Manipur, and Tripura and it lies between 22°05' and 29°30' N latitudes and 87°55' and 97°24' E longitudes. The concerns of the livelihood among heterogeneous traditional mountain communities living in close proximity to the nature and natural resources are directly or indirectly dependent upon forest resources of the hills. The soils are facing peculiar problems of poor fertility status, prone to soil erosion with loss of top fertile layer, acidic non-irrigated soils, low water holding capacity, poor water conservation practices, size of land holding is too small, undulating topography etc. In such fragile conditions, certain practices need to be undertaken to solve the issue of ecosystem degradation. Various researchers reported that huge soil loss through erosion and agricultural practices ranges from 3.46 t/ha/yr (bare land) to 170 t/ha/yr (shifting cultivation) in north-east India. Therefore, agroforestry being a holistic and integrated land use management system is solution of such vagaries and sustains the life. Apart from providing timber, fuelwood, fibre, food, it provides lot of NTFPs and not only this, but several intangible benefits in terms of carbon sequestration, soil quality improvement, water status, adaptation and mitigation to climate change etc.

Eastern Hill and Mountain region of India

This zone represents mainly the whole of north eastern states, parts of north Bengal, Sikkim. The region has several ethnic and cultural diversity, sparsely populated and fragile ecosystem with humid to sub humid, tropical, alpine belts. The topography is undulating with difficult terrain, slopes, soil depth variation, erosion prone, acidic uplands. Moreover, more than one-third of population practising jhum farming or slash and burn agriculture as a traditional food cultivation practice. Because of the fragile terrain, majority of the tribal population depends on shifting agriculture along with livestock rearing. Cultivation of rice along with maize, pineapple, citrus is practised, while the rearing of pig, poultry etc. are mostly popular in Eastern Himalayan region. In case of slash and burn agriculture, the farmers remove vegetation and burn all the debris and plant parts and cultivate the land for 2-3 years, after that the soil loses its fertility and then they moved to some new forest areas for following the same practice. They then return in 4-15 years time till then the soil will regain its fertility. But the jhuming cycle timing varies from region to region (place, population, tribal community etc.). Now a days, due to population pressure, the tribes used to have 3-4 years of jhuming cycle. This cultivation is done mainly at village boundaries, but demand for food and increasing population had made it unsustainable. Earlier, against 20-30 years of jhuming, now it has been

reduced to 3-4 years, these leads to formation of degraded lands, and more areas become erosion prone. Apart from jhuming, many traditional systems co-exists with local livelihood from generations to generations in eastern Himalayan region are presented in Table 1.

Alder based traditional agroforestry system

The cultivation of cardamom in eastern Himalayan region has been practiced since ages. The cardamom can easily grow along with Himalayan alder (*Alnus nepalensis*) which is a nitrogen fixing trees. In the shade of alder, the cardamom grows profusely, while there is production of high amount of biomass under storey along with addition of enough nitrogen in the soil beneath. This combination of alder and cardamom has proven to be both ecologically and economically viable. The alder can easily regenerate in landslide prone areas, which naturally makes it one of the unique species to grow synchronously with large cardamom especially in Sikkim Himalayan region. The soil loss under cardamom-alder based agroforestry systems reduces by more than 90% (30 kg/ha) over rainfed agriculture (477 kg/ha).

Alder-cardamom based agroforestry system. (Source: Maikhuri and Negi, 2011)

Traditional homestead agroforestry system (Bari)

The Bari agroforestry system has been practised over generations in Adi tribal community of eastern Himalayan region, the area mainly earmarked is hills of Assam, Meghalaya and Arunachal Pradesh. The model is basically a homestead agroforestry arrangement wherein, several combinations of tree and crop species have been grown by proper utilisation of solar light and making precise arrangement of crops by taking into consideration, light

Table 1. Traditional farming practices in sub-tropical to temperate agro-climatic belt of eastern Himalaya

Land Units	Traditional land-use classification	Attributes of practices
Khet System (wet rice)	Pakho khet	Slope >30°, terraced rice fields, trees grown on the terraces,terrace fall is frequent during rainy season
	Byanshi	Thang or fat paddy fields, along Teesta and Rangpo river, nutrient rich soil, good productivity
	Sim/kholyang	Water seepage round the year, also the source of potable water
	Bagarrey	Paddy fields along the river banks, pango (clay soil), fertile
	Birauto	Newly terraced field, soil conservation structures that are sometimes the test lands for new crops or the crops that are not suited for other land use types
Bari (dry land)	Tar bari	Flat dry field, rain-fed, for growing maize, wheat, vegetables, oil seeds, millets and buckwheat etc. These are mostly fertile terraced plots and are highly productive.
	Kothe bari	Field within the home-garden for many crops and vegetables, horticultural crops, banana etc., annual and inter-cropping done. Home gardens house traditional and cultural crops, medicinal plants, or preferred sacred species
	Pakho bari	Steep hill slopes are converted into cultivable, productive but narrow terraces, fodder grasses, fodder trees, other multipurpose agroforestry species, pulses and banana etc. are grown
	Bhasmey/Khoria	This is the remnant of shifting cultivation, scrublands, slash and burn in the sloping land, pulses, horse gram are grown
	Siru bari	*Imperata* sp. (for roof thatching) and trees are grown
	Alaninchi bari	Large cardamom plantations under the mixed tree species, support fuel, fodder and timber apart from economic return from cardamom
Niji Jungle (private forests)	Bans-ghari+jungle	Indigenous farmers conserved agroforests/forests at the edge of the farmland that functions as protective lands. Bamboo groves and other agro-forestry species grown

Source: Sharma and Rai, 2012.

requirement, shade loving nature, phenology, evapotranspiration rate, canopy configuration, nutrient and water requirement to make it more viable ecologically, economically as well as increasing biodiversity.

The arrangement of Bari system:

First Zone: Medicinal and aromatic plants, spices, vegetables like *Alocasia indica, Colocasia antiquorum, Curcuma longa, Zingiber officinale etc.*

Second Zone: Arecanut, Banana, Jackfruit, Citrus, Papaya, Bamboo

Third Zone: *Mangifera indica*, Terminalia species, Garcinia, Emblica etc.

Agroforestry increases soil biodiversity and soil quality

Scientific evidences suggest that, forest cover or agroforestry practices especially silvopastoral had more population of soil biota over arable land. This change was linked to difference in soil temperature especially in top 0-15 cm depth, as forest had undisturbed top cover, as well as in agroforestry, lot of tree litters had been added through leaf fall, root decomposition, less exposure to sunlight etc. that favours organic matter to be added and thus induce soil biota to flourish along with nutrient availability. While in cultivated soils, many studies suggest soil microbial population lower than the forest or agroforestry area, which can be attributed to reduced input through over story litter and disturbance of soil due to cultivation. Results indicated that natural vegetation, especially forest, contributes significantly to enhance the level of micronutrients in soil. Continuous addition of plant leaves/ litter into the soil may be a major source of these elements in soil. While, cultivated soil have lower content of soil nutrients than in the grassland and forest is attributed to soil management practices that have commonly been destructive as it favours serious water erosion and runoff. Improvement in organic matter content and nutrients would be expected from more C input practices such as agroforestry. In alley cropping systems, the interspaces between the paired tree-rows were completely covered by weeds and regenerated leucaena to act as a filter strip. When sediment deposited along these strips then flat bunds were formed leading to make tree rows an effective barrier to flow occurring over surface. With trees as hedgerows barrier, there helps in significant reduction in runoff due to filtering effect of vegetative barriers. Little runoff or nutrient flow may be attributed due to dense canopy architecture and good infiltration capacity and moreover, such vegetative barriers, remain stable and functional for longer period of time than conventional earthen bunds.

Sloping agricultural land technology (salt)

SALT is a land management setting, wherein there is integration of food production and soil conservation in a single platform. SALT technology involves growing of double rows of nitrogen fixing trees on contours to act as soil binder, nitrogen fixer and as livestock feed. Both perennial and annual field crops can be grown between double contoured rows of N fixing trees and shrubs, which can conserve soil against erosion, adds fertility to it. The legumes can be cut every 30-45 days interval and added to the soil to increase fertility. Especially in South-East Asia, the practice of SALT has been through long back. Originally, the SALT technology has been developed and perfected by Baptist Rural Life Centre at Kinuskusan, Bansalan on Mindanao island in the Philippines.

Originally, four SALT technologies were developed:

i) **SALT I**: It is simple and effective technology of agroforestry and the emphasis is more on food crop production and this technique reduces soil erosion to a great extent.

ii) **SALT II**: It is more of an agro-livestock system, integrating SALT I plus rearing of livestock. Mainly small ruminants are preferred for small farmer's upland agricultural system.

iii) **SALT III**: It involves SALT I, SALT II and side by side a separate piece of land for forest plantation mainly hedge rows or timber yielding trees to augment income as well as for food, fuel, fibre, fodder etc.

iv) **SALT IV**: SALT IV is horticulture and plantation based production system, where the emphasis is on increasing farm income and making hill agriculture more commercialized alongside conserving soil on the farmlands.

Way ahead

There is an urgent need for identifying promising tree species with high nutritive value for quality fodder production mass multiplication. Hill and mountain region of north east India is very fragile with respect to resource base and climatic vagaries, thus research should also employed modelling tools to monitor changes in climatic pattern or better prior strategy for adaptation. Need of strengthening the markets for agroforestry produce or NFTPs so that the practice become more remunerative. Awareness and technology transfer to the local communities related to agroforestry model suited to the local climatic conditions and had the potential of soil and water conservation component must be replicated.

SUMMARY

Appropriate agroforestry models for upland hill agriculture system suited to local climatic conditions emerged to be an important system for soil, nutrient and water conservation. Integrated use of organic manures with fertilizers will improve soil health along with increasing food crop yields. Sloping Agricultural Land Technology must be practiced for areas of traditional jhum farming practices, as the system had enough potency for ameliorating soil along with conserving soil against erosion, water conservation etc.

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